Standard Review Projects and AB 1082/1083 Pilots
Evaluation Year 2023 (Year 3)

Third-Party Evaluation Report
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Prepared for
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(on behalf of Pacific Gas & Electric,
San Diego Gas & Electric, and Liberty Utilities)
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Acronym List

Acronym	Definition
AB	Assembly Bill
AC	Alternating current
ACF	Advanced Clean Fleets
ACT	Advanced Clean Trucks
ADA	Americans with Disabilities Act
AFDC	Alternative Fuels Data Center
AHJ	Authority Having Jurisdiction
AL	Advice Letter
AMI	Advanced metering infrastructure
ARCHES	Alliance for Renewable Clean Hydrogen Energy Systems
AR5	IPCC’s published fifth assessment report
BAU	Business-as-usual
BEV	Battery electric vehicle
BTM	Behind-the-meter
CAISO	California Independent System Operator
CARB	California Air Resources Board
CBG	Census block group
CBO	Community-based organization
CCS	Combined charging system
CEC	California Energy Commission
CFI	Charging and Fueling Infrastructure
CH_4	Methane
CNG	Compressed natural gas
CO	Carbon monoxide
COBRA	CO-Benefits Risk Assessment Health Impacts Screening and Mapping tool
CO_2	Carbon dioxide
CPUC	California Public Utilities Commission
CTA	California Trucking Association
CVRP	Clean Vehicle Rebate Project
CVUSD	Cajon Valley Union School District
DAC	Disadvantaged Community
DC	Direct current
DCFC	Direct current fast charger
DGE	Diesel gallons equivalent
DMV	Department of Motor Vehicles
DOE	U.S. Department of Energy
DPR	Department of Parks and Recreation
ELRP	Emergency Load Reduction Program
EMFAC	Emissions Factors
EPA	U.S. Environmental Protection Agency
eTRU	Electric transportation refrigeration unit
EV	Electric vehicle
EV-HP	Electric vehicle high-power
EVSE	Electric vehicle supply equipment
EVSP	Electric vehicle service provider

Acronym	Definition
EY	Evaluation Year
FCEV	Fuel cell electric vehicle
GGE	Gasoline gallons equivalent
GHG	Greenhouse gas, here including CO_2, CH_4, and N_2O
GSE	Ground Support Equipment
GVWR	Gross vehicle weight rating
GWP	Global Warming Potentials
HVIP	Hybrid and Zero Emission Truck and Bus Voucher Incentive Project
ICE	Internal combustion engine
ICT	Innovative Clean Transit
IOU	Investor-owned utility
IPCC	Intergovernmental Panel on Climate Change
IRA	Inflation Reduction Act
IV-2SLS	Instrumental variable two-stage least squares
kW	Kilowatt
kWh	Kilowatt-hour
L1	Level 1
L2	Level 2
LCFS	Low Carbon Fuel Standard
LDV	Light-duty vehicle
LFP	Lithium iron phosphate
LMI	Low- and moderate-income
MDHD	Medium- and heavy-duty
ME&O	Marketing, education, and outreach
MPA	Master participation agreement
MW	Megawatt
MWh	Megawatt-hour
MT	Metric ton
NACS	North American Charging Standard
NEVI	National Electric Vehicle Infrastructure
N_2O	Nitrous oxide
NH_3	Ammonia
NO_x	Oxides of nitrogen
NPV	Net present value
NSP	Network service provider
NTG	Net to gross
OEM	Original equipment manufacturer
OIR	Order Instituting Rulemaking
OLS	Ordinary least squares
ORION	Off-Road Inventory Online
PAC	Program Advisory Committee
PAI	Program Attribution Index
PAO	Public Advocates Office
PG&E	Pacific Gas & Electric Company
PHEV	Plug-in hybrid electric vehicle
PM	Particulate matter
PMO	Program Management Office

Acronym	Definition
PTD	Program-to-Date
PYDFF	Power Your Drive for Fleets
RFID	Radio frequency identification
ROG	Reactive organic gases
SB	Senate Bill
SCE	Southern California Edison
SDG&E	San Diego Gas & Electric
SO_2	Sulfur dioxide
SO_x	Oxides of sulfur
SRP	Standard Review Projects
TCM	Truck Choice Model
TCO	Total cost of ownership
TE	Transportation electrification
TEAS	Transportation Electrification Advisory Services
TEC	The Energy Coalition
TOU	Time-of-use
TRU	Transportation refrigeration unit
TRUCRS	Truck Regulation Upload, Compliance, and Reporting System
TSE	Truck stop electrification
TTM	To-the-meter
VAP	Vehicle Acquisition Plans
V2B	Vehicle-to-building
V2G	Vehicle-to-grid
VGI	Vehicle-grid integration
VIO	Vehicles in operation
VOC	Volatile organic compound
VMT	Vehicle miles traveled
VSL	Value of statistical lives
V2X	Vehicle-to-everything
ZEV	Zero-emission vehicle

1. Executive Summary

This report summarizes findings and lessons learned from an independent evaluation of 14 programs to build electric vehicle (EV) charging infrastructure for light-, medium-, and heavy-duty vehicles, administered by four California Utilities. These programs were authorized under California Public Utilities Commission (CPUC) decisions in 2018 and 2019 and support goals in Senate Bill (SB) 350 Clean Energy and Pollution Reduction Act of 2015 and Assembly Bills (AB) 1082 and 1083. This report builds on last year's Evaluation Year (EY) 2022 report[1] with new findings and lessons learned for EY2023. This is the final report for the Vehicle-to-Grid (V2G) Pilot and the Liberty EV Bus Infrastructure programs.

Table 1 summarizes the 14 transportation electrification (TE) programs and their authorized budgets.

Table 1. Summary of Utility Programs

Utility	Program	Description	Budget
Southern California Edison (SCE)	Charge Ready Transport	Public and private fleet medium- and heavy-duty (MDHD) make-ready and customer infrastructure.	$342.6M
	Schools Pilot	Direct installation of and incentives for make-ready infrastructure and chargers at K–12 schools, community colleges, and universities.	$9.9M
	Parks Pilot	Direct installation of and incentives for make-ready infrastructure and chargers at public parks and beaches.	$9.9M
Pacific Gas & Electric (PG&E)	EV Fleet	Public and private fleet MDHD make-ready and customer infrastructure.	$236.3M
	Schools Pilot	Direct installation of and incentives for make-ready infrastructure and chargers at K–12 schools, community colleges, and universities.	$5.8M
	Parks Pilot	Direct installation of and incentives for make-ready infrastructure and chargers at public parks and beaches.	$5.5M
	EV Fast Charge	Installation of Utility-owned direct current fast charging (DCFC) chargers.	$22.4M
San Diego Gas & Electric (SDG&E)	Power Your Drive for Fleets (PYDFF)	Public and private fleet MDHD make-ready and customer infrastructure.	$107M
	V2G Pilot	Pilot to test electric school buses and bi-directional charging equipment.	$1.7M
	Schools Pilot	Direct installation of and incentives for make-ready infrastructure and chargers at K–12 schools, community colleges, and universities.	$9.9M
	Parks Pilot	Direct installation of make-ready infrastructure and chargers at public parks and beaches.	$8.8M
Liberty Utilities	EV Bus Infrastructure	Depot charging stations for Tahoe Transportation District to install.	$0.22M
	Schools Pilot	Direct installation of and incentives for make-ready infrastructure and chargers at K–12 schools, community colleges, and universities.	$3.9M
	Parks Pilot	Direct installation of and incentives for make-ready infrastructure and chargers at public parks and beaches.	$0.78M

[1] For EY2022 impacts, please see: Cadmus, Energetics, et al. (2023). *Standard Review Projects and AB 1082/1083 Pilots: Evaluation Year 2022 (Year 2).* https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/sb-350-te/publicjoint-iou-annual-srp-and-ab108283-evaluation-report-for-py-2022.pdf

1.1. Terminology

Throughout this report, the Evaluation Team uses several technical terms:

- **Site.** A single geographic location at which a Utility customer has installed charging stations and ports as part of one of the 14 Utility programs.[2]
- **EY2023 Sites.** Sites activated in calendar year 2023.
- **Program-to-Date (PTD) Sites.** Sites activated in the program from inception through the end of 2023.
- **2023 Actual.** Impacts in calendar year 2023 from PTD sites.
- **PTD Actual.** Impacts in all years from PTD sites.
- **10-Year Projection.** Projected impacts from PTD sites through 10 years of equipment life**.**
- **Electric Vehicle Supply Equipment (EVSE).** A charger with one or more ports.
- **Ports.** The connectors that can concurrently charge vehicles from a single EVSE.
- **Light-duty vehicles (LDVs).** Class 1 and Class 2a vehicles. Gross vehicle weight rating (GVWR) up to 8,500 lbs.
- **Medium-duty vehicles.** Class 2b through Class 6 vehicles. GVWR between 8,501 lbs. and 26,000 lbs.
- **Heavy-duty vehicles.** Class 7 and Class 8 vehicles. GVWR over 26,001 lbs.

This evaluation uses the following conventions to describe the status of sites as they advance toward activation and use:

- **Utility Construction Completed:** Sites where the Utility has completed its part of the installation. This could be to-the-meter (TTM), behind-the-meter (BTM), or a turnkey installation.
- **Activated:** Sites with charging stations installed and available for use.
- **Operational:** Sites for which advanced metering infrastructure (AMI) and/or electric vehicle service provider (EVSP) energy usage data have been received from the Utility or EVSP.
- **Closed Out:** Sites for which financial documentation has been finalized by the Utility and incentives for the installed chargers have been paid.[3]

Table 2 summarizes site counts denoted in this evaluation for EY2023 and the program to date. EY2023 sites, shown in white columns, include sites that reached a given site status (such as Activated) between January 1, 2023, and December 31, 2023. PTD sites, shown in gray columns, include all sites since the launch of the program that reached a given site status as of December 31, 2023.

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[2] Utilities sometimes refer to a site as a "project."

[3] At some closed out sites, the Utilities still plan to pay incentives for future chargers.

Table 2. Site Counts for EY2023 Sites and PTD Sites

Utility	Program	Utility Construction Completed		Activated		Operational		Closed Out	
		EY2023	PTD	EY2023	PTD	EY2023	PTD	EY2023	PTD
SCE	Charge Ready Transport	23	65	16	55	15	54	13	29
	Schools	8	21	8	21	8	17	0	1
	Parks	0	0	0	0	0	0	0	0
PG&E	EV Fleet	26	72	20	62	19	60	20	52
	Schools	10	11	10	11	10	11	7	7
	Parks	0	0	0	0	0	0	0	0
	EV Fast Charge	12	21	9	18	9	18	5	11
SDG&E	PYDFF	10	23	8	21	8	21	8	12
	Schools	6	15	8	15	8	15	4	5
	Parks	1	9	1	9	1	9	3	8
	V2G	0	1	0	1	0	1	1	1
Liberty Utilities	EV Bus Infrastructure	0	1	0	1	0	1	0	1
	Schools	0	0	0	0	0	0	0	0
	Parks	0	0	0	0	0	0	0	0
Total		**96**	**239**	**80**	**214**	**78**	**207**	**61**	**127**

Counts in Table 2 are not additive between the four site statuses (Utility Construction Completed, Activated, Operational, and Closed Out). In general, the site count in the Closed Out column is a subset of sites in the Operational column, which is a subset of sites in the Activated column, which is a subset of sites in the Utility Construction Completed column. Since program inception to the end of 2023, the four MDHD programs have had the most sites reach Utility Construction Completed (161), followed by the Schools Pilots (47), PG&E EV Fast Charge (21), and the Parks Pilots (9).

1.2. Findings

This section summarizes program findings. For simplicity, programs are grouped into three program bundles based on similarities in program design:

- **MDHD Bundle:** Liberty EV Bus Infrastructure, PG&E EV Fleet, SCE Charge Ready Transport, and SDG&E PYDFF
- **Public Charging Bundle:** Liberty Schools and Parks, PG&E EV Fast Charge, PG&E Schools and Parks, SCE Schools and Parks, and SDG&E Schools and Parks
- **V2G Pilot:** SDG&E V2G

Table 3 summarizes the program impacts by bundle for EY2023.

Table 3. EY2023 Program Impacts by Bundle

Impact Parameter	MDHD Bundle	Public Charging Bundle	V2G Bundle
Population of Activated Sites in EY2023 (#)	45	36	0
Ports Installed in Analyzed Sites (#)	752	247	0
EVs Supported (#) [a]	1,062	N/A	N/A
Electric Energy Consumption (MWh)	19,046	918	46
Petroleum Displacement (diesel gallons equivalent [DGE])	1,393,334	69,411	3,951
Greenhouse Gas (GHG) Emission Reduction (metric tons [MT] GHG) [b]	10,351	542	33
Oxides of Nitrogen (NO_x) Reduction (kg)	8,957	N/A	N/A
Particulate Matter (PM_{10}) Reduction (kg)	88	3	0
Particulate Matter ($PM_{2.5}$) Reduction (kg)	84	3	0
Reactive Organic Gases (ROG) Reduction (kg)	384	42	0
Carbon Monoxide (CO) Reduction (kg)	46,883	1,483	11

[a] The team derived the EVs supported value for MDHD programs from applicants' vehicle acquisition plan (VAP). This value represents the maximum number of vehicles expected to be supported by the charging infrastructure.

[b] GHGs include carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) multiplied by their respective Global Warming Potentials (GWP) as defined by the Intergovernmental Panel on Climate Change (IPCC) published fifth assessment (AR5). See *Appendix A* for more details).

1.3. Lessons Learned

Preliminary lessons learned supported by findings are provided below by bundle. Note that these lessons and findings were derived from a limited number of program participants across most but not all market sectors. Additional insights will be gained as more sites are completed in the coming years.

1.3.1. Medium-Duty Heavy-Duty Bundle

MDHD programs are having a meaningful impact on EV and charger deployments, but the number of total sites continues to lag program goals.

A total of 1,899 charging ports have been installed across 138 sites to support 2,552 vehicles across all Utility MDHD programs to date. The school bus market sector has seen the highest rate of deployment in the program to date, accounting for 70 activated sites with 566 charging ports serving 791 vehicles.

In EY2023 the SCE Charge Ready Transport program activated 16 new sites with 430 charging ports to support 459 vehicles based on customer VAPs, bringing totals to 55 activated sites with 1,019 charging ports to support 1,206 vehicles. This meets 11% of the program goal of 500 sites and 14% of the goal of 8,490 vehicles supported. A total of 156 contracts have been signed in the program to date to support 3,337 vehicles, which would meet 31% of the program's site goal and 39% of its vehicles supported goal.

In EY2023 the PG&E EV Fleet program activated 20 new sites with 250 charging ports to support 383 vehicles based on customer VAPs, bringing totals to 62 activated sites with 630 charging ports to support 874 vehicles. This meets 9% of the program goal of 700 sites and 14% of the goal of 6,500 vehicles supported. A total of 239 contracts have been signed in the program to date to support 4,942 vehicles, which would meet 34% of the program's site goal and 76% of its vehicles supported goal.

In EY2023 the SDG&E PYDFF program activated eight new sites with 76 charging ports to support 227 vehicles based on customer VAPs, bringing totals to 21 activated sites with 261 charging ports to support 472 vehicles. This meets 7% of the program goal of 300 sites and 16% of the goal of 3,000 vehicles supported. A total of 35 contracts have been signed in the program to date to support 668 vehicles, which would meet 12% of the program's site goal and 22% of its vehicles supported goal.

Staff across Utilities have expressed continued concerns about reaching programmatic site goals, noting that program requirements are a challenge for small fleets, because some customers do not own their sites or are unable to commit to the required number of vehicles per site. According to the 2022 EMFAC Fleet Database,[4] over 50% of MDHD fleets in California have three or fewer vehicles. Customers have also expressed apprehension about evolving regulations and requirements, such as the Advanced Clean Fleets (ACF) program and ISO-15118, leading to reduced interest in both EV adoption and program participation. The California Public Utilities Commission (CPUC) has approved reduced site count goals from 870 to 500 for SCE and extended both the SCE and PG&E program timelines by two years. SDG&E's PYDFF original program goals and timelines have not been adjusted; at its current trajectory, SDG&E's program is not expected to meet its original goals for number of sites.

Program spending is ramping up slowly; however, spending in DACs exceeds targets in most programs.

Utilities spent a total of $31.4 million in EY2023 across MDHD programs, bringing total spending to $100.2 million in the programs to date, or 14.6% of the total program budget. Total program spending of $31.72 million in EY2023 was almost identical to EY2022 spending, though spending trends varied between Utilities.

SCE spent a total of $12.8 million of the Charge Ready Transport program budget in EY2023, a 24% increase over EY2022. This brings total spending to $34.8 million out of $342.6 million, or 10.2% of available funding. Forty-four percent of Charge Ready Transport program spending has been on DAC sites, exceeding the 40% program target. Additionally, in both EY2023 and the program to date, more than 70% of sites, charging ports, and vehicles are located in DACs.

PG&E spent a total of $13.7 million of the EV Fleet program budget in EY2023, a 32% increase over EY2022. This brings total spending to $49.5 million out of $236.3 million, or 21% of available funding. Forty-three percent of EV Fleet program spending has been on DAC sites, exceeding the 25% program target. Additionally, in both EY2023 and the program to date, more than 40% of sites, charging ports, and vehicles are located in DACs.

SDG&E spent a total of $4.9 million of the PYDFF program budget in 2023, a 55% decrease from EY2022 spending. However, EY2022 was the first year of operations for program sites completed in prior years but not activated until 2023. This brings total spending to $15.9 million out of $107 million, or 14.8% of available funding. No sites in the PYDFF program to date are located in a DAC, despite increased

4 California Air Resources Board. Retrieved September, 18, 2024. "EMFAC Fleet Database. https://arb.ca.gov/emfac/fleet-db/0b5c4b8cc96ebae8c1feda6cdd14ca9166654697

prioritization of and outreach to potential participants located in DACs in 2023. In 2023, SDG&E had a challenge for meeting the DAC goal given only 5% of its service territory are DACs under the statewide definition of DACs. This suggests SDG&E is highly unlikely to meet its DAC spending goal under the statewide definition; however, with the approval of AL 4436-E, SDG&E may have a higher likelihood of meeting the DAC spending goal under the utility territory definition.[5]

> **Recommendation:** The Evaluation Team found that the vehicle counts observed during site visits tend to be significantly lower than customers' VAPs (even when compared with the expected annual procurement). Taking a proactive approach to tracking progress towards the VAP (with an annual customer contact about vehicle procurement, for example), would allow Utilities to ensure that customers are following their VAP, which could contribute to improved program performance with respect to energy consumption, petroleum displacement, emissions reductions, and health impacts.

> **Recommendation:** Utilities are significantly lagging in their progress toward site goals and are spending their allocated budgets more slowly than expected. Ongoing lessons learned by Utility staff and from evaluation findings should be incorporated into programs to promote improvements. To ensure changes can be implemented in a timely manner, Utilities should continue to communicate recommendations for updates to program design and metrics to regulators and other stakeholders. For many changes, regulatory support will be needed to implement these recommendations. An example of a potential barrier is the cost threshold metric the Utilities use to determine whether to accept or reject a site into their programs. These metrics are in terms of dollars per charging port and dollars per vehicle—based on CPUC decisions—and vary by Utility. Ultimately, the thresholds reduce the number and diversity of participants, which is an unnecessary constraint in the current early market stage of electric MDHD vehicles. Utilities need greater flexibility in program design to meet the overarching goals of the Standard Review Projects (SRP) related to advancing TE.

Utility MDHD programs are displacing petroleum, reducing GHG and local emissions, and achieving health benefits overall and within DACs.

To date over 3 million gallons of petroleum have been displaced through Utility MDHD programs, with the largest portion attributed to the heavy-duty vehicle market sector. Over a 10-year period, activated program sites are expected to displace over 23.3 million gallons of petroleum.

MDHD programs have also reduced GHG emissions by nearly 20,000 MT to date, and activated sites are expected to reduce GHG emissions by over 176,000 MT over a 10-year period. In terms of local emissions, Utility MDHD programs have had the greatest impact on CO emissions, achieving a reduction

[5] San Diego Gas & Electric. "AL 4436-E: Second Update on the Implementation of San Diego Gas & Electric Company's Medium-Duty and Heavy-Duty Electric Charging Infrastructure Program in Disadvantaged Communities Pursuant to Decision 19-08-026." May 2, 2024. ELEC_4436-E.pdf (sdge.com)

of nearly 173,000 kg to date. The estimated share of health benefits in DACs is 36% for SCE, 31% for PG&E, and 14% for SDG&E.

Though overall demand for EV charging increased substantially in EY2023, customers are only using a small percentage of installed charging capacity, and the majority of fleet operators are not implementing load management.

Across all Utility MDHD programs, more than 39 MW of new charging capacity was installed in EY2023, up from 21.5 MW in EY2022, an increase of 81%. On average, activated sites in EY2023 were larger than previous program years and included several of the largest sites in the program, bringing the total installed capacity to 68.5 MW.

In the SCE Charge Ready Transport program, overall EV charging demand increased by over 250% from EY2022, but peak demand in EY2023 never exceeded 4.7 MW, or 12.6% of installed capacity in the program to date. In the PG&E EV Fleet program, overall demand increased by over 150% from EY2022, but peak demand in EY2023 never exceeded 4.9 MW, or 21.5% of installed capacity. In the SDG&E program, overall demand doubled from EY2022, but peak demand in EY2023 never exceeded 1.6 MW, or 19.2% of installed capacity. Charger utilization is expected to increase as fleet operators receive additional planned vehicles and integrate them into daily operations.

Across all Utility programs, only 28 of 135 activated sites exhibited use of load management to date, shown by sharp increases in load after 9 p.m. when the peak rate time period ends. Most fleet managers have an opportunity to decrease operational costs and achieve greater emissions reductions by shifting charging from periods of peaks demand to periods when electricity prices are lower and the grid is cleaner. For SCE Charge Ready Transport, 40% of school bus charging sessions and 10% of non-school bus charging sessions have enough flexibility to avoid charging during peak periods. For PG&E, over 40% of all charging sessions have enough flexibility to avoid charging during peak periods.

> **Recommendation**: Utilities should continue to contact customers on an annual basis (at minimum) following site activation to ensure that sites are proactively identifying load management opportunities. The Evaluation Team recommends focusing on school bus sites—which typically do not manage load—and large sites such as those with greater than 1 MW installed capacity—which have the greatest opportunity to manage load. By identifying and documenting reasons why customers are not actively managing load, program staff and the Evaluation Team can build more-targeted recommendations for addressing load management barriers.

Despite Utility staff focus on improving activation timelines, the timelines have been increasing each of the last three years due to program and non-program challenges.

The start-to-finish median calendar days in EY2021 was 600 days, compared to 723 days in EY2022 and 862 days in EY2023 across all MDHD market sectors. The Design and Permitting phase has typically been the longest in duration across Utility MDHD programs for all evaluation years. The extension of site activation timelines can be attributed to a number of factors, most prominently supply chain delays and the activation of larger, more complex projects than in previous years.

The time from application to activation in the SCE Charge Ready Transport program was 592 days on average in EY2023 compared to 530 days in EY2022 and 462 days in EY2021. The Design and Permitting phase increased to 288 days in EY2023, from 208 days in EY2022, which is a 38% increase, and represents almost half (49%) of the total average activation timeline.

The timeline for application to activation in the PG&E EV Fleet program was 663 days on average in EY2023 compared to 570 days in EY2022 and 410 days in EY2021. The Design and Permitting phase increased to 446 days in EY2023 from 374 days in EY2022 and 252 days in EY2021. This represents a 19% increase over EY2022 and accounts for 67% of the total average activation timeline.

The timeline for application to activation in the SDG&E PYDFF program was 930 days on average in EY2023 compared to 751 days in EY2022 and 543 days in EY2021. While the Design and Permitting Phase was the longest in duration in EY2022 (316 days), in EY2023, the Construction Complete phase more than doubled in length to 398 days, while Design and Permitting dropped by 38% to just 196 days. This was driven by two transit bus sites, which had an average total activation timeline of 1,236 days.

The electric regional and long-haul truck market share is projected to increase to above 30% by 2030 according to an expert Delphi panel but lags behind the ACT sales requirements.

Panelists noted several reasons why this market sector could struggle to meet the ACT sales requirements, citing costs, constraints of batteries, and lack of charging infrastructure as the most consistent challenges. Panelists noted uncertainty in how vehicle manufacturers will price future electric and diesel trucks given the ACT regulation, which could have follow-on impacts on fleet decision making. Other experts cited the weak business case for deploying public charging infrastructure for electric trucks and that government funding would be needed.

1.3.2. Public Charging Bundle

All Public Charging Programs

The Schools and Parks Pilots' sites and the EV Fast Charge program sites are resulting in displacement of petroleum, reduction of GHG and local emissions, and improvement in health outcomes overall and within DACs.

Combined, the schools and parks sites have displaced more than 177,000 gallons of petroleum PTD, with between 25% and 72% of the impact occurring within DACs, respectively. The SCE Schools Pilot sites account for 12,000 gallons; PG&E Schools Pilot sites for 6,700 gallons; PG&E EV Fast Charge sites for 101,000 gallons; and SDG&E Schools and Parks sites for 58,000 gallons. In addition, the PTD sites collectively reduced 1,317 MT of GHG emissions across the programs. These sites all contributed to lowering local emissions. Finally, these sites accounted for between 14% and 27% of the health benefits in DACs with the annual monetary health benefits ranging from $375 (SCE Schools Pilot) to $5,507 (PG&E EV Fast Charge).

The Schools and Parks Pilots' sites and the EV Fast Charge program sites are promoting regional EV adoption.

The SDG&E Schools and Parks Pilots, SCE and PG&E Schools Pilot, and PG&E EV Fast Charge program positively influenced EV adoption in households neighboring the charging infrastructure. Across programs, the increase in household EV adoption that can be attributed to program sites ranged from 8 to 55 additional EVs, as determined through a two-stage spatial regression described in the report.

With higher-than-expected site costs and project delays that continue to strain approved budgets for the Schools and Parks Pilots and the EV Fast Charge program, staff are interested in adapting the Pilots and program to mitigate impacts and encourage customer engagement.

All of the Schools and Parks Pilots and PG&E's EV Fast Charge program began during the COVID-19 pandemic, which had subsequent economic impacts across nearly every market. These changes were so large that the estimates the Utilities originally developed for Decision 19-11-017 (which mandated the Schools and Parks Pilots at their determined funding levels) and Decision 18-05-040 (which mandated the EV Fast Charge at its determined funding level) did not reflect the actual costs of implementation. Additionally, Utilities experienced site development delays in 2023, due to factors such as vandalism, accommodation of Americans with Disability Act (ADA) requirements, and EVSP staff turnover. Utility staff have made several significant efforts to adjust to market conditions. For example, PG&E staff modified the EV Fast Charge program design to allow partnering site hosts to contribute to project costs if those costs exceeded the program funding limits. SCE staff focused on seeking approval for AL 4926-E, which adjusted the Schools Pilot target from 27 to 21 sites and from 25% DAC to 25% DAC or DAC-adjacent. Also in 2023, PG&E identified several key strategies as effective for keeping school site costs low, including pre-desktop reviews, regular reviews of actual costs, and open communication during construction**.**

Parks Pilot

Although cross-jurisdiction coordination remains a challenge, Utility staffs' commitment to the Parks Pilot development is starting to show progress.

The plan for the Parks Pilot in 2021 was for all Utilities to enter into a collective participation agreement with the Department of Parks and Recreation (DPR). However, in 2022, the Utilities separated their efforts and began pursuing independent agreements with the DPR.

- In 2023, though the discussions generally went well, coordinating with site-specific and state-level staff, paired with DPR staff turnover led to minor delays throughout the site planning and implementation process. However, SCE was able to secure the first eight site-specific addendum agreements in 2023 for the Parks Pilot.
- In 2023 the PG&E and DPR legal teams were still finalizing decisions about which parties would be responsible for costs, liabilities, and risks. In addition, PG&E staff noted that the negotiation process faced delays because of staff turnover, as new DPR staff joined the negotiations and needed to get up to speed on the process. Ultimately, PG&E staff are optimistic about securing a master participation agreement (MPA) in 2024.

- In 2023, SDG&E continued to capitalize on the inclusion of local parks as part of the Pilot design. At the state-level in 2023, SDG&E staff realized that DPR staff and site-level DPR staff have different priorities: whereas state-level staff are focused on enforcing policies and compliance, site-level staff are more interested in what is most beneficial for their given park. Though state DPR negotiations continue, SDG&E staff are hopeful for a signed agreement in 2024.
- With the Utilities making process in 2023 on MPAs at the state-level, Liberty hopes to leverage the acceptable terms of the MPA that DPR establishes with the other Utilities in 2024.

1.3.3. V2G Pilot

V2G financial benefits from the site's perspective could be increased by offering V2G-specific rates and utilizing energy generation and battery storage outside of emergency load reduction program (ELRP) events and potentially for on-site load reduction.

The total electric energy generation for the V2G Pilot during 2022 and 2023 was only 2,850 kWh, with most of the generation occurring during ELRP months (July, August, and September). The site host received $2 per kilowatt-hour for electricity that was fed back to the electric grid. There is opportunity for sites to reduce their operating costs by expanding their generation beyond the limited ELRP event periods to support on-site load reduction.

V2G is still a nascent technology, and additional third-party evaluations and data collection efforts are needed to understand and resolve the issues associated with it.

Grid, hardware, and software interconnection issues were a consistent challenge for this Pilot and delayed steady-state operation until mid-2023. Data challenges—including inconsistent data sets between the chargers, vehicles, and fleet records as well as poor NSP EV charging session data quality—hindered the Team's ability to obtain a comprehensive understanding of the single V2G Pilot site's operation. The evaluation of this site is complete with this report. Given that the data challenges and evaluation findings could be unique to this site, The Evaluation Team was unable to offer overarching conclusions about the Pilot.

> **Recommendation**: Future V2G projects should prioritize interoperability of buses, chargers, and battery software during the project planning phase to enable successful bus operation from the start.

> **Recommendation**: While this Pilot evaluation is complete, additional third-party evaluations of other V2G projects are needed to assess the challenges and opportunities for different V2G use cases to reduce operational costs (e.g., maximizing energy export, maximizing behind-the-meter load management, participation in CAISO grid services). The Evaluation Team recommends that similar data points be collected for future V2G pilots, including AMI, NSP EV charging session, and telematics data, and that utilities consider installing generation and consumption check meters for each charging station to more accurately monitor V2G operation.

1.4. Structure of Report

The evaluation report is organized into the following sections:

Chapter 1. Executive Summary

Chapter 2. Introduction

Chapter 3. Statewide Findings

Chapter 4. SCE Programs: Charge Ready Transport, Schools and Parks Pilots

Chapter 5. PG&E Programs: EV Fleet, Schools and Parks Pilots, EV Fast Charge

Chapter 6. SDG&E Programs: PYDFF, Schools and Parks Pilots, V2G Pilot

Chapter 7. Liberty Utilities Programs: EV Bus Infrastructure, Schools and Parks Pilots

Appendix A. Methodology

Appendix B. Deep Dives

Appendix C. Data Collection Instruments

Each of the 14 program-specific sections in Chapter 4 to Chapter 7 contain the same three sections:

- **Overview:** Describes the evaluation objectives, logic model, theory of program impacts, and research questions.
- **Findings:** Details results from the program materials review, market research, in-depth interviews, surveys, analyses, or other methods.
- **Lessons Learned:** Varies, as appropriate, according to the needs of each evaluation bundle.

2. Introduction

In support of the TE goals of the SB 350 Clean Energy and Pollution Reduction Act of 2015 and ABs 1082 and 1083, the CPUC issued major decisions in 2018 and 2019 authorizing investment in 14 Utility programs designed to spur adoption of light-, medium-, and heavy-duty EVs among fleets and households. Approximately 90% of the funding for these 14 programs targets MDHD EVs as shown in Table 4.

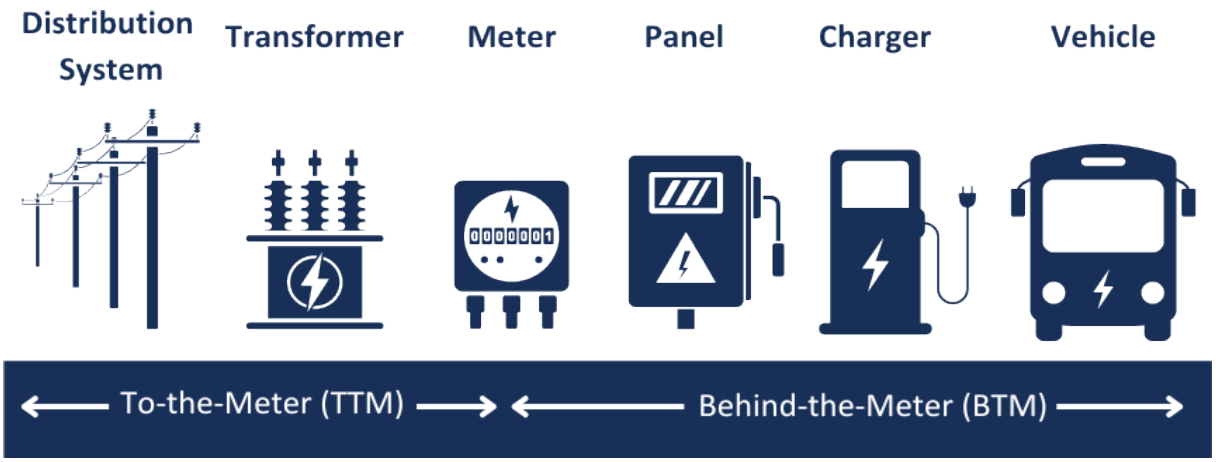
Table 4. Summary of Utility Programs

Utility	Program	Description	Decision [a]	LDV Budget	MDHD Budget
SCE	Charge Ready Transport	$342.6M for TTM and some or all of the BTM infrastructure up to the charging station for MDHD fleets. Additional rebates for charging stations are available for certain fleets.	1		$342.6M
	Schools Pilot	$9.9M for installation of approximately 250 Level 1 (L1) and Level 2 (L2) charging ports at 40 K–12 schools.	2	$9.9M	
	Parks Pilot	$9.9M for installation of approximately 120 L2 charging stations, 10 DCFC charging ports, and an optional 15 mobile stations across 27 state parks and beaches.	2	$9.9M	
PG&E	EV Fleet	$236.3M for TTM and some or all BTM infrastructure up to the charging station for MDHD fleets. Additional rebates for charging stations are available for certain fleets.	1		$236.3M
	Schools Pilot	$5.8M for installation of four or six L2 charging ports at 22 schools.	2	$5.8M	
	Parks Pilot	$5.5M for installation of L2 and DCFC charging ports at state parks and beaches.	2	$5.5M	
	EV Fast Charge	$22.4M for make-ready infrastructure of 52 DCFC and rebates for EVSE.	1	$22.4M	
SDG&E	PYDFF	$107M for TTM and some or all BTM infrastructure up to the charging station for MDHD fleets. Additional rebates for charging stations are available for certain fleets.	3		$107M
	Schools Pilot	$9.9M for installation of and incentives for installing 184 L2 and 12 DCFC charging ports at 30 schools and educational institutions.	2	$9.9M	
	Parks Pilot	$8.8M for installation of 74 light-duty public charging ports in 12 state parks and beaches within SDG&E's service territory and 66 light-duty public charging ports at 10 city and county park sites.	2	$8.8M	
	V2G Pilot	$1.7M for installation of V2G-capable chargers for MDHD school buses at the Cajon Valley Union School District (CVUSD).	3		$1.7M
Liberty Utilities	EV Bus Infrastructure	$0.2M for TTM and BTM infrastructure for MDHD electric transit bus.	4		$0.2M
	Schools Pilot	$3.9M for up to 56 L2 and DCFC charging ports at 17 schools.	2	$3.9M	
	Parks Pilot	$0.8M for five dual-pedestal EVSE at three sites.	2	$0.8M	
Total Approved Budget				$76.9M	$687.8M
Percentage of Total Approved Budget				10%	90%

[a] 1. Decision 18-05-040; 2. Decision 19-11-017; 3. Decision 19-08026; 4. Decision 18-09-034

The programs support EV infrastructure, typically categorized as to-the-meter (TTM) and behind-the-meter (BTM) as shown in Figure 1. Across Utility programs, the Utilities pay for and own 100% of the TTM infrastructure. BTM infrastructure funding varies by program and includes up to 100% of BTM costs in some programs. BTM ownership also varies by program and includes utility ownership, private sector ownership, and government ownership.

Figure 1. Illustration of TTM and BTM Infrastructure



2.1. Market Landscape

This section summarizes market changes occurring in calendar year 2023. The Evaluation Team summarized the market landscape in the previous EY2022 evaluation report.[6]

2.1.1. Market Segmentation

The 14 programs in this evaluation support charging infrastructure for a wide range of vehicles and use cases, including LDVs (e.g., passenger cars and trucks), medium-duty vehicles (e.g., step vans and straight trucks), heavy-duty vehicles (e.g., tractor trucks and refuse trucks), school buses, and transit buses, all of which are on-road vehicles and registered with the Department of Motor Vehicles (DMV). The 14 programs also support off-road vehicle electrification, including port cargo trucks, transportation refrigeration units (TRUs), airport ground support equipment (GSE), truck stop electrification (TSE), and forklifts.

Table 5 provides an overview of the vehicle segmentation used throughout the report. Given that 90% of the funding (detailed in Table 4) for these programs targets MDHDs, the bulk of the remainder of this section will focus on these vehicles, with less of an emphasis on LDVs.

[6] Cadmus, Energetics, et al. October 2023. *Standard Review Projects and AB 1082/1083 Pilots: Evaluation Year 2022 (Year 2).* https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/sb-350-te/publicjoint-iou-annual-srp-and-ab108283-evaluation-report-for-py-2022.pdf

Table 5. Overview of Vehicle Segmentation

Market Sector	Weight Class	Weight Rating	Description	Examples
On-Road				
Light-Duty Vehicle	Class 1	Up to 6,000 lbs.	Small Cargo Van, Compact Pickup, Small SUV, Minivan	 
	Class 2a	6,001–8,500 lbs.	Cargo Van, Standard Pickup, SUV	
Light-/Medium-Duty Vehicle	Class 2b	8,501–10,000 lbs.	Panel Van, Heavy-Duty Pickup, Large SUV, Large Passenger Van	
Medium-Duty Vehicle	Class 3	10,001–14,000 lbs.	Large Panel Van, Heavy-Duty Pickup, Straight Truck	  
	Class 4	14,001–16,000 lbs.	Step Van, Small Dump Truck, Medium Straight Truck	
	Class 5	16,001–19,500 lbs.	Step Van, Large Maintenance Truck, Medium Straight Truck	
	Class 6	19,501–26,000 lbs.	Large Step Van, Medium Straight Truck	
Heavy-Duty Vehicle	Class 7	26,001–33,000 lbs.	Large Straight Truck, 2-Axle Tractor	
	Class 8	33,001 lbs. and over	Coach Bus, Large Straight Truck, Tractor, Refuse Truck	
School Bus	Class 6 and Class 7	19,501–33,000 lbs.	Medium School Bus (Class 6), School Bus (Class 7)	
Transit Bus	Class 7 and Class 8	26,001 lbs. and over	Transit Bus (Class 7), Large Transit Bus (Class 8)	
Off-Road				
Port Cargo Truck	N/A	N/A	Also known as a terminal tractor, off-road, low speed, to move semi-trailers within port	

Market Sector	Weight Class	Weight Rating	Description	Examples
Transportation Refrigeration Unit (TRU)	N/A	N/A	Alternative to diesel refrigeration system; refrigeration system compressor is driven by electric motor	
Airport Ground Support Equipment (GSE)	N/A	N/A	Equipment used to service aircraft between flights (e.g., refueler, tugs/tractors, potable water trucks)	
Truck Stop Electrification (TSE)	N/A	N/A	High power fast charging at truck stops enabling longer distance travel	
Forklift	N/A	N/A	Off-road vehicle with a pronged device in front for lifting and carrying heavy loads	

Photo permissions (in order): Tesla Motors. May 20, 2024. https://cars.usnews.com/cars-trucks/advice/tesla-model-y-vs-tesla-model-3; Ford. May 20, 2024. https://www.ford.com/trucks/f150/f150-lightning/; Commercial Carrier Journal. May 20, 2024. https://www.ccjdigital.com/business/article/amazon-orders-electric-vans; The Australian Electric Vehicle Association Ltd. May 20, 2024. https://aeva.asn.au/articles/jac-n55-electric-delivery-truck-review/; ISP Fleet. May 20, 2024. https://www.ispfleet.com/2021-ford-f59-morgan-olson-22-p1200-step-van/; Transport Topics. May 20, 2024. https://www.ttnews.com/articles/electric-trucks-advance; The School District of Philadelphia. May 20, 2024. https://www.philasd.org/capitalprograms/exterior-renovations-at-passyunk-garage/; Change.org. May 20, 2024. https://www.change.org/p/jasper-municipal-council-to-stop-ev-buses-procurement-until-study-is-finalized; Wikipedia. May 20, 2024. https://en.wikipedia.org/wiki/Terminal_tractor; Fleet Owner. May 20, 2024. https://www.fleetowner.com/refrigerated-transporter/; Alibaba. May 20, 2024. https://www.alibaba.com/product-detail/Airport-Tractor; Source: Evaluation Team; Quora Inc. May 20, 2024. https://forklifttrainingpretoria.quora.com/

2.1.2. Electric Vehicle Share of New Vehicles

Figure 2 shows the continued strong growth of light-duty zero-emission vehicles (ZEVs) in California, including battery electric vehicles (BEVs), fuel cell electric vehicles (FCEVs), and plug-in hybrid electric vehicles (PHEVs). California saw light-duty ZEVs account for one in four (25%) of all new LDV sales in 2023, with BEVs accounting for 21.3% of LDV sales and PHEVs accounting for 3.6%, compared to 15.9% and 2.8%, respectively, in 2022.[7] EV adoption in the wider U.S. market is also increasing, although sales shares are lower than in California. In the United States, new light-duty EVs increased their share of LDVs sold from 5.9% in 2022 to 7.6% in 2023.[8]

Figure 2. 2011–2023 Light-Duty ZEV Sales Share in California

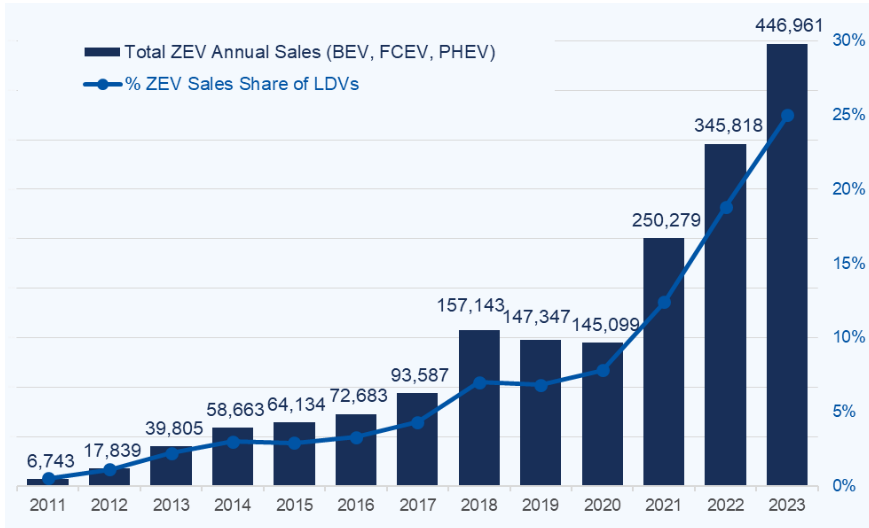


Table 6. Top 10 U.S. Metropolitan Areas for Light-Duty EV Sales Share in 2023

Rank	Metropolitan Area
1	San Jose, CA
2	San Francisco, CA
3	Los Angeles, CA
4	San Diego, CA
5	Sacramento, CA
6	Seattle, WA
7	Portland, OR
8	Riverside, CA
9	Denver, CO
10	Las Vegas, NV

California's large metropolitan areas continue to lead the nation in EV adoption (Table 6), with the top five metro areas (San Jose, San Francisco, Los Angeles, San Diego, and Sacramento) and six of the eight cities with the highest ratio of EVs to total new auto registrations all located in California.[9]

In terms of population, the California Energy Commission (CEC) estimates that the light-duty EV fleet in California comprised approximately 1.5 million vehicles at the end of 2023, representing just over 5% of the overall LDV fleet.[10]

7 California Energy Commission. Last updated February 1, 2024. "New ZEV Sales in California." https://www.energy.ca.gov/data-reports/energy-almanac/zero-emission-vehicle-and-infrastructure- statistics/new-zev-sales

8 Electrek, January 10, 2024. "2023's best-selling EVs – Rivian R1S outsells Tesla Model X and Ford F-150." https://electrek.co/2024/01/10/best-selling-evs-2023/

9 New York Times, March 6, 2024. "Where Electric Vehicles Are (and Aren't) Taking Off Across the U.S." https://www.nytimes.com/interactive/2024/03/06/climate/hybrid-electric-vehicle-popular.html

10 California Energy Commission. Last Updated May 1, 2024. "Light-Duty Vehicle Population in California." https://www.energy.ca.gov/data-reports/energy-almanac/zero-emission-vehicle-and-infrastructure-statistics/light-duty-vehicle

Focusing on MDHD vehicles, Table 7 provides MDHD new registrations (sales) by vehicle category and shows EV MDHD sales as a percentage of total MDHD sales. Looking at the overall MDHD market (Class 2b through Class 8), EV sales make up 12% of total MDHD sales, while school buses and transit buses exceeded the overall average with nearly 25% and nearly 32% of total sales, respectively.[11] However, the other heavy-duty vehicles (Class 7 and Class 8 non-school, non-transit bus), which saw sales roughly on the same order as school buses and transit buses in total, represent less than 2% of sales share. Medium-duty EVs had a sales share of 13%; however, these sales are heavily weighted by one vehicle manufacturer, Rivian, which produces SUV's and trucks classified as Class 2b that are most often used as personal vehicles and not for commercial fleet purposes.[12]

Table 7. 2023 MDHD (Class 2b through Class 8) Sales by Vehicle Category in California

Vehicle Category	New Vehicle Sales	New EV Sales	EV Sales Share
Medium-Duty (Class 2b to Class 6)	89,052	11,968	13.4%
School Bus (all classes)	1,034	256	24.8%
Transit Bus (Class 7 and Class 8)	833	265	31.8%
Other Heavy-Duty (Class 7 and Class 8, non-school bus, non-transit bus)	15,562	279	1.8%
Total MDHD (Class 2b to Class 8)	**106,481**	**12,768**	**12.0%**

Source: S&P Global

Table 8 focuses on 2023 MDHD EV sales in California for Class 2b and Class 3, both of which comprise vehicles primarily for personal use (such as pickups and SUVs) and vehicles that are traditional fleet vehicles such as cargo vans. Class 2b and Class 3 MDHD EVs that are primarily for fleet use (i.e., cargo vans, cab chassis, cutaway) make up only about 12% of the total Class 2b and Class 3 MDHD EV sales in California in 2023 as can be seen in Table 8. Of the remaining 88%, approximately 86% are Rivian pickups and SUV's, which are mostly for personal use. The Ford Lightning extended range model is an additional Class 2b vehicle that is not shown in Table 8 due to data limitations in the S&P Global dataset.

Table 8. 2023 MDHD Class 2b and Class 3 Sales by Make and Model in California

Make	Model(s)	Type(s)	Primary User	2023 Sales
BrightDrop	ZEVO 600	Cargo Van	Fleet Use	24
Ford	T-350	Cargo Van, Cab Chassis, Cutaway	Fleet Use	794
Rivian	EDV 500 and EDV 700	Cargo Van	Fleet Use	564
GMC	Hummer Pickup and SUV	Pickup, SUV	Personal Use	285
Rivian	R1T Pickup and R1S SUV	Pickup, SUV	Personal Use	10,124
Tesla	Cybertruck	Pickup	Personal Use	12

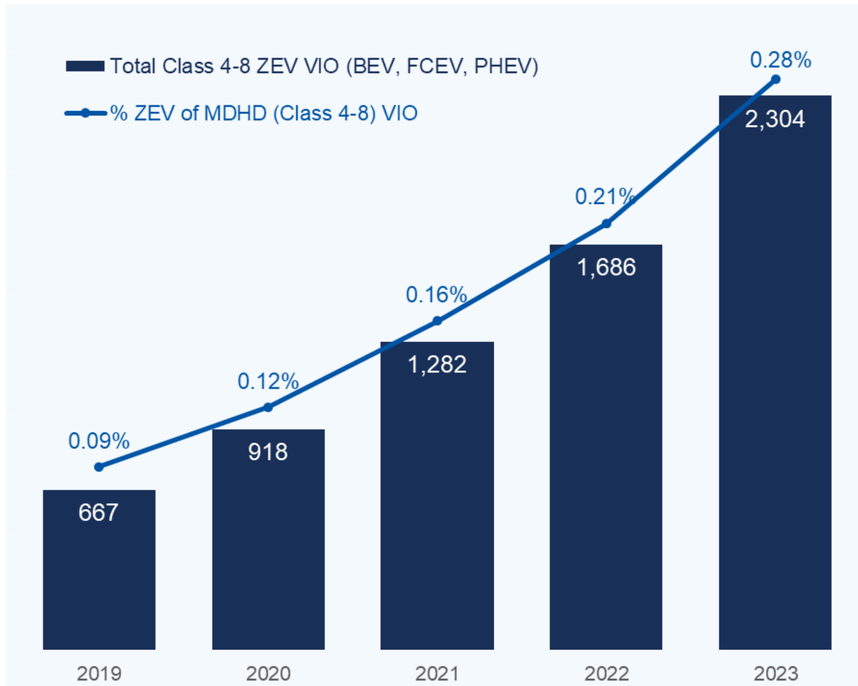
Source: S&P Global

11 CARB published 2023 MDHD sales figures on May 22, 2024, showing a total of 116,483 sales, of which 18,473 or 15.9% were ZEV's. https://ww2.arb.ca.gov/resources/fact-sheets/ACT-Credits-Summary%202023

12 CARB published an additional press release on June 6, 2024, highlighting that one in six new trucks, buses and vans in California are zero emission. https://ww2.arb.ca.gov/news/1-6-new-trucks-buses-and-vans-california-are-zero-emission

In terms of vehicles in operation (VIO), the MDHD sector trails significantly behind the LDV sector but is growing. Focusing in on Class 4 through Class 8 vehicles to isolate primarily fleet vehicles, Figure 3 shows MDHD ZEVs (Class 4 through Class 8) in operation for years 2019 through 2023 and the percentage those ZEVs are of the total MDHD (Class 4 through Class 8) VIO. Class 4 through Class 8 MDHD ZEVs in operation have increased from less than 700 (0.09% of VIO) in 2019 to more than 2,300 (0.28% of VIO) in 2023.

Figure 3. 2019–2023 Class 4 through Class 8 MDHD EVs in Operation in California



Source: S&P Global.
Note, VIO is a point-in-time measurement in September each year.

According to the CEC, 3,784 MDHD ZEVs were on the road in California as of December 31, 2023.[13] This includes 2,062 buses, 853 trucks, and 869 delivery vans. An important note regarding this data is the CEC classifies MDHD vehicles as all vehicles over 10,000 lbs. GVWR and does not include Class 2b vehicles (8,501 lbs. to 10,000 lbs.) Figure 4 shows these MDHD vehicles broken out by body style.

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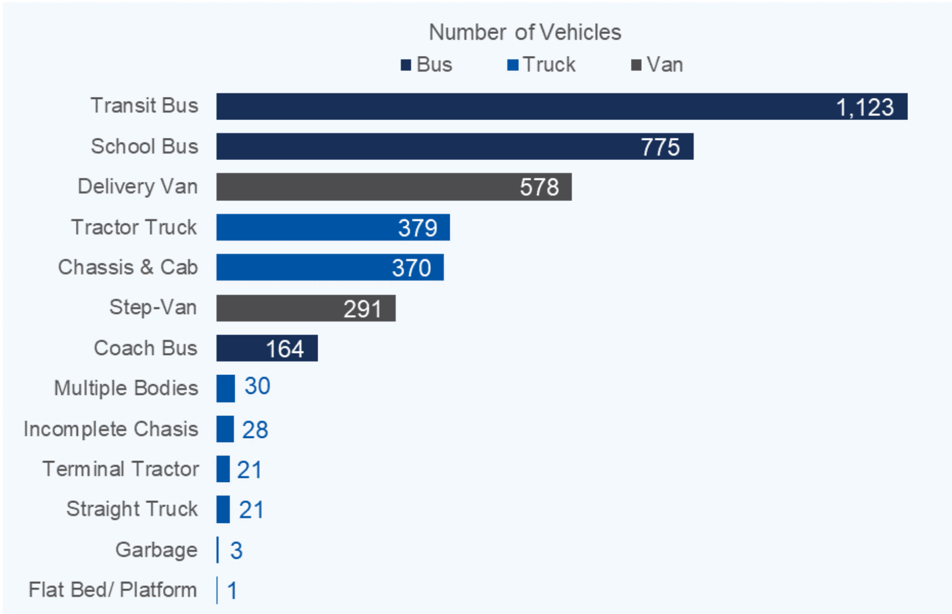
13 California Energy Commission (2024). Medium- and Heavy-Duty Zero-Emission Vehicles in California. Data last updated 05/01/2024. Retrieved 05/03/2024 from https://www.energy.ca.gov/zevstats

Figure 4. 2023 MDHD ZEV Population in California by Body Style

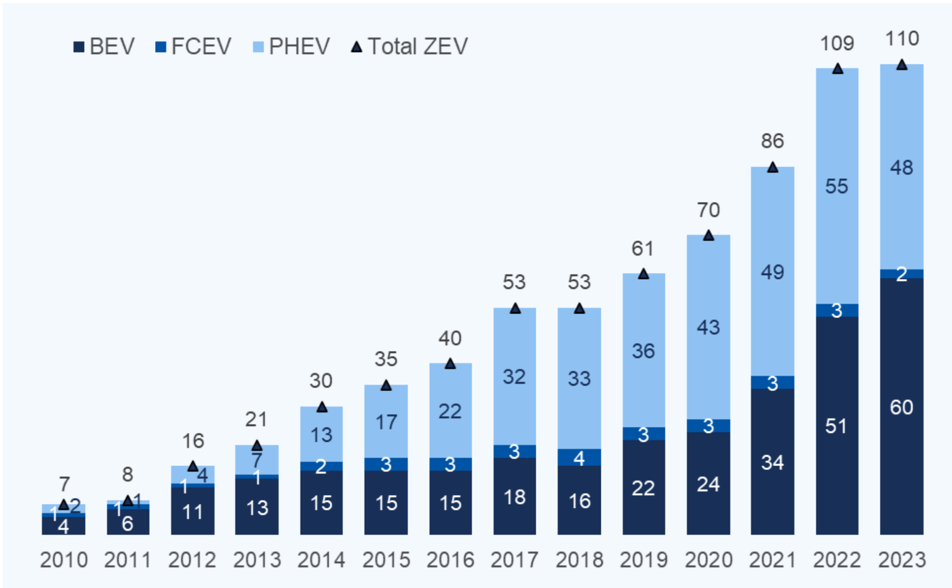


Source: CEC

2.1.3. Electric Vehicle Models

In total, 110 unique make/model light-duty ZEVs were sold in California in 2023, one more than in the previous year. However, the market has shifted toward BEVs and away from PHEVs, with 60 BEV models versus 48 PHEVs (and two FCEVs). Notably, 2023 is the first year since 2014 with more sales of BEV than PHEV models as can be seen in Figure 5.

Figure 5. Unique Light-Duty ZEVs With Sales by Year in California



Source: Figure derived from California Energy Commission (2024). California Energy Commission Zero Emission Vehicle and Infrastructure Statistics. Data last updated 01/31/2024. Retrieved 03/14/2024 from http://www.energy.ca.gov/zevstats.

Table 9 shows the top 12 light-duty EVs sold in California in 2023, which account for 70% of the market. The Tesla Model Y was the sales leader, with 30% of the market, while the remaining 98 make/models capture the bottom 30% of the market.

Table 9. Top 12 EVs in California, 2023 LDV Sales

Rank	Make	Model	Type	2023 Light-Duty ZEV Sales	% of 2023 Light-Duty ZEV Sales	Cumulative % of 2023 Light-Duty ZEV Sales
1	Tesla	Model Y	BEV	134,105	30%	30%
2	Tesla	Model 3	BEV	81,417	18%	48%
3	Jeep	Wrangler	PHEV	13,572	3%	51%
4	Volkswagen	ID.4	BEV	12,264	3%	54%
5	Chevrolet	Bolt EUV	BEV	12,081	3%	57%
6	Ford	Mustang Mach-E	BEV	11,467	3%	59%
7	Tesla	Model X	BEV	10,131	2%	62%
8	Hyundai	IONIQ 5	BEV	9,176	2%	64%
9	BMW	i4	BEV	8,870	2%	66%
10	Chevrolet	Bolt EV	BEV	7,338	2%	67%
11	Toyota	RAV4 Prime	PHEV	7,261	2%	69%
12	Rivian	R1S	BEV	7,100	2%	70%
Remaining 98 Makes and Models				132,179	30%	100%
Total				**446,961**	**100%**	

Source: Table derived from California Energy Commission (2024). California Energy Commission Zero Emission Vehicle and Infrastructure Statistics. Data last updated 01/31/2024. Retrieved 03/14/2024 from http://www.energy.ca.gov/zevstats

Table 10 shows Class 4 through Class 8 MDHD EV sales (new registrations) by make/model in California in 2023.

Table 10. Class 4 through Class 8 MDHD EV Sales by Make/Model in 2023 in California

Make	Model	Class	Type	2023 Sales
Blue Bird	AAC3707-3808	Class 7	School Bus	10
	AAC3904-4100	Class 7	School Bus	130
	BB3007-3108	Class 7	School Bus	7
	BB3109-3400	Class 7	School Bus	4
BYD Coach and Bus LLC	30 FT	Class 8	Bus – Non School	57
	35 FT	Class 8	Bus – Non School	3
	40 FT	Class 8	Bus – Non School	10
	60 FT	Class 8	Bus – Non School	5
Freightliner	EB2 Chassis	Class 7	School Bus	16
	eCascadia 116	Class 8	Tractor Truck	94
	MT50E	Class 6	Incomplete (Strip Chassis)	29
Gillig	Low Floor	Class 8	Bus – Non School	29
Greenpower Motors	EV250	Class 7	Bus – Non School	4
	EV350	Class 8	School Bus	19
	EVC210	Class 4	Bus – Non School	5
	EVC210	Class 4	Incomplete (Strip Chassis)	12
IC Corporation	CE School Bus	Class 7	School Bus	20
	CE School Bus	Class 8	School Bus	43
International	MV60E	Class 6	Straight Truck	11
	MV60E	Class 7	Straight Truck	7
Kalmar	Ottawa T2	Class 8	Tractor Truck	1
Kenworth	K270/K370	Class 6	Straight Truck	1
	T680	Class 8	Tractor Truck	12
Lion	LION C V2	Class 8	School Bus	7
Mack	LR	Class 8	Straight Truck	1
Motor Coach Industries	J3500/J4500	Class 8	Bus – Non School	3
New Flyer	Xcelsior	Class 8	Bus – Non School	74
Nikola	BEV	Class 8	Tractor Truck	42
Orange EV	Terminal Tractor	Class 8	Tractor Truck	16
Peterbilt	220	Class 6	Straight Truck	1
	579	Class 8	Tractor Truck	6
Proterra	35 FT	Class 8	Bus – Non School	6
	40 FT	Class 8	Bus – Non School	14
Tesla	Semi	Class 8	Tractor Truck	1
Van Hool	Commuter Coach CX	Class 8	Bus – Non School	12
	TDX Double Decker Coach	Class 8	Bus – Non School	48
Volvo	VNR	Class 8	Tractor Truck	99
Xos	SA01	Class 6	Step Van	106
Total Class 4 through Class 8 MDHD EVs				965

Source: S&P Global

2.1.4. Electric Vehicle Prices

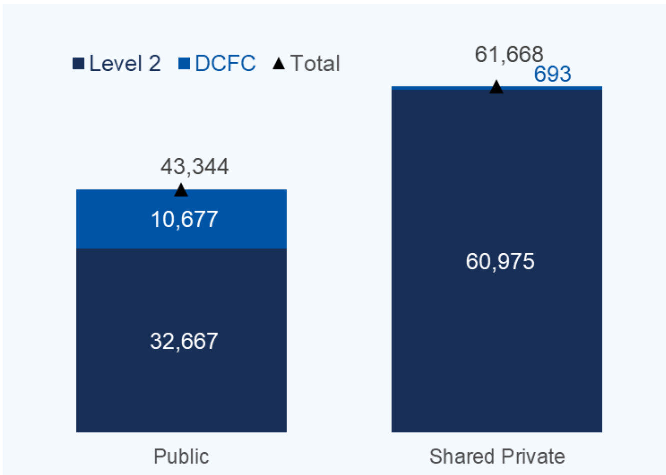
According to Kelley Blue Book and the U.S. Energy Information Administration, in December 2023 the average transaction price for BEVs decreased to $50,798, marking a 24.2% reduction from the peak in the second quarter of 2022.[14] Tesla's price cuts were a major factor in this decline, with the average transaction price for Tesla vehicles dropping by 29.0% between June 2022 and December 2023. Meanwhile, the average price for all LDVs increased by 1.5% during the same period. Consequently, the gap between BEV and overall LDV transaction prices decreased from $19,000 in June 2022 to $2,000 by the end of 2023. Comparable statistics of the average transaction price for MDHD EVs are not readily available.

EV price reductions combined with fuel savings and various incentives may lead to EVs having a lower total cost of ownership (TCO) than conventional internal combustion engine (ICE) vehicles in some cases. Even with a higher up-front cost, EVs may achieve a lower TCO through operating cost savings. Achieving a net TCO reduction depends heavily on annual driving distance, cost of EVSE installation, and frequency of public DCFC use among other factors.

2.1.5. Charging Infrastructure Deployment

According to the CEC, there are over 105,000 L2 and DCFC EV chargers in California as of March 1, 2024, as can be seen in Figure 6. This includes 43,344 public chargers (32,667 L2 and 10,677 DCFC) and 61,668 shared private chargers (60,975 L2 and 693 DCFC). The CEC derives these numbers from multiple sources, including lists of public and shared private chargers by the Alternative Fuels Data Center (AFDC), PlugShare, and CEC surveys.

Figure 6. Total Public and Shared Private EV Chargers in California



Source: California Energy Commission (2023). Electric Vehicle Chargers in California. Data last updated 03/01/2024. Retrieved 04/16/2024 from https://www.energy.ca.gov/zevstats

2.1.6. Charging Infrastructure Costs

The CEC breaks out charger costs for projects rebated under the CALeVIP rebate program into two categories: average unit cost and average additional cost. According to the CEC,[15] average charger costs are $1,347 per kilowatt ($469 per kilowatt for the average

14 U.S. Energy Information Administration (2024). "Electric vehicles and hybrids surpass 16% of total 2023 U.S. light-duty vehicle sales." Data last updated 01/31/2024. Retrieved 03/18/2024 from https://www.eia.gov/todayinenergy/detail.php?id=61344

15 California Energy Commission (2024). CALeVIP Level 2 and DC Fast Chargers, Average Rebate, Unit Cost, and Total Project Cost Per Rated kW. Data last updated unknown. Retrieved 03/18/2024 from https://www.energy.ca.gov/programs-and-topics/programs/clean-transportation-program/california-electric-vehicle/calevip-0.

unit cost and $878 per kilowatt for the average additional cost) for L2 chargers and $1,999 per kilowatt ($316 per kilowatt for the average unit cost and $1,683 per kilowatt for the average additional cost) for DCFC chargers.

2.1.7. Standardization of North American Charging Standard (NACS)

On December 19, 2023, SAE International published the Technical Information Report (TIR) for J3400,[16] which is an EV charging connector standard based on the North American Charging Standard (NACS) and is also known as the Tesla connector. The NACS connector (now SAE J3400), which is one of several connector types that enable fast charging of EVs, has the added benefit of working for both AC and DC chargers using the same pins for power. NACS/J3400 can also be used for AC L2 charging and is compatible with the J1772 connector through an adapter. In May 2023, the Federal Highway Administration (FHWA) allowed for NACS/J3400 adapters to be installed on all federally funded DCFC chargers as long as there is also a Combined Charging System Combo 1 (CCS1) connector.[17]

With the formal certification of SAE J3400, all major automakers in the United States have announced that they will use this charging connector moving forward (through a CCS1 to NACS/J3400 adapter at first and natively installed in vehicles beginning in 2025).[18] In fact, as of March 2024, both Ford and Rivian vehicles can now access Tesla's Supercharger network in the United States by using an adapter.[19]

2.2. Policy and Legislative Landscape in 2023

The 14 Utility programs exist within a larger policy ecosystem aimed at increasing EV adoption through regulation, incentives, and other instruments. This section describes major policy changes at the federal and state levels in 2023. The EY2022 Evaluation Report[20] describes other policies enacted before 2023.

2.2.1. Federal Policy

The Biden-Harris Administration made a major effort on the Federal level in 2023 to support TE. On February 15, 2023, the Administration published "FACT SHEET: Biden-Harris Administration Announces New Standards and Major Progress for a Made-in-America National Network of Electric Vehicle Chargers," which was designed to make significant strides toward establishing a national network of EV chargers, aligning with the Administration's commitments to bolstering American manufacturing and

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16 SAE International. "SAE completes next step to standardize Tesla-developed EV charging connector." Retrieved 06/11/2024 from https://www.sae.org/news/2023/12/sae-j3400-tir-released#

17 Joint Office of Energy and Transportation. "SAE J3400 Charging Connector." Retrieved 03/18/2024 from https://driveelectric.gov/charging-connector

18 MotorTrend. "The Great NACS Migration: Who Is Switching to Tesla's Charging Port?" Retrieved 06/11/2024 from https://www.motortrend.com/features/tesla-nacs-charging-port-automaker-compatibility/

19 TechCrunch. "Rivian starts offering adapters to access Tesla's Supercharger network." Retrieved 06/11/2024 from https://techcrunch.com/2024/03/18/rivian-nacs-access-tesla-supercharger-adapter/

20 Cadmus, Energetics, et al. October 2023. "*Standard Review Projects and AB 1082/1083 Pilots: Evaluation Year 2022 (Year 2).*" https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/sb-350-te/publicjoint-iou-annual-srp-and-ab108283-evaluation-report-for-py-2022.pdf

combating climate change.[21] This publication detailed a number of specific actions the Administration has taken to support EV adoption:

- The Department of Transportation (DOT) announced the National Electric Vehicle Infrastructure (NEVI) Formula Program, which is a $5 billion initiative to create a coast-to-coast network of EV chargers focused on major highways that support the majority of long-distance trips. In California, Caltrans and the CEC are partnering to implement the NEVI Program and note that California's share will be approximately $384 million over five years.[22]
- In August 2023, Caltrans and the CEC published the Annual Update to California's Deployment Plan for the NEVI Program to the FHWA and Joint Office for Energy and Transportation (Joint Office).[23]
- The DOT, along with the Department of Energy (DOE) (together the Joint Office of Energy and Transportation), introduced new standards to make charging EVs more accessible and dependable for everyone in the country. These new standards apply to all federally funded EV chargers, including NEVI-funded chargers, and are intended to ensure that the national EV charging network is user-friendly, reliable, and accessible. The standards impact such things as connector types, payment methods, data privacy, speed and power of chargers, reliability, and overall user experience.
- The FHWA unveiled its definitive strategy to comply with the Build America, Buy America Act for federally financed EV chargers. All EV chargers funded through the Bipartisan Infrastructure Law (which established the NEVI Program) are mandated to be manufactured within the United States, which necessitates that the final assembly and all manufacturing processes for iron or steel charger enclosures or housing take place domestically. Additionally, by July 2024 a minimum of 55% of the total cost of all charger components must be domestically manufactured.
- The Joint Office of Energy and Transportation announced its intention to offer funding opportunities for the Ride and Drive Electric research and development program. The Joint Office followed up with an announcement on May 8, 2023, making available $51 million in

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21 The White House. "FACT SHEET: Biden-Harris Administration Announces New Standards and Major Progress for a Made-in-America National Network of Electric Vehicle Chargers." Retrieved 06/11/2024 from https://www.whitehouse.gov/briefing-room/statements-releases/2023/02/15/fact-sheet-biden-harris-administration-announces-new-standards-and-major-progress-for-a-made-in-america-national-network-of-electric-vehicle-chargers/

22 California Energy Commission. "National Electric Vehicle Infrastructure (NEVI) Formula Program." Retrieved 06/11/2024 from https://www.energy.ca.gov/programs-and-topics/programs/national-electric-vehicle-infrastructure-nevi-formula-program

23 Caltrans. "California's Deployment Plan for the National Electric Vehicle Infrastructure (NEVI) Program: Annual Update." Retrieved 06/11/2024 from https://dot.ca.gov/-/media/dot-media/programs/esta/documents/nevi/2023-ca-nevi-plan-update-final-a11y.pdf

funding for the program.[24] This initiative aims to further the objective of constructing a nationwide network of EV chargers.

- The U.S. DOE announced $7.4 million in funding for seven projects to develop innovative MDHD EV charging and hydrogen corridor infrastructure plans.
- The FHWA unveiled specifics for its Charging and Fueling Infrastructure (CFI) discretionary grant program that will offer over $2.5 billion in funding over five years, with an initial $700 million available in the first round of funding for states, localities, Tribes, territories, and public authorities. The aim is to facilitate the deployment of publicly accessible charging and alternative fueling infrastructure in various community settings nationwide, including schools, grocery stores, parks, libraries, apartment complexes, and other locations.
- The Administration highlighted major manufacturing and other new facilities spurred by these investments and the Biden-Harris Administration's Made in America policies, including new commitments from domestic EV charging manufacturers and network operators.

In 2023, a key provision in the Inflation Reduction Act (IRA) of 2022 kicked in that offers purchasers of new MDHD electric trucks a tax credit of up to $40,000.[25]

Although this did not happen during the 2023 evaluation time period, the Biden-Harris Administration announced a national strategy regarding zero-emission infrastructure for freight trucks on March 12, 2024.[26] The strategy, crafted by the Joint Office of Energy and Transportation alongside the U.S. DOE in partnership with the DOT and the U.S. Environmental Protection Agency (EPA), will steer the rollout of zero-emission MDHD EV charging and hydrogen fueling infrastructure between 2024 and 2040. Its purpose is to address escalating market needs by directing public investment to bolster private sector progress, streamline utility and regulatory energy planning, synchronize industry efforts, and enhance air quality in communities significantly affected by diesel emissions. The National Zero-Emission Freight Corridor Strategy takes a phased approach.[27] Given the timing of this announcement, a deeper dive into this strategy will be covered in the EY2024 report.

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24 DOE–DOT Joint Office of Energy and Transportation. "Biden-Harris Administration Invests $51 Million in America's Electric Vehicle Charging Network" Retrieved 06/11/2024 from https://www.energy.gov/eere/articles/biden-harris-administration-invests-51-million-americas-electric-vehicle-charging

25 IRS. "Commercial Clean Vehicle Credit." Retrieved 06/11/2024 from https://www.irs.gov/credits-deductions/commercial-clean-vehicle-credit

26 U.S. Department of Transportation, Federal Highway Administration. March 12, 2024. "Biden-Harris Administration Releases First-Ever National Strategy to Accelerate Deployment of Zero-Emission Infrastructure for Freight Trucks." https://highways.dot.gov/newsroom/biden-harris-administration-releases-first-ever-national-strategy-accelerate-deployment

27 DOE–DOT Joint Office of Energy and Transportation. March 2024. "National Zero-Emission Freight Corridor Strategy." Retrieved 06/11/2024 from https://driveelectric.gov/files/zef-corridor-strategy.pdf

2.2.2. State Policy

Table 11 below provides an historical overview of important and significant legislation, policies, and programs in California relevant to TE. Subsequent sections focus on new initiatives in 2023.

Table 11. Legislation, Policy, and Program History of TE in California

History of TE by Year	
Key: CA Executive Orders CA Legislative Actions (SB and AB) CARB Regulations and Programs	CEC Programs CPUC OIRs, Decisions and Resolutions Other
Pre-2015	(2012) EO B-16-12: 1 million ZEVs by 2025 (2006) AB 32: Global Warming Solutions Act (2008) SB 375: Sustainable Communities and Climate Protection Act (2009) SB 626: Evaluate policies to develop charging infrastructure (2009) CARB Approves Low Carbon Fuel Standard (LCFS) (2009) CARB begins Hybrid and Zero Emission Truck and Bus Voucher Incentive Project (HVIP) (2010) CARB begins Clean Vehicle Rebate Project (CVRP) (2011) CARB begins implementing LCFS (2011) CPUC D.11-07-029 addressed a range of EV policy issues (2012) CARB adopts Advanced Clean Cars I for model years 2015–2025 (2009) CPUC OIR R.09-08-009 (2013) CPUC D.13-06-014 extended the treatment of EV charging costs (2013) CPUC OIR R.13-11-007 (2014) CPUC D.14-12-079 adoption of rules to expand EV infrastructure (2014) CPUC D.14-12-083 directed the investor-owned utilities (IOUs) to receive credits for electricity and natural gas sold as a fuel (2012) $102.5 million NRG settlement to deploy EV charging infrastructure
2015	SB 350: Clean Energy and Pollution Reduction Act of 2015, which enacted Public Utilities Code Section 740.12.1 requiring the CPUC, CEC, and CARB to support the acceleration of widespread TE CARB approves readoption of LCFS
2016	CARB begins implementing readoption of LCFS CPUC D.16-01-023 authorized $22 million for SCE Charge Ready Pilot CPUC D.16-01-045 authorized $45 million for SDG&E Power Your Drive Pilot CPUC D.16-12-065 authorized $130 million for PG&E EV Charge Network pilot
2017	AB 1082: EV Charging Infrastructure: Schools and Educational Institutions AB 1083: EV Charging Infrastructure: State Parks and Beaches CEC Electric Vehicle Infrastructure Project (CALeVIP 1.0) Launched VW settlement requires Electrify America to invest $800 million in California
2018	EO B-48-18: 5 million ZEVs by 2030, 250,000 chargers by 2025 SB 1014: Clean Miles Standard and Incentive Program: ZEVs SB 1000: EV Charging Infrastructure AB 2127: EV Charging Infrastructure: assessment CARB approves amendments to LCFS CPUC 18-12-006 authorized SCE to spend an additional $22 million CPUC OIR: R.18-12-006, DRIVE Rulemaking CPUC D.18-01-024 approved the first TE applications under SB 350 CPUC D.18-05-040 approved $738 million for IOUs' SRP CPUC D.18-09-034 authorized TE funding for Bear Valley, Liberty, and PacifiCorp

History of TE by Year	
2019	SB 676: EV-Grid Integration CPUC D.19-08-026 approved $107 million for SDG&E MDHD & V2G school bus CPUC D.19-09-006 authorized $4 million for PG&E low- and moderate-income (LMI) customers CPUC D.19-10-055 authorized PG&E subscription-based EV rate CPUC D.19-11-017 approved pilots for EV charging at schools, parks, and beaches
2020	EO N-79-20: 100% Light-duty ZEV sales by 2035; 100% MDHD ZEV sales by 2045 AB 841: TE and School Energy Efficiency Stimulus Program CARB approved Advanced Clean Trucks (ACT), ZEV sales requirements CPUC D.20-08-045 authorized $436 million for SCE on Charge Ready program CPUC D.20-09-025 clarified that EVSPs for MDHD are not public utilities CPUC D.20-12-023 established SDG&E's rate for separately metered EV CPUC D.20-12-027 directed utilities to spend LCFS credits on equity programs CPUC D.20-12-029 implementation of SB 676
2021	CARB adopts Clean Miles Standard for Transportation Network Companies CEC Funded CALeVIP 2.0 Launched CPUC D. 21-04-014 approved $43.5 million for SDG&E on a pilot extension CPUC D.21-07-028 established near-term priorities for utility investment CPUC D. 21-11-017 authorized PG&E to offer an optional day-ahead rate CPUC D.21-12-033 extended common treatment policy for PEVs CPUC Resolution E-5175 clarified EVSE communications protocols CPUC Resolutions E-5167 and E-5168 established new EV Infrastructure rules
2022	AB 2061: Requires the CEC to develop uptime recordkeeping and reporting standards for EV chargers and charging stations CARB adopts Advanced Clean Cars II for model years 2026–2035 CPUC R.22-07-005 widespread demand flexibility through electric rates CPUC D.22-08-024 authorizes Plug-In EV Submetering Protocol CPUC D.22-11-040 adopted a long-term TE policy framework CPUC D.22-12-054 authorized $52.2 million for PG&E's EV Charge 2 program CPUC Resolution E-5192 approved $11.7 million for PG&E's vehicle-grid integration (VGI) pilots CPUC Resolution E-5227 approved SCE's low port rebate proposal CPUC Resolution E-5236 approved SCE programs from LCFS Holdback credits CPUC Resolution E-5247 establishing an energization timeline
2023	SB 123: Harmonizes requirements between EVSE requirements and the NEVI Program SB 410: CPUC to establish reasonable energization time periods AB 50: CPUC to establish criteria for customers to receive timely energization CARB approves ACF CARB closes new enrollments to the CVRP CPUC R.23-12-008 establishes venue for TE policy and closes 18-12-006 CPUC Resolution E-5257 approved modifications to PG&E and SCE's *per se reasonableness* metrics

2.2.3. Advanced Clean Fleets

On April 28, 2023, the California Air Resources Board (CARB) approved a groundbreaking regulation that is aimed at expediting the deployment of MDHD ZEVs to mitigate air pollution and greenhouse gas (GHG) emissions. The regulation, known as Advanced Clean Fleets, complements existing efforts by mandating the phase-in of ZEVs for targeted fleets and requiring manufacturers to exclusively produce and sell ZEV trucks from the 2036 model year onward in California. Figure 7 shows an example of a ZEV truck. The initiative aligns with Executive Order N-79-20 and is expected to introduce 1.7 million MDHD

ZEVs into California's fleet by 2050, resulting in substantial health benefits and cost savings. The ACF Regulation is designed to play a pivotal role in California's broader strategy to promote clean transportation options and enhance system efficiency statewide.

Figure 7. Electric Semi Truck Example

Under the new regulation, fleet operators providing private services such as last-mile delivery, federal entities like the Postal Service, and state and local government fleets will embark on their transition to ZEVs starting in 2024, with provisions allowing the continued operation of existing vehicles until the end of their useful life. In response to the significant impact of truck traffic on communities residing near busy thoroughfares, drayage trucks are mandated to be zero-emission by 2035. Other fleet operators will have the flexibility to transition a portion of their vehicles to meet specified zero-emission targets, permitting them to retain combustion-powered vehicles as necessary during the transition to cleaner technologies. This flexibility is designed to consider available technology and prioritize the replacement of the most polluting vehicles. For instance, last-mile delivery and yard trucks are required to transition by 2035, work trucks and day cab tractors by 2039, and sleeper cab tractors and specialty vehicles by 2042.[28]

On November 15, 2023, CARB requested a waiver from the EPA to enable CARB to enforce the ACF Regulation.[29] This is still unresolved as of the time of this report.

There are four distinct components for fleets to demonstrate compliance with the ACF regulation as shown in Figure 8.

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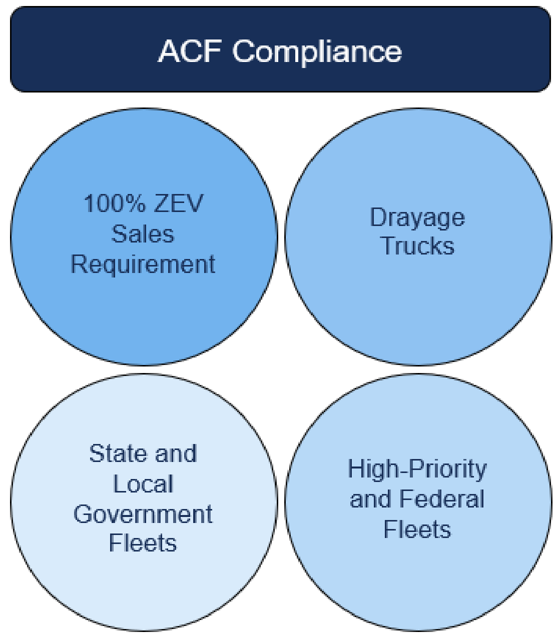
28 California Air Resources Board. "Advanced Clean Fleets, Resources." Retrieved 06/11/2024 from https://ww2.arb.ca.gov/our-work/programs/advanced-clean-fleets/resources

29 Federal Register. "California State Motor Vehicle Pollution Control Standards; Advanced Clean Fleets Regulation; Request for Waiver of Preemption and Authorization; Opportunity for Public Hearing and Public Comment." Retrieved 7/18/2024 from https://www.federalregister.gov/documents/2024/07/12/2024-15343/california-state-motor-vehicle-pollution-control-standards-advanced-clean-fleets-regulation-request#:~:text=The%20California%20Air%20Resources%20Board%20%28CARB%29%20has%20notified,vehicles%2C%20to%20incorporate%20zero-emitting%20vehicles%20beginning%20in%202024.

State and Local Government Fleets: Requires California State and local government (including cities, counties, special districts, and state agencies) fleets to ensure that 50% of vehicles purchased are zero emissions beginning on January 1, 2024, and 100% of vehicle purchases are zero emissions by January 1, 2027. An initial compliance report must be submitted by April 1, 2024. There are exceptions for small fleets (10 or fewer vehicles) and for those in designated counties (primarily counties in the north and eastern Sierra) that push compliance with that regulation back to January 1, 2027. The ZEV Milestones Option available to high priority and federal fleets is also available for state and local government fleets. For more details on this component, please see the Final Regulation Order, Appendix A-1.[30]

Figure 8. Advanced Clean Fleets



100% ZEV Sales Requirement: Requires manufacturers to sell only zero-emissions MDHD vehicles (over 8,500 lbs. or Class 2b through Class 8) in California starting with the 2036 model year. This component of the regulation is intended to provide certainty to the market and supply chain and is designed to expand market choice. The component of the regulation applies only to on-road vehicles and does not apply to authorized emergency vehicles. For more details on this component, please see the Final Regulation Order, Appendix A-4.[31]

Drayage Trucks: Multipart component that requires all legacy drayage trucks to be registered in CARB's Truck Regulation Upload, Compliance, and Reporting System (TRUCRS) by December 31, 2023, and allows these trucks to continue to operate through their minimum useful life. Beginning on January 1, 2024, the regulation requires all new drayage trucks registered in TRUCRS to be ZEVs and all drayage trucks operating in seaports and intermodal railyards to have zero emissions by 2035. This component is limited to on-road vehicles over 26,000 lbs. (Class 7 and Class 8) and includes limited exceptions for dedicated use vehicles, emergency vehicles, military vehicles, and vehicles subject to additional regulations. For more details on this component, please see the Final Regulation Order, Appendix A-3.[32]

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30 California Air Resources Board. "Appendix A-1, Final Regulation Order, Advanced Clean Fleets Regulation, State and Local Government Agency Fleet Requirements." Retrieved on 06/11/2024 from https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2022/acf22/ac/acffro11.pdf

31 California Air Resources Board. "Appendix A-4, Final Regulation Order, Advanced Clean Fleets Regulation, 2036 100 Percent Medium- and Heavy-Duty Zero Emissions Vehicle Sales Requirements." Retrieved on 06/11/2024 from https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2022/acf22/ac/acffro41.pdf

32 California Air Resources Board. "Appendix A-3, Final Regulation Order, Advanced Clean Fleets Regulation, Drayage Truck Requirements." Retrieved on 06/11/2024 from https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2022/acf22/ac/acffrod31.pdf

High Priority and Federal Fleets: Multi-option component that requires all high priority and federal fleets to comply with the Model Year Schedule (newly added trucks must be ZEVs or near-ZEVs, and ICE vehicles must be removed after end of useful life beginning on January 1, 2024), or the ZEV Milestones Option (fleets must meet ZEV milestones as a percentage of total California fleet). High priority fleets are defined as fleets with over 50 vehicles (excluding light-duty package delivery vehicles), fleets with $50 million or more annual revenue, federal government fleets, and entities that hire or dispatch fleets with over 50 vehicles. This component of the regulation impacts all MDHD vehicles greater than 8,500 lbs. (Class 2b through Class 8), light-duty package delivery vehicles, and yard tractors operating in California. For more details on this component, please see the Final Regulation Order, Appendix A-2.[33]

2.2.4. California Senate Bill 123

SB 123, signed into law on July 10, 2023, modifies SB 454 Electric Vehicle Charging Stations Open Access Act, signed into law in 2013, to align requirements between the EVSE Standards Regulation and federal funding requirements from the NEVI Program. The bill grants the CEC authority to develop a new regulation superseding the current CARB-adopted rule, while CARB is given interim authority to enforce the regulation in line with SB 123. Consequently, CARB will prioritize compliance with SB 123's payment hardware requirements, and any future amendments to the EVSE Standards Regulation will be considered to ensure alignment with the new law. For more information, please visit CARB's website on EVSE Standards, including this factsheet, which provides a regulation summary and FAQs.[34]

2.2.5. California Senate Bill 410 and California Assembly Bill 50

SB 410, known as The Powering Up Californians Act, was signed into law on October 7, 2023, and is aimed at decreasing the time it takes customers to connect to the electrical distribution grid and at helping the state to electrify buildings and vehicles. SB 410 directs the CPUC to set "reasonable average and maximum target energization time periods" by September 30, 2024, and will also set utility reporting requirements "so that electrical corporation performance can be tracked and improved."[35] Reporting, mandated to occur at least annually, will encompass data concerning the average, median, and standard deviation times for interconnection requests surpassing designated maximum timelines.

AB 50, signed into law on October 7, 2023, requires the CPUC to determine the criteria for timely service for electric customers to be energized, including among other things categories of timely electric service through energization. AB 50 also requires the electrical corporations to meet certain energization

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33 California Air Resources Board. "Appendix A-2, Final Regulation Order, Advanced Clean Fleets Regulation, High Priority and Federal Fleets Requirements." Retrieved on 06/11/2024 from https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2022/acf22/ac/acffro21.pdf

34 California Air Resources Board. "Electric Vehicle Supply Equipment Standards Regulation Background and FAQs." Retrieved 06/11/2024 from https://ww2.arb.ca.gov/resources/documents/electric-vehicle-supply-equipment-standards-regulation-background-and-faqs

35 LegiScan. "California Senate Bill 410 Bill Text." Retrieved 03/18/2024 from https://legiscan.com/CA/text/SB410/id/2844430

timeliness, targets and make changes to their distribution planning processes, to be determined by the CPUC.

In response to SB 410 and AB 50, the CPUC opened an Order Instituting Rulemaking (OIR) R.24-01-018 on January 25, 2024, "to provide guidelines and set timelines for the energization of electrical corporation customers."[36] Specifically, the CPUC identifies four workstreams it will undertake to support the direction from the legislature:

1. Establish average and maximum energization timelines
2. Institute annual energization reporting requirements, shedding light on completion times, reasons for delays, and barriers faced by IOUs
3. Develop a procedure for customers to report energization delays to the CPUC
4. Implement public reporting requirements

For more information and to keep up-to-date on this new rulemaking, please visit the CPUC website CPUC Starts Work to Establish Customer Energization Timelines.[37]

2.2.6. CPUC OIR 23-12-008

On December 14, 2023, the CPUC issued OIR R.23-12-008 to Continue Development of Rates and Infrastructure for Vehicle Electrification. This OIR is intended to establish a venue for considering future TE policy matters and closes the previous OIR (CPUC OIR R.18-12-006) that was in place since 2018. Since the issuance of R.18-12-006, the CPUC has addressed three main TE issues: funding for BTM charging infrastructure, lack of oversight on IOU spending, and ambiguity regarding IOU roles. These problems were resolved by ensuring funding for charging infrastructure moving forward, implementing checks on IOU spending, and clarifying the IOUs' role in TE.

The CPUC ensured funding for BTM charging infrastructure, with D.22-11-040 establishing a program starting in 2025 with $600 million and potentially accessing up to $1 billion. This funding includes substantial investments from ratepayers and approved federal and state funds, such as those from the Infrastructure Investment and Jobs Act of 2021, California's 2021 Budget Act, and the Federal IRA.

The CPUC also implemented checks and balances on IOU spending for BTM TE programs and streamlined administrative processes for ongoing program proposals, as outlined in D.22-11-040. That decision aimed to reduce administrative burdens, control unnecessary spending, and establish checkpoints for reevaluation of IOU support for TE programs.

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36 CPUC. 01/25/2024. "Order instituting rulemaking to establish energization timelines." Retrieved 06/11/2024 from https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M524/K427/524427971.PDF.

37 CPUC. "CPUC Starts Work to Establish Customer Energization Timelines." Retrieved 06/11/2024 from https://www.cpuc.ca.gov/news-and-updates/all-news/cpuc-starts-work-to-establish-customer-energization-timelines-2024

The CPUC clarified the IOUs' role in TE, emphasizing their responsibility in supporting and enabling the market while also considering the importance of ratepayer subsidies for BTM infrastructure. D.22-11-040 outlined these roles and authorized ratepayer funding for TE investments through Funding Cycle 1 (2025–2029).

Looking forward, CPUC OIR R.23-12-008 identified five emerging TE issues that the CPUC, the IOUs, and stakeholders face to support the pace and scale of TE growth required to meet California's ZEV goals.[38]

1. Timely energization of EV charging sites (now under CPUC OIR R.24-01-018);
2. Grid planning for TE
3. Rate affordability
4. VGI that is oriented to evolving business models, market strategies, and vehicle support of grid needs
5. Deployment of BTM charging infrastructure to support statewide charging infrastructure goals

In 2024, several actions have taken place under the OIR, including the CPUC seeking feedback on whether to pause the implementation of the FC1 rebates program. Interested parties can follow along with the OIR through the CPUC's website.[39]

2.2.7. Clean Vehicle Rebate Project

The CVRP, which began back in 2010 and was funded by the CARB and administered statewide by the Center for Sustainable Energy (CSE), was closed to new applications as of November 8, 2023. The CVRP was implemented to promote the production and use of ZEVs, including EVs, PHEVs, and FCEVs, and provided rebates of up to $7,500 per vehicle. Table 12 shows the rebates issued/approved through March 19, 2024, which totaled over $1.4 billion.

Table 12. CVRP Rebates Issued/Approved as of March 19, 2024

Vehicle Type	Vehicle Type Description	Number of Rebates	Percentage of Total Rebates	Rebate Amount
PHEV	Highway-capable, four-wheeled, plug-in hybrid electric vehicle (electricity and gasoline)	151,306	26.2%	$246,136,945
BEV	Highway-capable, four-wheeled, all-battery electric vehicle	410,227	71.1%	$1,121,094,034
FCEV	Fuel-cell electric vehicle (hydrogen)	14,010	2.4%	$71,470,818
Other	Non-highway BEVs, highway-capable zero-emission motorcycles, and city and commercial zero-emission vehicles	1,399	0.3%	$2,183,990
Total		**576,942**	**100%**	**$1,440,885,787**

Source: CVRP Rebate Statistics. "Rebates Issued or Approved to Date Table." Data last updated 3/19/2024. Retrieved 3/29/2024 from https://cleanvehiclerebate.org/en/rebate-statistics

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38 CPUC. 12/20/2023. "Order instituting rulemaking regarding transportation electrification policy and infrastructure and closing rulemaking 18-12-006." https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M521/K872/521872957.PDF, pg. 8.

39 CPUC. "R2312008 – Proceeding." Retrieved 06/11/2024 from https://apps.cpuc.ca.gov/apex/f?p=401:56

3. Statewide MDHD Vehicle Findings

This section discusses statewide findings for school buses, transit buses, medium-duty vehicles, and heavy-duty vehicles across all IOU programs and all years. These four market sectors are the only market sectors with a sufficient number of sites that meet the 15-15 Rule criteria[40] to be isolated and discussed in detail. Other market sectors, such as Airport GSE, do not meet the 15-15 Rule criteria. The chapter is an important contribution to this evaluation report because policy makers, fleet managers, and other key stakeholders typically make fleet electrification and programmatic decisions for individual vehicle categories.

3.1. Summary Statistics

Table 13 shows the number of sites for five key program statuses (applications, contracts, activated, operational, and sites visited) for the four market sectors as of the end of 2023. Medium-duty vehicles lead in terms of applications, but school buses lead in the number of activated sites with 67, compared with 22 for heavy-duty vehicles, 21 for medium-duty vehicles and 17 for transit buses.

Table 13. Sites by Program Status and Vehicle Category in the Program to Date

Market Sector	Applications	Contracts	Activated	Operational	Sites Visited
School Bus	192	131	67	65	58
Transit Bus	74	53	17	17	12
Medium-Duty Vehicle	282	133	21	19	19
Heavy-Duty Vehicle	152	80	22	22	18

Table 14 focuses in on activated sites across the same four market sectors, but also provides the number of vehicles and the number of ports. Once again, school buses dominate the programs thus far, with 765 vehicles and 594 ports activated, compared with 577 vehicles and 426 ports for HDVs, 370 vehicles and 181 ports for MDVs, and 215 vehicles and 165 ports for transit buses.

Table 14. Activated Sites, Vehicles, Ports by Vehicle Category in the Program to Date

Market Sector	Activated Sites	Vehicles	Ports
School Bus	67	765	594
Transit Bus	17	215	165
Medium-Duty Vehicle	21	370	181
Heavy-Duty Vehicle	22	577	426

40 The 15-15 Rule protects customer privacy by limiting the reporting of metrics and data when an insufficient number of customers exist. In practice, this means certain metrics cannot be included in public reporting unless there are at least 15 sites and as long as no single site accounts for more than 15% of all energy consumption. More information on the 15-15 Rule can be found in Decision 14-05-016.

Figure 9 shows the difference between the full vehicle acquisition plan (VAP) and the number of vehicles observed during site visits by market sector. Although not shown in the graph, when compared with the expected vehicle procurement schedule outlined site VAP, actual vehicles counts are lower than expected, illustrating the need for better tracking and follow-up on the original VAPs. The school bus and heavy-duty vehicle sector sites had the largest portion of their VAPs delivered in the first year after site activation (about half), while the medium-duty vehicle sector sites had the smallest portion (about a quarter).

Figure 9. Full VAP and Site Visit Observed Vehicles by Market Sector

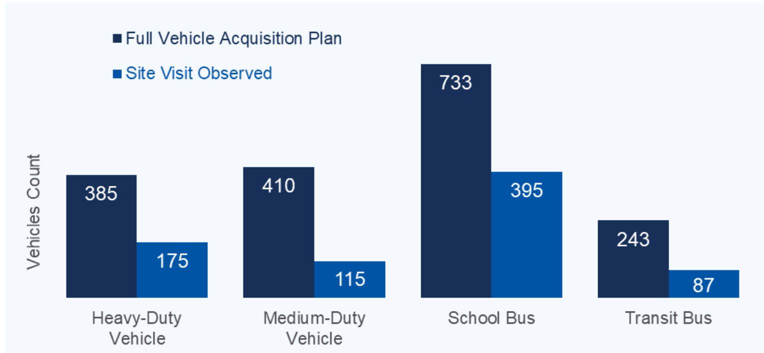
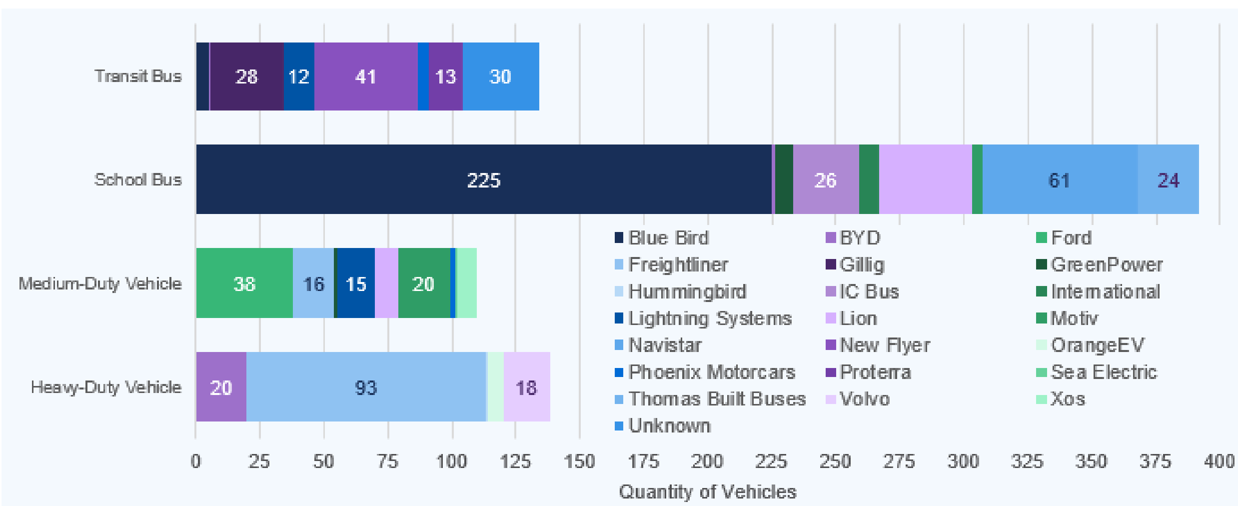


Figure 10 shows the vehicle make by market sector for all vehicles observed at activated sites in the program to date.

Figure 10. Vehicle Make by Market Sector for PTD Sites



3.2. Site Activation Timelines

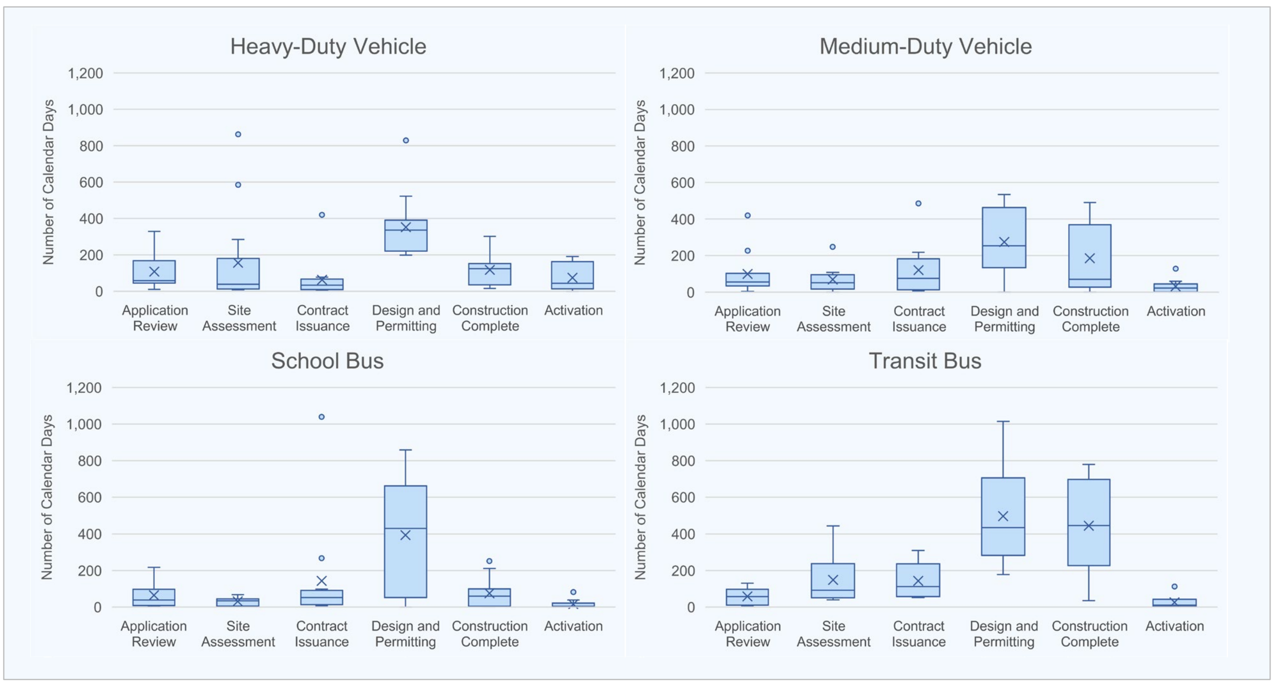
Table 15 shows the median calendar days aggregated across the same four market sectors (school bus, transit bus, medium-duty vehicle, and heavy-duty vehicle) for EY2021, EY2022, and EY2023 by CPUC program phase. As can be seen in Table 15, unfortunately median calendar days have been steadily increasing in each of the last three years. For example, the start-to-finish median calendar days in EY2021 was 600 days, compared to 728 days in EY2022 and 852 days in EY2023.

Table 15. Median Calendar Days by Evaluation Year and Program Phase

CPUC Program Phase	Median Calendar Days		
	EY2021	EY2022	EY2023
Application Review	37	33	59
Site Assessment	37	54	46
Contract Issuance	32	45	58
Design and Permitting	224	280	344
Construction Complete	83	133	79
Activation	26	20	19
Start-to-Finish	600	728	852

Figure 11 expands the analysis of program phase duration by displaying the average number of calendar days per phase (denoted by X), calendar day median (middle line inside box), first quartile (bottom of box), third quartile (top of box), minimum (bottom tail), maximum (top tail), and outliers (dots) for each of the four market sectors.

Figure 11. Calendar Days per Phase for EY2023 Sites by Market Sector



3.3. Infrastructure Costs

This section examines costs of BTM and TTM infrastructure for financially closed out sites in the program-to-date.[41] The Evaluation Team's dataset includes cost information for 126 sites to date with a total of 43 MW of installed capacity and 1,246 ports. Of these sites, 54 are school bus sites, 16 transit

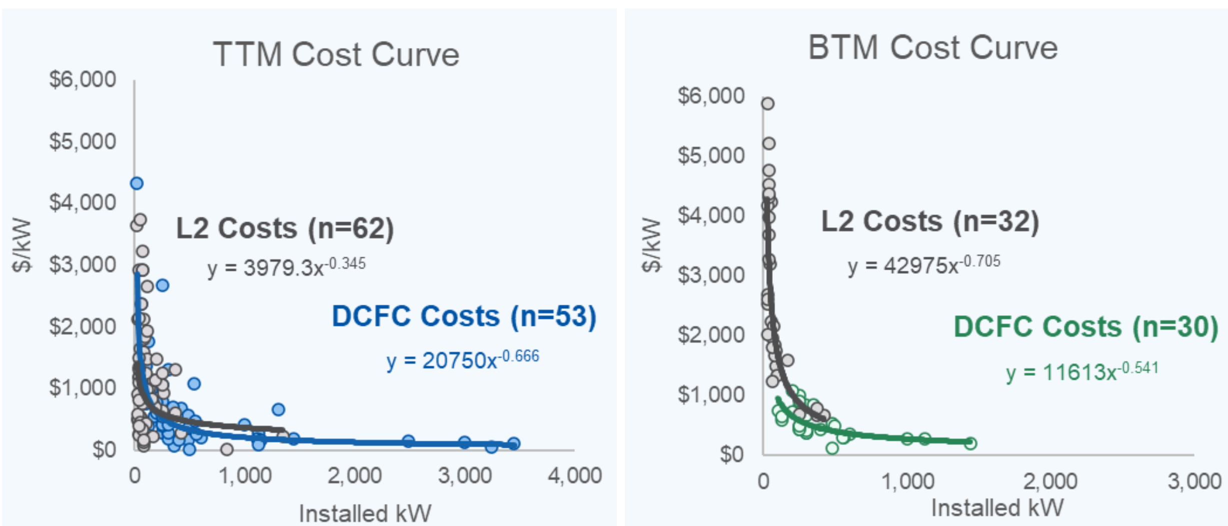
41 Financially closed out sites are a subset of activated sites for which the Utilities have administratively completed financial paperwork.

bus sites, 11 medium-duty vehicle sites, and 7 heavy-duty vehicle sites. All but one of the 126 sites in the dataset have Utility-owned TTM infrastructure, but only 54% have Utility-owned BTM infrastructure. The other 46% of sites have customer-owned BTM infrastructure.

Sites with Utility-owned infrastructure are useful for understanding the full cost of site development, because Utilities track payments for each incurred cost of installing the infrastructure. On the other hand, for customer-owned infrastructure, Utilities report only costs incurred by the Utility, including rebates and incentives.

For sites with Utility-owned TTM and BTM, Figure 12 plots the relationship between the cost of TTM (left) and BTM (right) installation and installed site capacity for L2 and DCFC sites. Sites with mixed L2 and DCFC are not shown for simplicity. The curves illustrate that small sites (i.e., sites with less installed capacity) have a much higher cost per kilowatt than large sites, but the curves flatten for both TTM and BTM sites and for both L2 and DCFC sites at around 500 kW of installed capacity. This is likely too large for most public L2-only sites but could be a design consideration for public mixed (L2 and DCFC), public DCFC, and fleet sites. Power equations of the form $Y=Ax^b$ provide the best fit of the data. R-squared values for the curves vary from 0.05 to 0.6. Thus, given the relatively low R-squared value of both trendlines, the reader should take caution when interpreting these curves.

Figure 12. TTM and BTM Cost versus Installed Site Capacity



As shown in Figure 12, BTM costs are generally higher than TTM costs for both L2 and DCFC sites. Additionally, all curves flatten at around 500 kW to 1,000 kW of installed site capacity.

Using the curves shown in Figure 12, the Evaluation Team generated TTM and BTM distributions for the four market sectors in Figure 11; these are shown in Figure 13 through Figure 16.

Figure 13. Heavy-Duty Vehicle Costs (n=7 sites)

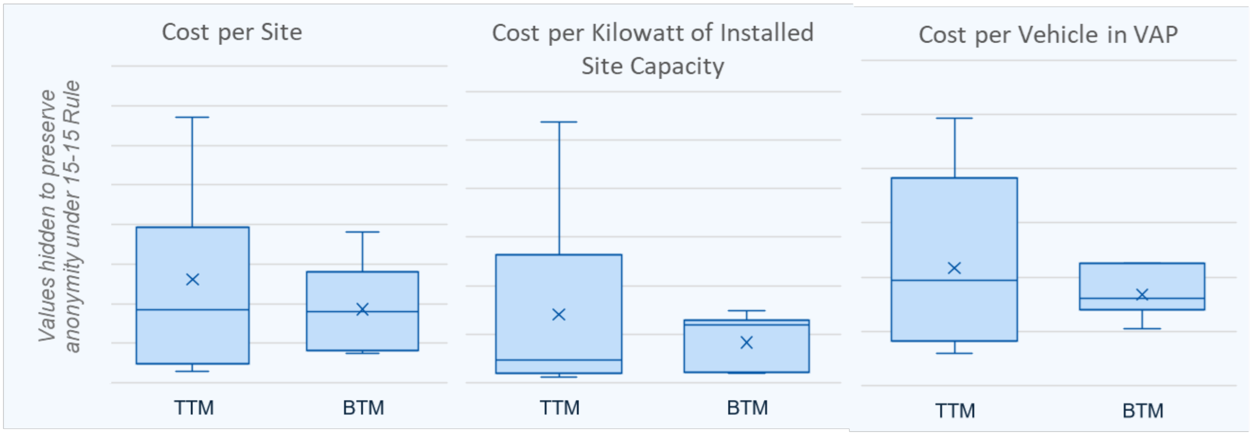


Figure 14. Medium-Duty Vehicle Costs (n=11 sites)

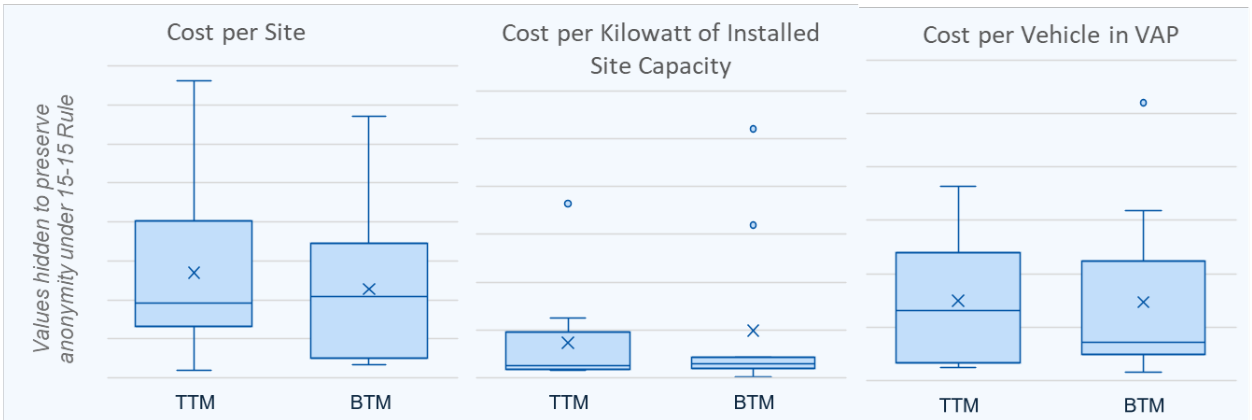


Figure 15. School Bus Costs (n=51 sites)

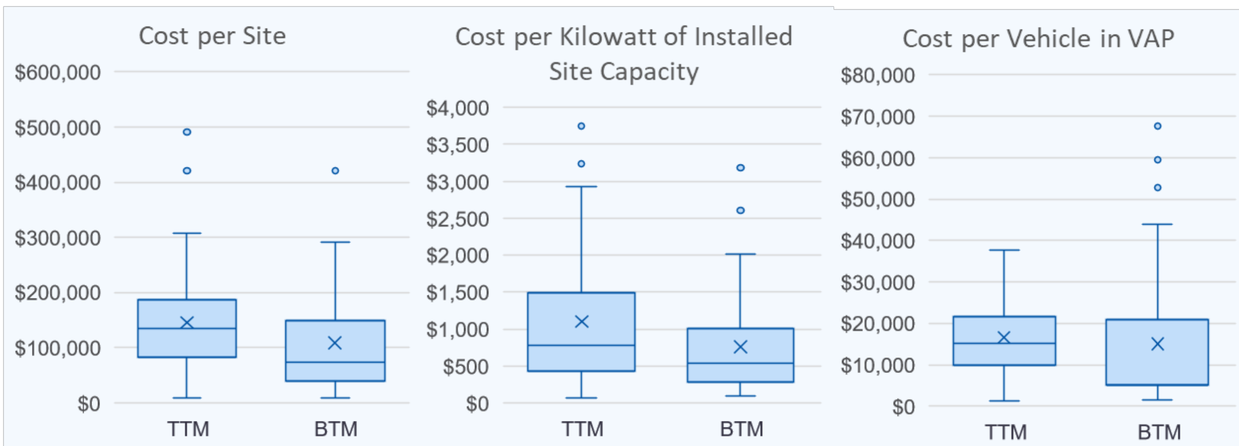
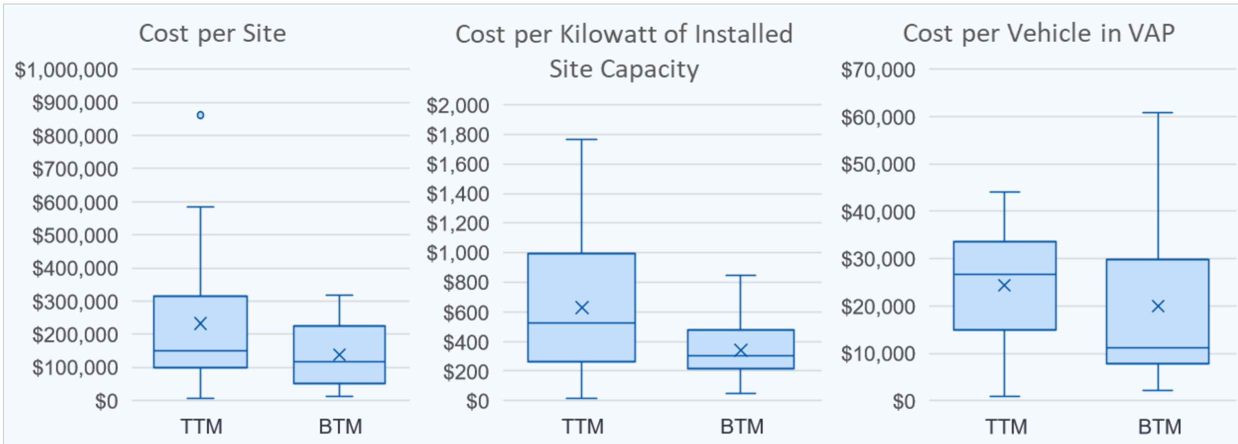


Figure 16. Transit Bus Costs (n=16 sites)

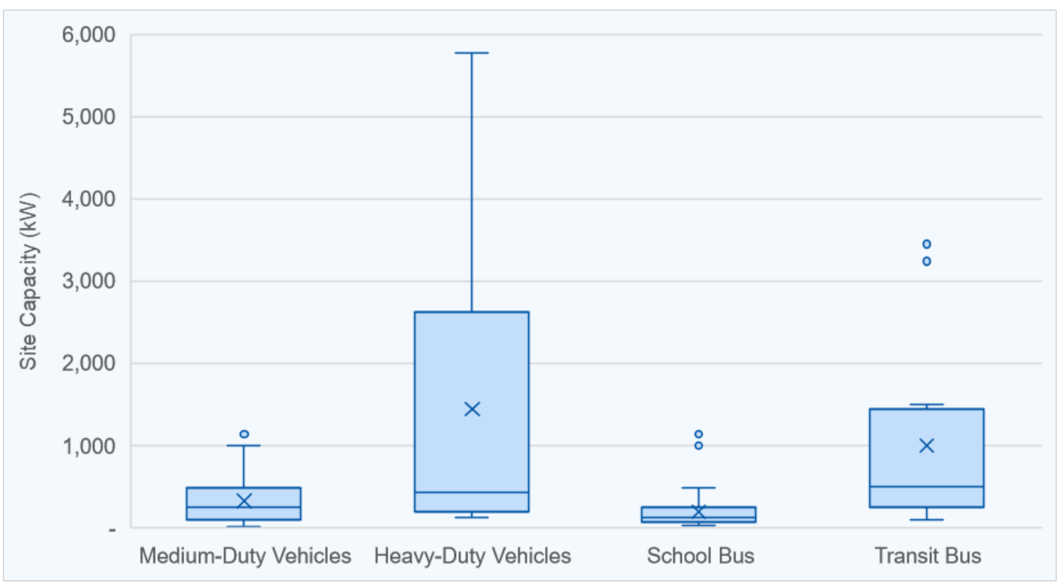


3.4. Grid Impacts

Installed Charging Capacity

Figure 17 shows the distribution of average installed charging capacity per site by four market sectors: school bus, transit bus, medium-duty vehicles and heavy-duty vehicles across all Utility programs. As shown, the heavy-duty vehicle sector has both the highest average installed capacity (approximately 1,200 kW per site), and the largest variation in site capacity, with multiple sites below 200 kW of capacity as well as sites in excess of 5,000 kW of installed capacity. School bus sites have the lowest average installed capacity of approximately 200 kW per site and are also the most uniform in size, with only two sites exceeding 500 kW of installed capacity.

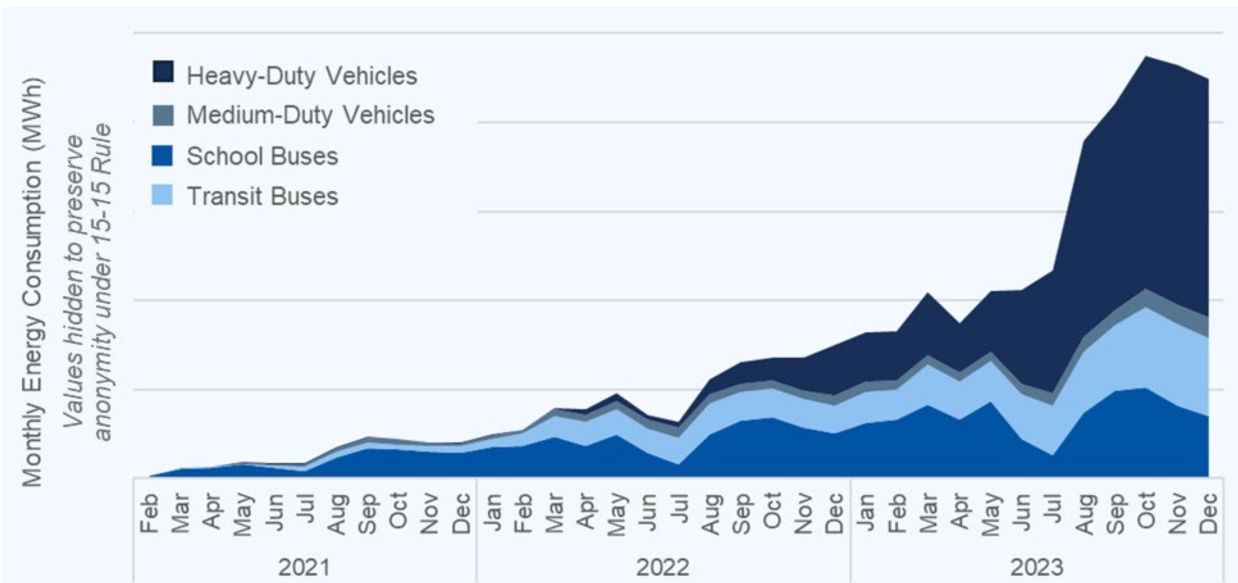
Figure 17. Average Installed Charging Capacity per Site by Market Sector, All Utilities



Monthly Energy Consumption

Figure 18 shows the total energy consumption by month across four market sectors in all Utility MDHD programs. As shown, total monthly consumption increased significantly in EY2023, rising from approximately 800 MWh in January 2023 to a peak of 2,400 MWh in October 2023, a 200% increase. As shown, this growth was driven primarily by the heavy-duty market sector, which accounted for approximately 1,500 MWh of consumption by December 2023, up from just 250 MWh at the beginning of the year as new large sites came online. Figure 18 also shows a divergence in consumption trends for the heavy-duty vehicle sector. In 2021 and 2022, all four market sectors showed a decrease in consumption during the months of June and July. In 2023, the school bus, transit bus, and medium-duty vehicle sectors continued this trend, while the heavy-duty vehicle sector continued to increase—though at a slower pace than during the rest of the year.

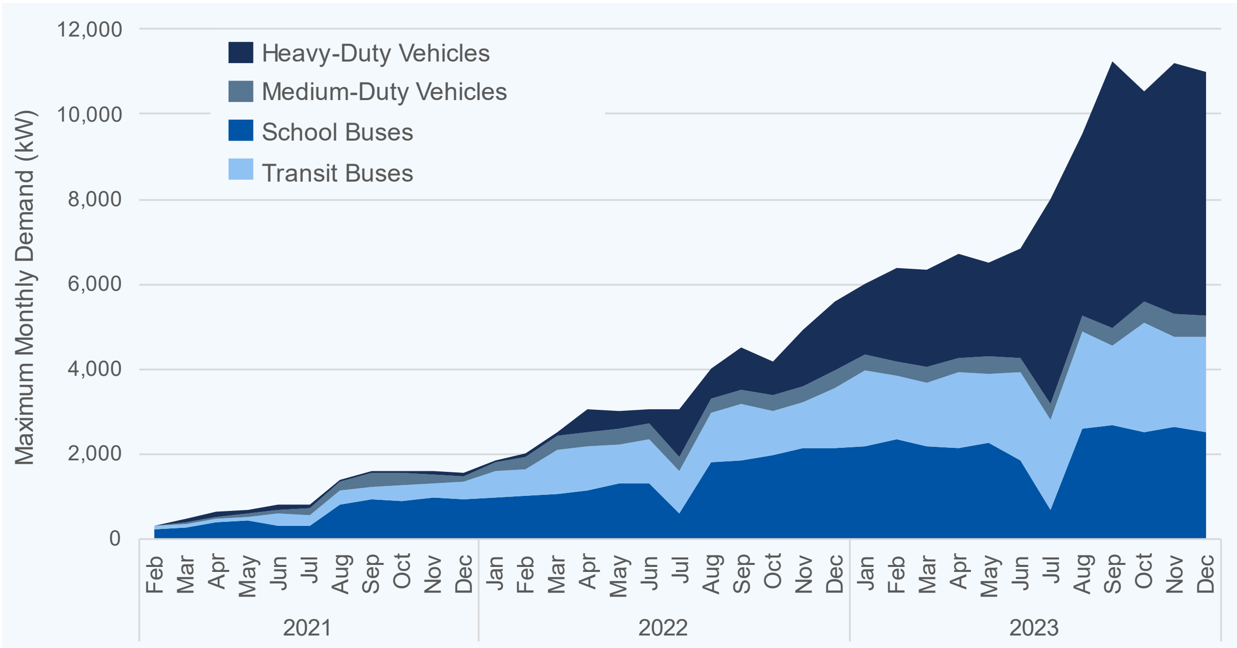
Figure 18. Cumulative Monthly Energy Consumption across Four Utility Program Market Sectors, 2021–2023



Maximum Monthly Demand

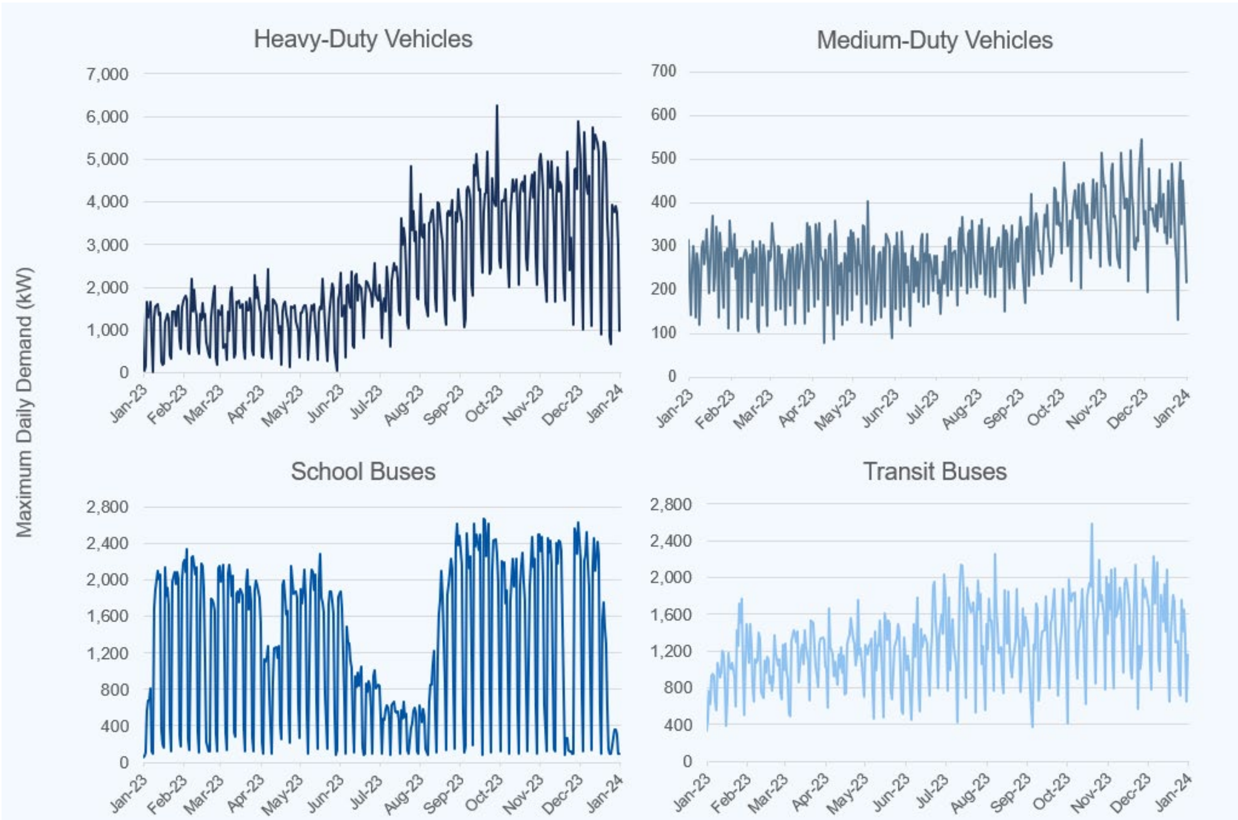
Figure 19 shows the total maximum demand by month across four market sectors in all Utility MDHD programs. As shown, peak demand followed a general upward trend similar to cumulative monthly energy consumption, with heavy duty vehicle sites accounting for an increasingly large share of peak demand throughout 2023. For school bus market sector, peak demand fell dramatically (>50%) in July for each year from 2021 to 2023 due to summer break for schools.

Figure 19. Maximum Monthly Demand across Four Utility Program Market Sectors, 2021–2023



Delving further into maximum monthly demand, Figure 20 shows the variations in high and low maximum demand days throughout 2023, displayed by market sector. Note that the Y-axis (kW) scale varies between market sectors due to relative size of overall energy demand. Across all market sectors, peaks are typically weekdays, while valleys are weekends, when charging drops significantly with lower vehicle operation; maximum demand also falls precipitously in the summer in conjunction with the school year ending. While all market sectors show drastic variability, the school bus sector is most pronounced with numerous days with near zero energy demand, and peaks of over 2,500 kW. The heavy-duty sector shows the greatest variation, with daily maximum growing to over 5,000 kW on multiple days but falling to less than 1,000 kW as frequently—a shift of over 4,000 kW. Notably, the medium-duty vehicle market sector showed the most stable maximum demand across 2023, with a difference in daily maximum and minimum demand of approximately 200 kW. This analysis highlights the continuous growth in demand since the inception of the MDHD programs as new sites come online and older sites continue to increase their vehicle counts.

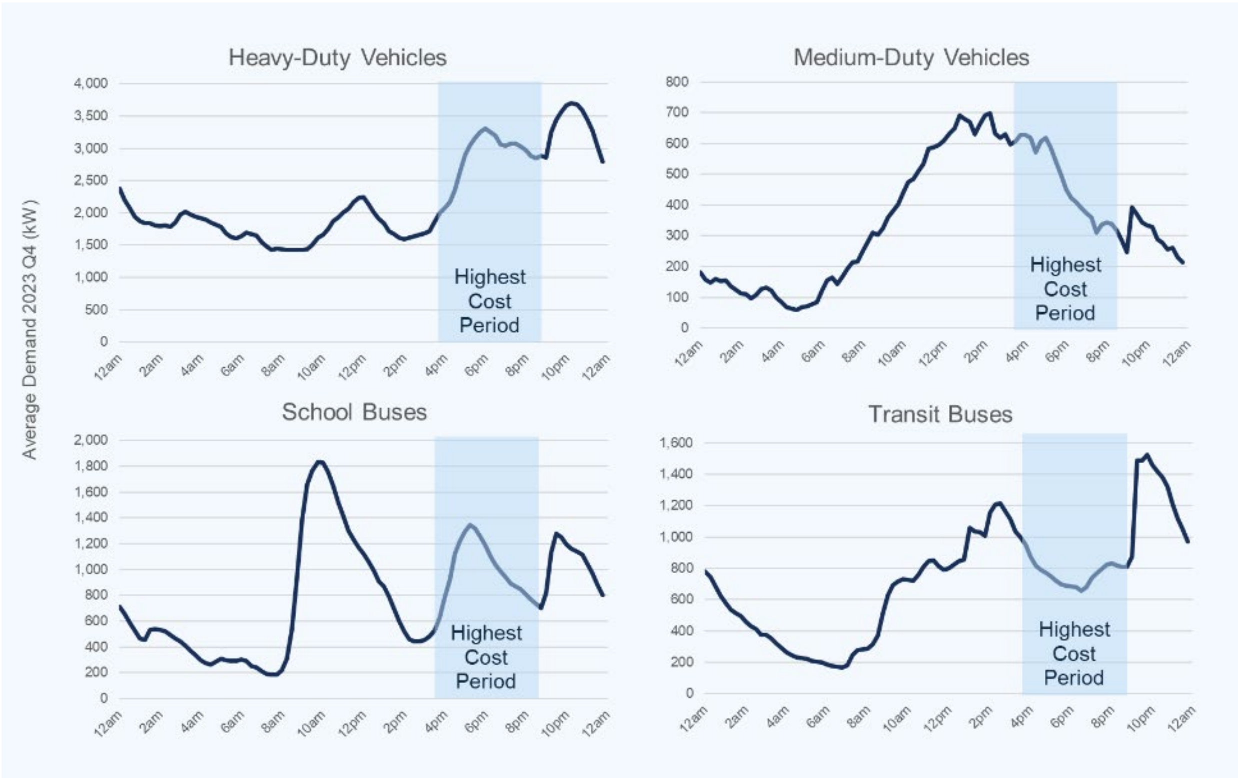
Figure 20. Variations in Maximum Daily Demand for Four Market Sectors across Utility MDHD Programs in 2023



Daily Load Curves

Figure 21 shows the average daily load curve for each of four market sectors in Q4 2023 and highlights the variation in daily charging behavior between sectors, with notable difference in the amount of charging demand that occurs during the highest cost period of 4 p.m. to 9 p.m. Each of the four market segments shows a significant spike in demand beginning at 9 p.m., which indicates that sites are implementing load management to avoid charging during the highest cost period. This is most pronounced in the transit bus sector, which sees a drop in demand of nearly 50% between 2 p.m. and 6 p.m., followed by an increase of almost 50% at 9 p.m.—exhibiting a significant load shift. The school bus sector continues to exhibit charging peaks after completing morning routes and again in the late afternoon, which occurs during this peak period, offering significant opportunity to reduce costs through load management. The heavy-duty vehicle sector has the highest demand between 4 p.m. and 9 p.m., with a large portion of total daily consumption occurring during this period. The medium-duty vehicle market segment has the most consistent load profile, with demand consistently growing from 5 a.m., peaking at 2 p.m., and then consistently falling from 2 p.m. until 5 a.m. the following day, except for a small uptick in demand at 9 p.m. resulting from load-managed sites.

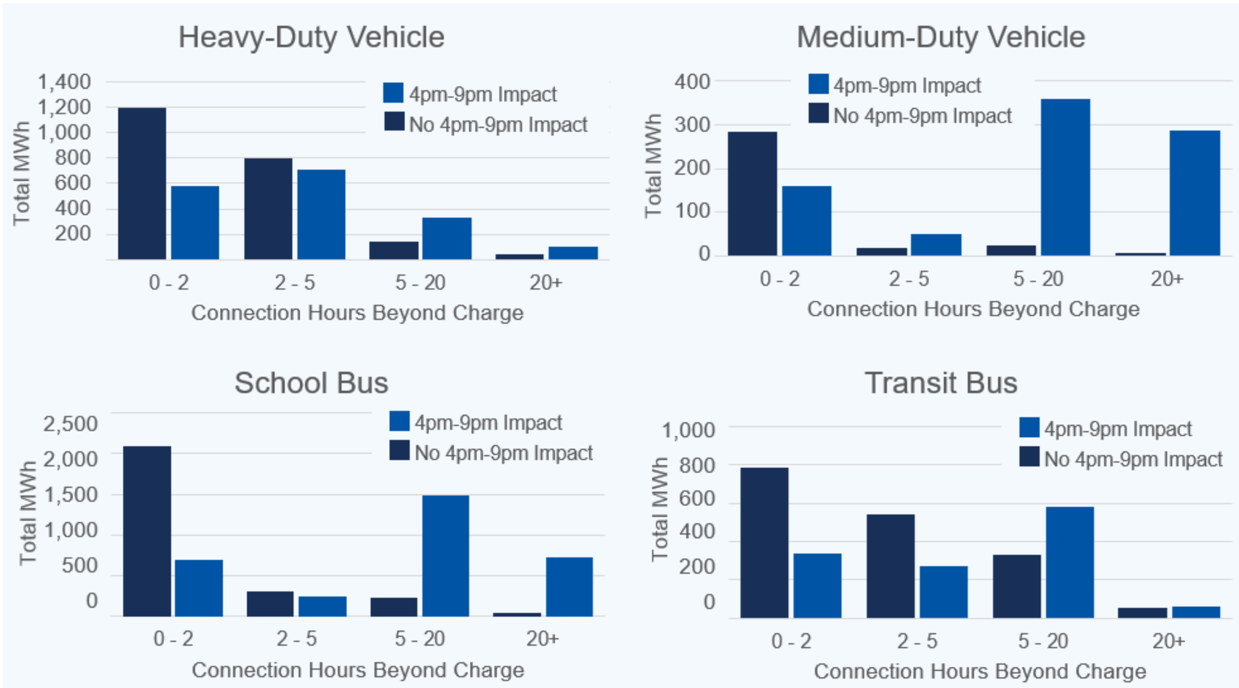
Figure 21. Daily Average Load Curve for Four Market Sectors across Utility MDHD Programs in Q4 2023



Charging Flexibility

Site charging data was used to determine the amount of time vehicles of each market sector are connected to a charging port but not actively consuming energy. This allowed the Team to assess charging flexibility, or the ability for a vehicle to shift charging from periods of high-cost electricity to low-cost electricity without impacting vehicle operations. Figure 22 shows the relative charging flexibility of each of the four market sector fleets, represented by the number of hours that fleet vehicles are connected to a charging port but not consuming electricity. The columns in each of the four graphs represent whether or not a charging session overlaps with the 4 p.m. to 9 p.m. time period and the number of hours that fleet vehicles are connected to a charger but not consuming energy. The columns in dark blue in each graphic represent the number of hours and total energy that could be shifted away from peak demand periods through implementation of load management.

Figure 22. Charging Flexibility of Four Market Sectors Across Utility MDHD Programs in 2023



The medium-duty vehicle and school bus market sectors both show significant charging flexibility, with a large portion of energy consumption taking place during the 4 p.m. to 9 p.m. time period by vehicles that are connected to a charger but not consuming energy for five hours or more. Charging flexibility of five hours or more would allow 100% of charging that occurs during peak periods to be shifted to periods with lower-cost electricity.

The transit bus sector has a moderate level of charging flexibility, followed by the heavy-duty vehicle sector, which has the lowest opportunity to gain cost efficiency through charge management. This is partially driven by charging speed; DCFC charging sessions typically do not last as long as those of L2 charging, and vehicles are far less likely to remain plugged in after a charging session is completed. Transit buses have somewhat greater flexibility when vehicles are domiciled overnight, in comparison to heavy-duty vehicles, which often run multiple daily shifts.

Optimization

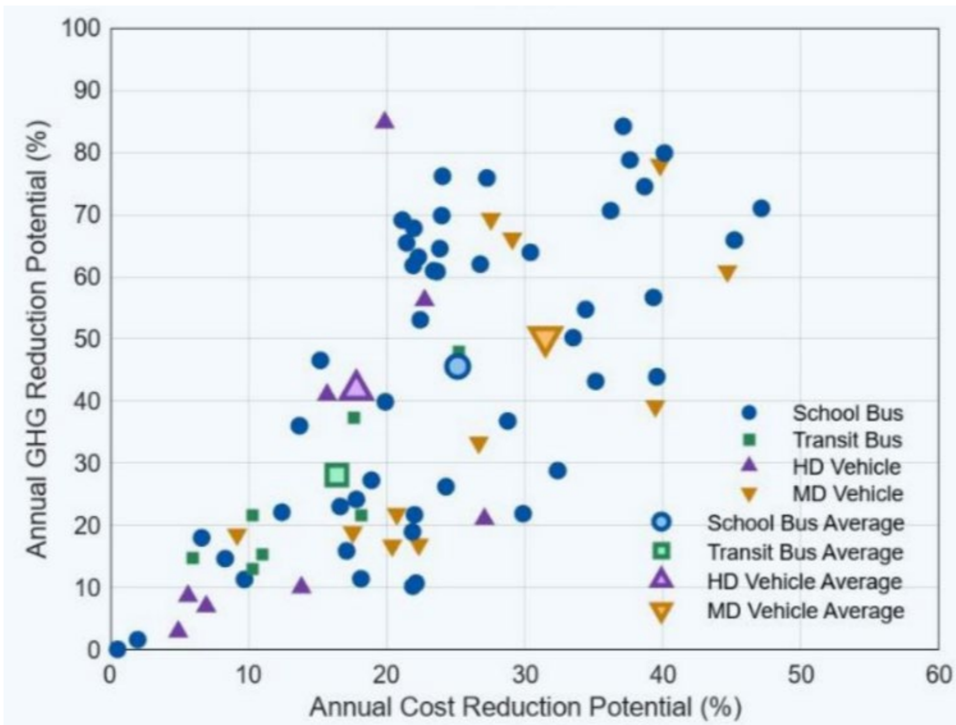
The Evaluation Team conducted further analysis based on charging flexibility. This effort estimated reductions in cost and GHG emissions based on current time-of-use (TOU) rates for only sites with continuous charging session data. The analysis considered a conservative amount of energy that could be shifted from the 4 p.m. to 9 p.m. time period to a less costly time.

The current phase of optimization analysis included 76 fleets that had enough charging session data to provide a statistical foundation. Follow-up phases of analysis will include sites with less or no charging session data. Energy was not necessarily shifted to the lowest cost time period. Furthermore, the

Evaluation Team did not evaluate to what extent maximum demand (kW) could be mitigated as a component of PG&E and SDG&E EV rates with capacity “subscription charges.”

Figure 23 depicts results for each fleet and average results for each market segment. Two of the Utilities have year-round TOU rates that generally align the lowest cost energy with lowest emissions. SDG&E has requested adding late morning and early afternoon year-round to its current Super Off-Peak period, which may further align costs with emissions. Many of the fleets appear to save 20% to 40% of their energy costs based on billing data available during 2023. Successful network-hardware-vehicle environments are crucial for load management and smart charging automation as few fleets have staff on site late at night (9 p.m.) when prices drop.

Figure 23. 2023 Cost and GHG Reduction Potential if Each Site Used Load Management



3.5. Petroleum and GHG Emissions Impacts

Table 16 shows the annual petroleum displacement and GHG emissions reductions associated with counterfactual vehicles that were replaced by EVs supported by charging infrastructure deployed under the Utilities’ MDHD programs; average values per vehicle are shown based on the total reduction and total number of observed EVs during site visits. The heavy-duty vehicle market sector has the largest annual and per-vehicle reductions for both petroleum and GHG emissions, followed by the transit bus market sector. While the school bus market sector has significantly larger reductions than the medium-duty vehicle market sector, because many more school bus sites have been activated in the programs, reductions per vehicle for these two sectors are almost identical.

Table 16. Annualized Petroleum Displacement and GHG Emissions Reductions of Four Market Sectors across Utility MDHD Programs in 2023

Market Sectors (number of sites)	Annual Petroleum Displacement (gallons)	Annual CO2e Reduction (MT)	Site Visit Observed EVs	Annual Petroleum Displacement per Vehicle (gallons)	Annual CO2e Reduction per Vehicle (MT)
Heavy-Duty Vehicle	907,319	7,128	148	6,131	48.2
Medium-Duty Vehicle	73,490	589	80	919	7.4
School Bus	363,908	3,082	365	997	8.4
Transit Bus	751,543	5,243	206	3,648	25.5

Figure 24 and Figure 25 show the average petroleum displacement per vehicle in DGE and GHG emissions reductions per vehicle in MT of GHG per site along with their variation among the sites. Average petroleum displaced and GHG emissions reduced per vehicle per site are lower for the heavy-duty vehicle market sector than shown in Table 16 due to a few very large sites.

Figure 24. Average Petroleum Displacement per Vehicle by Market Sectors for All Utilities

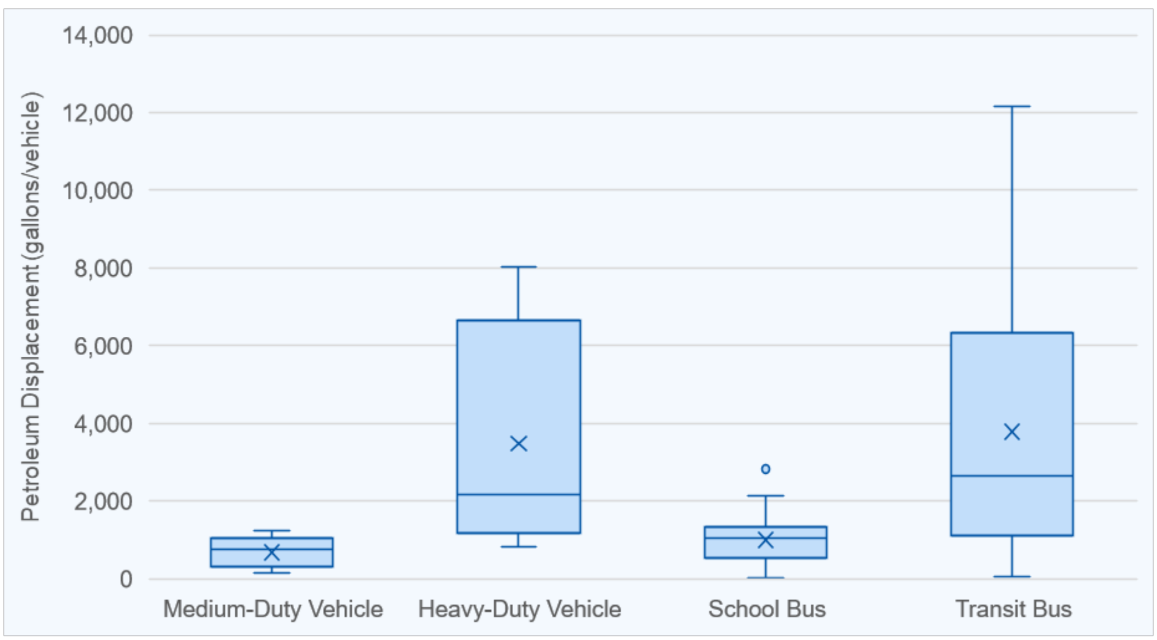
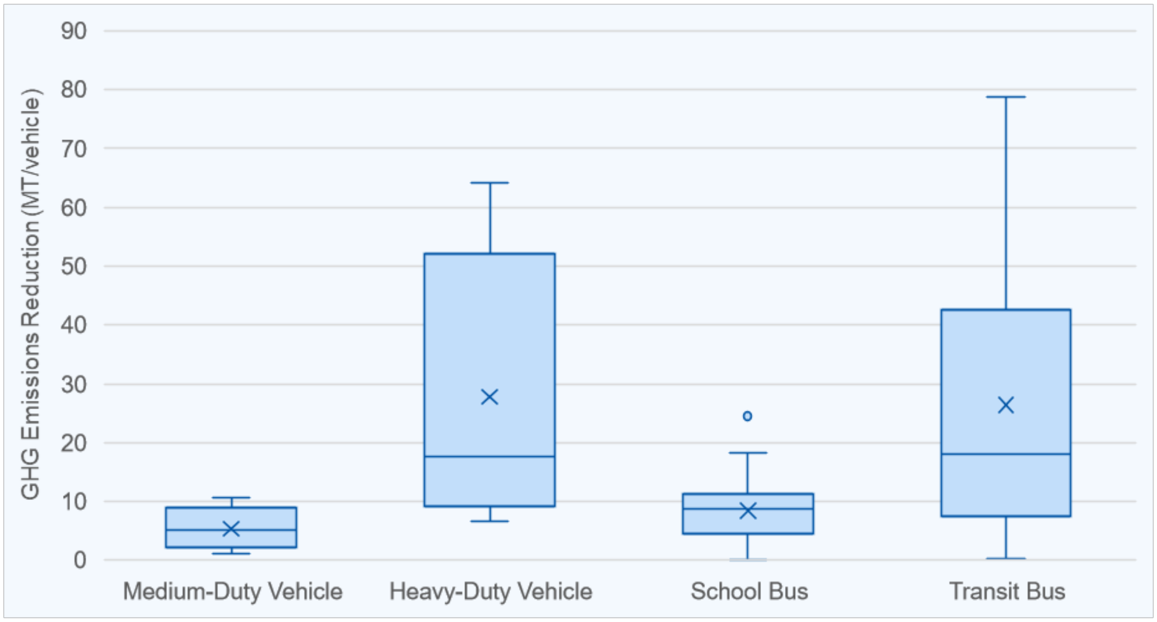


Figure 25. Average GHG Emissions Reduction per Vehicle by Market Sectors for All Utilities



3.6. Fleet Manager Net-to-Gross Analysis

The Evaluation Team based our approach for the MDHD programs enhanced self-report net-to-gross (NTG) analysis on information obtained as part of in-depth surveys with participating fleet managers. The Evaluation Team conducted the survey via an online survey platform, Qualtrics, and delivered the survey using email contact information provided by IOUs. The fleet manager NTG analysis results represent estimates of the proportion of program activity that would not have occurred in the MDHD program's absence, which can also be expressed as the proportion of program activity that is estimated to be attributable to the MDHD programs.

The estimated NTG ratios by market sector are presented in Table 17, along with the overall average fleet manager NTG ratio of 0.50 for all surveyed sites. The school bus market sector was estimated to have the highest NTG ratio at 0.58, while the transit bus market sector had the lowest estimated NTG ratio at 0.37, indicating that the MDHD programs had the greatest impact on the school bus market sector compared to the other market sectors.

Table 17. MDHD Fleet Manager NTG Analysis Results

Market Sector	Responding Sites (n)	NTG
School Bus	13	0.58
Transit	5	0.37
Distribution	4	0.50
Heavy-Duty Vehicle	3	0.39
Overall	**25**	**0.50**

3.7. Truck Choice Model

The Evaluation Team assessed the impacts of the Utility MDHD programs using a modified version of the Truck Choice Model (TCM) developed at the University of California-Davis.[42] The model helps predict MDHD fleet operators' new vehicle purchase decisions accounting for lifecycle vehicle and operating costs and human preferences. The model does not capture certain non-cost barriers to electric MDHD vehicle adoption, such as availability of makes and models.

The Evaluation Team used the TCM to assess the effect of Utility funding for TTM, BTM, and EVSE on vehicle adoption. The utility funding can be viewed as an incentive for fleets that would otherwise have to pay for the installation of this infrastructure. Importantly, AB 841 requires utilities to pay for all TTM infrastructure necessary to upgrade the TTM infrastructure. Therefore, scenarios examining the impact of TTM funding are more relevant outside of California.

The Evaluation Team averaged cost data for each vehicle type from completed sites to estimate the average TTM and BTM costs for each market sector. For sectors that had relatively few sites, the data may not represent actual infrastructure costs. We divided the average site costs by the number of installed chargers to estimate these costs on a per vehicle basis. Table 18 shows the TTM and BTM Utility funding on a per charger basis for each market sector. Costs in the table are based on actual program site costs.

The Utility costs can be viewed as a disincentive or barrier to BEV sales. In the TCM, the generalized cost is increased because the infrastructure is an added expense. All such increases reduce the sales shares for that technology (i.e., BEVs or eTRUs).

Table 18. Cost of TTM and BTM Utility Funding on a Per Charger Basis for Each Market Sector

Vehicle Type	TTM Cost	BTM Cost
Medium-Duty Delivery	$21,853	$38,025
Transit Bus	$19,503	$36,276
School Bus	$13,920	$30,629
Short-Haul	$24,573	$39,544
TRUs	$7,627	$34,630

The BTM and TTM costs are averages of present (2025) Utility funding for hardware installation. We assume that future funding may be reduced because some hardware installed in 2025 will not have to be reinstalled in 2030. We assume that TTM and BTM costs in 2030 are reduced by 20% from the 2025 values.

[42] University of California–Davis Institute of Transportation Studies (Miller, Marshall, Qian Wang, and Lewis Fulton). 2017. *NCST Research Report: Truck Choice Modeling: Understanding California's Transition to Zero-Emission Vehicle Trucks Taking into Account Truck Technologies, Costs, and Fleet Decision Behavior*." Research Report UCD-ITS-RR-17-36.

3.7.1. Truck Choice Model Results

This section shows the results of running the model using two trajectories. The first assumes that the Utility will cover TTM costs, but the customer will cover some or all of the BTM and EVSE costs. The second trajectory assumes that customers cover both BTM and TTM costs. For each trajectory, we consider the full cost of the Utility funding as well as lower values. We ran the model using 0%, 25%, 50%, 75%, and 100% of the BTM costs and of the BTM plus TTM costs for both 2025 and 2030.

For each of the five values of BTM-only funding and five values of BTM-plus-TTM funding, the model produced projected sales shares for EVs or eTRUs for each market sector. Table 19 through Table 23 and Figure 26 through Figure 30 show the BTM incentives, the BTM-plus-TTM incentives, and the resulting projected sales shares for each of the five market sectors for 2025 and 2030.

Table 19. Choice Model Results for Transit Bus

Incentive Percentage	0%	25%	50%	75%	100%
BTM Incentive					
2025	0	$9,069	$18,138	$27,207	$36,276
2030	0	$7,255	$14,510	$21,765	$29,020
BTM Sales Share					
2025	35.4%	37.6%	39.1%	40.1%	40.8%
2030	60.9%	66.3%	72.1%	77.8%	83.0%
BTM+TTM Incentive					
2025	0	$13,944	$27,889	$41,834	$55,779
2030	0	$11,155	$22,311	$33,467	$44,623
BTM+TTM Sales Share					
2025	28.0%	33.7%	37.4%	39.6%	40.8%
2030	51.7%	57.9%	65.9%	74.8%	83.0%

Figure 26. Sales Share by BTM Incentive for Transit Bus

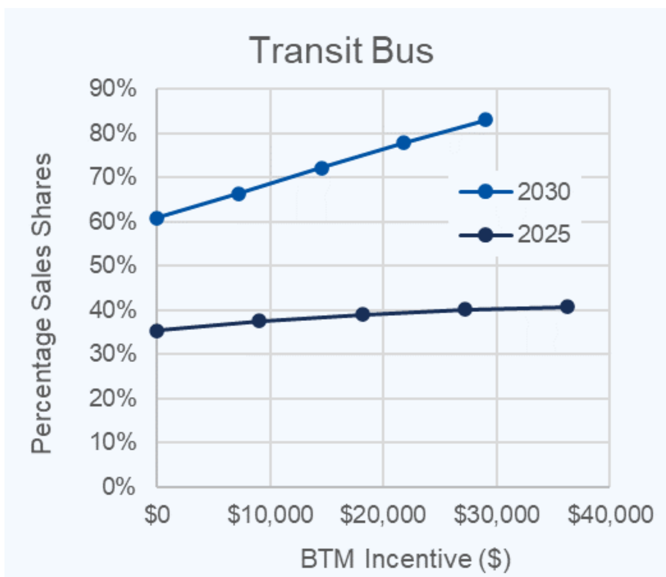


Table 20. Choice Model Results for School Bus

Incentive Percentage	0%	25%	50%	75%	100%
BTM Incentive					
2025	0	$7,657	$15,314	$22,971	$30,629
2030	0	$6,125	$12,251	$18,377	$24,503
BTM Sales Share					
2025	11.8%	15.4%	19.6%	24.1%	28.7%
2030	34.0%	38.5%	43.0%	47.7%	52.7%
BTM+TTM Incentive					
2025	0	$11,137	$22,274	$33,411	$44,549
2030	0	$8,909	$17,819	$26,729	$35,639
BTM+TTM Sales Share					
2025	6.8%	10.6%	15.8%	22.0%	28.7%
2030	25.9%	32.3%	38.9%	45.6%	52.7%

Figure 27. Sales Share by BTM Incentive for School Bus

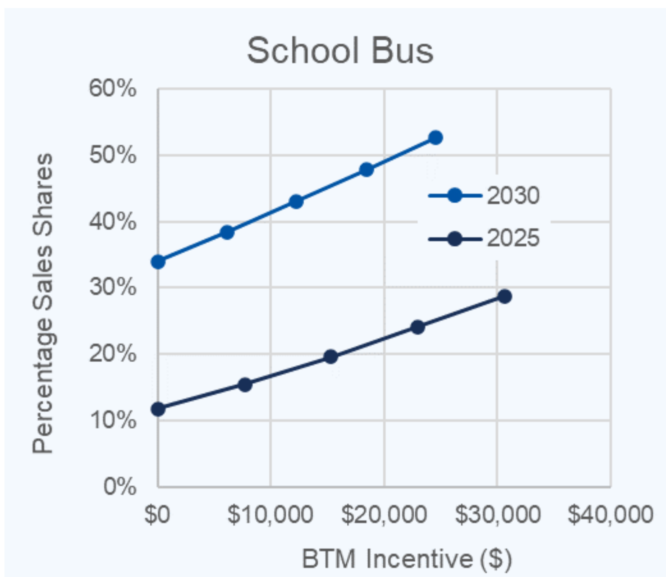


Table 21. Choice Model Results for Short-Haul

Incentive Percentage	0%	25%	50%	75%	100%
BTM Incentive					
2025	0	$9,886	$19,772	$29,658	$39,544
2030	0	$7,908	$15,817	$23,726	$31,635
BTM Sales Share					
2025	0.1%	0.2%	0.4%	0.6%	0.9%
2030	10.5%	15.1%	20.4%	25.9%	31.5%
BTM+TTM Incentive					
2025	0	$16,029	$32,058	$48,087	$64,117
2030	0	$12,823	$25,646	$38,470	$51,293
BTM+TTM Sales Share					
2025	0.0%	0.1%	0.2%	0.4%	0.9%
2030	3.8%	7.4%	13.9%	22.5%	31.5%

Figure 28. Sales Share by BTM Incentive for Short-Haul

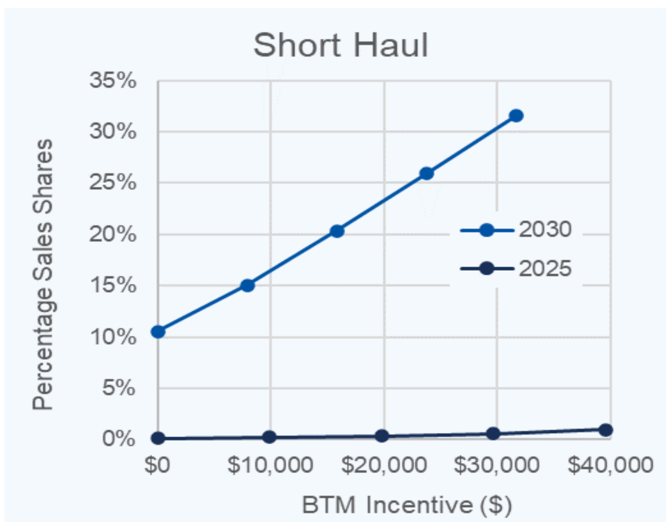


Table 22. Choice Model Results for Medium-Duty Delivery

Incentive Percentage	0%	25%	50%	75%	100%
BTM Incentive					
2025	0	9,506	19,012	28,518	38,025
2030	0	7,605	15,210	22,815	30,420
BTM Sales Share					
2025	4.3%	7.2%	11.4%	16.8%	22.8%
2030	23.0%	30.4%	38.8%	47.9%	57.1%
BTM+TTM Incentive					
2025	0	14,969	29,939	44,908	59,878
2030	0	11,976	23,951	35,927	47,902
BTM+TTM Sales Share					
2025	1.2%	2.9%	6.6%	13.6%	22.8%
2030	9.4%	18.1%	29.3%	42.6%	57.1%

Figure 29. Sales Share by BTM Incentive for Medium-Duty Delivery

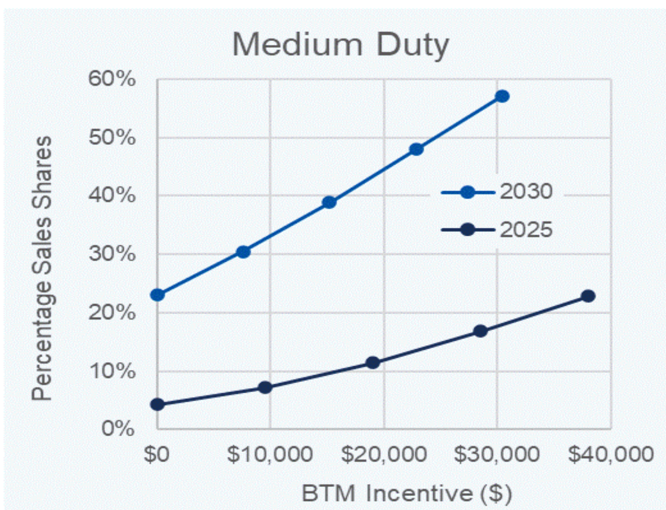
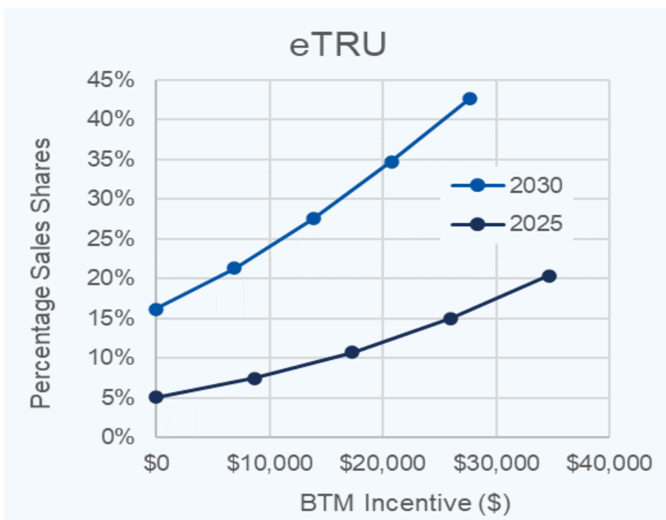


Table 23. Choice Model Results for eTRU

Incentive Percentage	0%	25%	50%	75%	100%
BTM Incentive					
2025	0	$8,657	$17,315	$25,972	$34,630
2030	0	$6,926	$13,852	$20,778	$27,704
BTM Sales Share					
2025	5.1%	7.5%	10.8%	15.0%	20.4%
2030	16.2%	21.3%	27.5%	34.7%	42.7%
BTM+TTM Incentive					
2025	0	$10,564	$21,128	$31,692	$42,257
2030	0	$8,451	$16,902	$25,354	$33,805
BTM+TTM Sales Share					
2025	3.6%	5.8%	9.2%	14.0%	20.4%
2030	12.5%	17.8%	24.6%	33.0%	42.7%

Figure 30. Sales Share by BTM Incentive for eTRU



3.7.2. Truck Choice Model Limitations

This analysis relies heavily on several inputs that could change significantly over time. In some cases, these inputs rely on policies that may change in future years. Other inputs make use of technology cost projections which are always somewhat uncertain. This section discusses some of the critical inputs and how their values could differ from those used in this analysis.

Hybrid and Zero Emission Truck and Bus Voucher Incentive Project

HVIP is a California public program that has made funding incentives available for advanced technology MDHD vehicles. Presently, a varying amount of HVIP funding is allocated every year. Once ZEVs show significant market penetration, it is unclear how the HVIP funding will change. We have assumed that HVIP will allocate enough funding to meet the needs of all fleets purchasing ZEVs, but that scenario would require large increases in the total allocation. Without substantial increases in HVIP funding incentives, funding would decrease and could be completely eliminated.

Vehicle Costs

Currently BEV cost is dominated by the cost of the batteries. Most vehicle cost analyses assume very large reductions in battery costs over time resulting in BEV costs that approach diesel costs. If battery cell prices do not decrease at the rates currently expected, BEV costs could remain much higher than we projected in this analysis. Projections of battery costs assume significant increases in volume sales. These increases are likely to occur in LDVs, but the magnitude of the increases is much smaller for truck original equipment manufacturers (OEMs). The projections for truck batteries could be optimistic resulting in lower cost reductions in the 2030 time period.

Low Carbon Fuel Standard Program

The LCFS program has been successful in reducing the average carbon intensity of transportation fuels. The incentives are based on trading LCFS credits and result in large reductions in electricity and hydrogen costs for fleets. The LCFS credit price and the program target carbon intensities as a function of time to determine the potential cost savings for the various fuels. The credit price has varied over time and could become higher or lower than we assume in this analysis. In 2022, the LCFS credit price was over $150 per credit, but as of May 2024, it has fallen to under $75 per credit. We expect CARB to attempt to increase the credit price to maintain a large enough incentive for electricity and hydrogen fueling. If the credit price increases to recent past values, the fleet cost of electricity would decrease, which would cause an increase in projected choice model BEV sales shares.

Advanced Clean Fleets/Advanced Clean Trucks Regulations

California's ACF and ACT regulations have set an aggressive schedule for mandating the sale and purchase of zero-emission trucks and buses to accelerate MDHD ZEV truck adoption. We have explicitly ignored these regulations to understand the effect of the utility incentive programs without external policy interference.

Hydrogen Price and Availability

Currently, hydrogen fuel is available only in limited locations, and few FCEVs are on the road. This means the demand for hydrogen fuel is low causing the price to remain high. The lack of fuel availability and the high price of fuel act as large disincentives for fleets to purchase FCEVs. If these two barriers were reduced, FCEVs could better compete with BEVs for market share, which could reduce the projected sales shares of BEVs.

Highlights

- When the Utility fully funds the TTM and BTM is shared between the Utility and customer, the model results suggest a positive correlation between Utility BTM incentive and EV adoption. For example, an increase in BTM funding from 0% to 100% increases EV adoption by between 4.3% and 22.8% in 2025 and between 23.0% and 57.1% in 2030 for the medium-duty delivery sector.
- Of all market sectors, the model suggests eTRUs are most sensitive to the availability of BTM funding.
- Factors that are not easily captured in the model (such as ACF regulation, switchgear wait times, and vehicle availability) could change the trajectories.

3.8. Market Effects

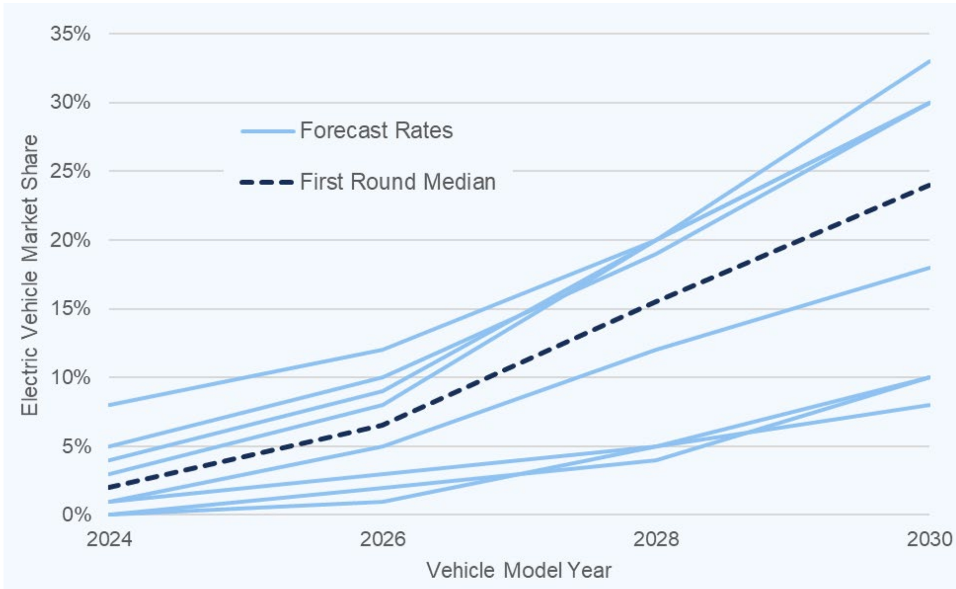
For the market effects analysis, the Evaluation Team assessed structural long-term changes in the TE market by comparing actual market activity to what would have happened in the absence of the programs.

3.8.1. Regional and Long-haul Truck Electrification Market Share Baseline

The Evaluation Team forecasted the baseline market share of electric regional and long-haul trucks[43] in California through vehicle model year 2030 following two rounds of input from the Delphi method, which involved surveying a panel of subject matter experts about future EV market adoption rates over multiple rounds. After each round, panelists were presented with the answers from the other panelists and asked if they wanted to change their previous answer. This iterative method sometimes results in consensus and near-consensus forecasts. The baseline represents electrification in the California market in the absence of Utility incentives. Figure 31 shows the individual curves from the first round of input (Round 1) along with the median curve. The horizontal axis indicates vehicle model year and applies to only new vehicles, not the entire statewide vehicle stock.

[43] Regional and long-haul trucks were defined to participants as tractor trailers with four or more axles in weight Class 7 or 8.

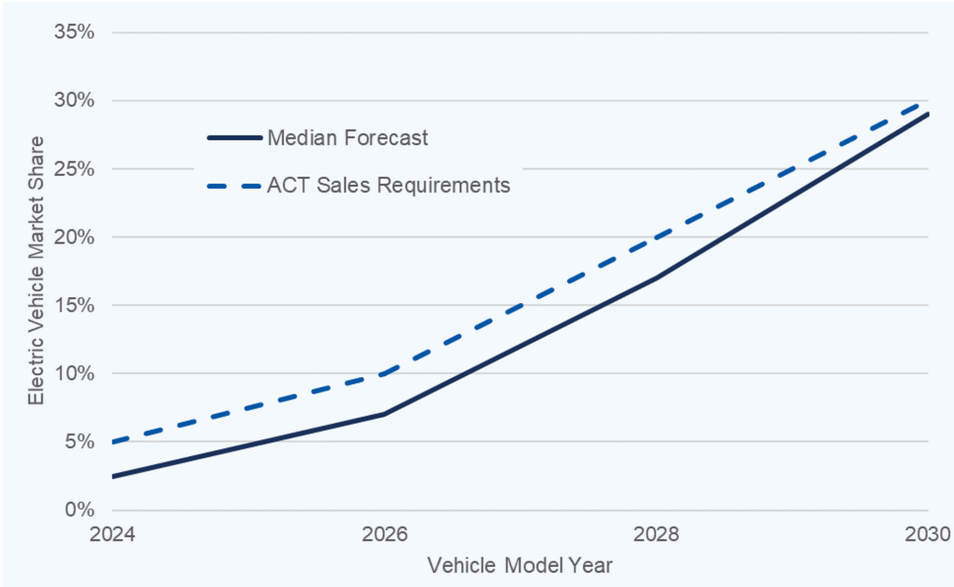
Figure 31. Delphi Panel's Round 1 Baseline Electric Regional and Long-Haul Truck Adoption Forecasts



Participant forecasts in Round 1 fell into two main groups. One group estimated that the electric regional and long-haul truck market will capture around a third of market share by 2030, while the other was more conservative offering forecasts of around 10% of market share by 2030. One forecast fell in the middle of these two groups and ended up close to the overall median. In Round 2, three of eight panelists agreed with the median or consensus forecast, while five panelists submitted new forecasts and rationales. As described in the Methodology section, the study was closed after the second round, and we considered the Round 2 median forecast to be the final consensus result.

Figure 32 shows the final consensus estimate compared to the zero-emission sales schedule from the ACT regulation for Class 7 and 8 tractor trucks.

Figure 32. Delphi Panel's Electric Regional and Long-Haul Truck Baseline Market Share Forecasts



The consensus forecast shows that experts estimate that the adoption of electric regional and long-haul trucks will fall below the ACT sales requirements. Of the experts who did not agree with the median, three increased their forecasts and two decreased their forecasts. All Round 2 forecast modifications were relatively minor (less than 5%) except for that of one expert whose Round 1 forecast included only long-haul trucks and increased more than 5% when factoring in regional-haul trucks in Round 2.

Panelists who increased their forecasts cited lower market share by fuel cell trucks and higher levels of hub and spoke deliveries. According to one expert, a lower market share of fuel cell trucks will increase the share of battery electric, and market share for fuel cell trucks depends very heavily on the performance of the Alliance for Renewable Clean Hydrogen Energy Systems (ARCHES) hub, which may fall short of expectations due to vehicle costs, fuel costs, and number of FCEV models. Both panelists who decreased their forecasts also cited increased market share for FCEVs along with assumptions that the ACT and ACF regulations will persist and remain enforceable in their current form. According to one expert, there is a strong possibility that the ACT regulation will either be modified when the technological and operational hurdles become clearer or be canceled if the EPA waiver is modified (or revoked altogether).

Although the main goal of the Delphi panel was to derive the consensus forecast, panelists' supporting rationales also contain valuable qualitative information. Aggregating the supporting comments revealed deeper insights into factors that panelists predict will accelerate or impede delivery vehicle electrification in California.

The median trajectory shows the electric regional and long-haul market falling short of the ACT sales requirements, which started in 2024. Panelists noted several reasons why this market sector could struggle to meet the ACT targets with costs and constraints of batteries and lack of charging infrastructure as the two most commonly cited. Four panelists mentioned the high costs and technological constraints of batteries, including range, recharge time, and weight. One panelist specifically mentioned that cost parity analysis from the U.S. DOE projects that Class 7 and Class 8 BEV trucks will not reach cost parity until after 2030, so trucks are unlikely to see market share beyond the ACT requirements. Another panelist posited that longer recharge times (compared to filling a diesel tank) combined with reduced freight capacity due to battery weight contributions to GVWR, means that more than one BEV (and likely more than 1.5) will be needed to move the same amount of freight as a diesel equivalent (and to produce the same revenue). Another expert expressed that there may be unforeseen manufacturer and fleet responses to increased costs. Manufacturers may restrict supply of diesel trucks to attempt to meet the ACT requirement, resulting in higher vehicle prices for all powertrains and a reduction in total annual truck sales; fleets might hedge against this potential outcome and consider preordering diesel engines to avoid further price increases. Where geographically possible, fleet operators may also respond by moving their facilities—both headquarters and depots—outside of California to continue to diesel.

Four panelists mentioned charging infrastructure. One expert wrote that although more public infrastructure will be installed over the next decade, it will likely be insufficient to provide recharging capacity for any significant portion of the on-road tractor truck stock. This panelist went on to say that there is no business case for deploying public charging infrastructure and not enough government funding in place to roll out charging infrastructure sufficient for even a small portion of the tractor fleet. Another panelist mentioned that the need for utilities to install utility-side (make-ready) infrastructure could delay charger energization. Sites that require significant power may see delays from the permitting, planning, and installation processes as well as from supply chain issues.

Other reasons for delays with delivery vehicle electrification included competition from FCEVs, an uncertain policy environment, and the California Trucking Association (CTA) suit. According to one panelist, the CTA suit will likely delay implementation of the ACT. Because OEMs need more sales and more time to produce trucks to lower truck costs, the delay could affect several years of the regulations. Regarding uncertainty around the future policy environment, one expert raised the point that California's ability to enforce its regulation of the heavy truck market via the ACT and ACF relies on waivers issued by the EPA. At the time of the survey fielding, the ACT (before modifications) had a waiver, and the ACF did not. Therefore, a forecast that includes only current regulations would incorporate enforcement of the ACT but not the ACF. Additional uncertainty could also result from policy changes to the EPA's authority to issue these waivers. In other words, there is considerable uncertainty surrounding the enforcement of both the ACT and the ACF due to political volatility over the forecast period.

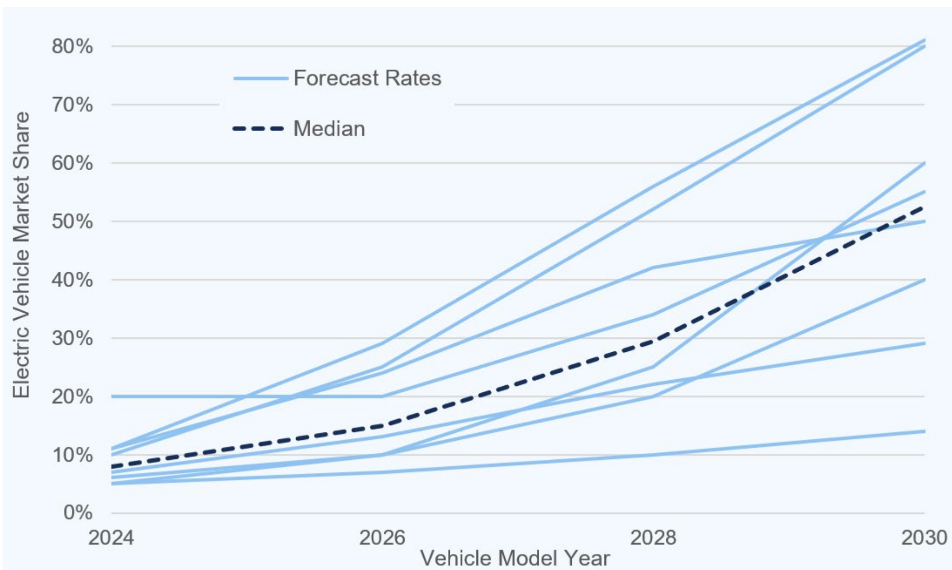
Highlights

- The consensus forecast for electric regional and long-haul truck market share in California falls short of the ACT regulation requirements for 2024 through 2030.
- Experts most commonly cited the costs and constraints of batteries and lack of charging infrastructure as the reasons for why the electric regional and long-haul market share would not meet ACT regulations.

3.8.2. School Bus Electrification Market Share Update

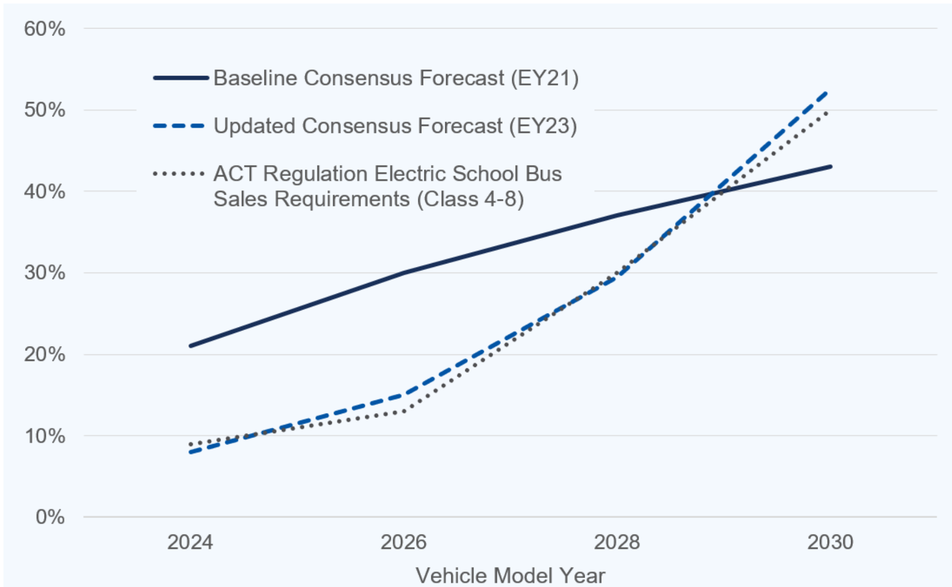
The Evaluation Team updated the baseline forecast for electric school bus market share in California through vehicle model year 2030 following two rounds of input from a Delphi panel. This baseline represents electrification in the California market in the absence of Utility incentives. The Evaluation Team updated the consensus forecasts developed during a previous Delphi panel conducted in February 2022 as part of the EY2021 report. Figure 33 shows the individual curves from the first round of input (Round 1), along with the median curve. The horizontal axis indicates vehicle model year and applies to only new vehicles, not the entire statewide vehicle stock.

Figure 33. Delphi Panel's Round 1 Updated Electric School Bus Adoption Forecasts



Round 1 forecasts of market share by 2030 varied widely, ranging from the most conservative estimate of 14% to the most aggressive estimate of 98%. In Round 2, six of eight panelists agreed with the median or consensus forecast, while two panelists submitted new forecasts and rationales. As described in *Appendix A*, the forecasting rounds continue until a majority consensus is reached. Because over half of the panelists were in agreement after Round 2, the median forecast is considered to be the final consensus result. Figure 34 shows the final consensus estimate compared to the previous consensus estimate conducted in the EY2021 evaluation and the school bus sales schedule from the ACT regulation. The ACT regulation specifies calendar year sales requirements for ZEVs in California (where a certain percentage of all new vehicle sales must be ZEVs). The updated final consensus forecast aligns closely with the sales schedule of the ACT regulation and shows that experts believe the regulation will drive adoption of electric school buses.

Figure 34. Delphi Panel's Electric School Bus Updated Market Share Forecast



Of the two experts who did not agree with the median, one slightly decreased their projections while one increased their projection. The expert who decreased their forecast argued that BEV school bus adoption will remain heavily dependent on incentive funding as schools' capital budgets are largely tied to tax revenues for the local municipality. Without access to Utility make-ready programs, schools will have to divert CapEx funding to infrastructure, and that will impact the schools' ability to adopt electric buses at higher rates. The panelist who increased their forecast argued that the median did not account for California regulations and funding through the CEC's Zero Emission School Bus and Infrastructure (ZESBI) Program and Public School Bus Set-Aside, and the EPA's Clean School Bus Program. While none of these funding sources are guaranteed beyond 2025, there is little reason to expect this funding to disappear.

Although the main goal of the Delphi panel was to derive the consensus forecast, panelists' supporting rationales also contain valuable qualitative information. Aggregating the supporting comments revealed deeper insights into factors that panelists predict will accelerate or impede school bus electrification in California.

In general, most panelists were relatively optimistic about electric school bus adoption. Three panelists mentioned various market effects they believe will drive electric bus adoption and specifically called out how an economy of scale will reduce material costs and improve the supply chain by increasing production and manufacturing capacity among suppliers. A couple of panelists mentioned improvements in battery and EVSE technologies, with one specifically mentioning lithium iron phosphate (LFP), which they claimed is more durable, less expensive, and based on materials that can be sustainable sourced. Other rationales included mentions of other (non-Utility) incentive programs and funding sources, such as the EPA awarded buses to California, HVIP and CARB funding, the ZESBI Program, and the Clean School Bus program. One expert mentioned that the ACT and ACF will become irrelevant with AB 579 becoming law.

Panelists who submitted forecasts that were more conservative than the consensus also mentioned market effects. One said that the growing pains of developing technology will create challenges for charging infrastructure and vehicle availability. Another mentioned that federal funding for electric school buses will taper off if it is not entirely eliminated.

Highlights

- The updated forecast for the electric school bus market share aligns with ACT sales requirements.
- Most experts were optimistic about electric school bus adoption, citing increasingly favorable economics as well as funding support from (non-Utility) incentive programs and legislation.

4. Southern California Edison Transportation Electrification Programs

4.1. Charge Ready Transport Program

4.1.1. Overview

This overview provides a detailed description of the SCE Charge Ready Transport program; summaries of the program implementation process, performance metrics, materials, and budget; and a timeline of major milestones. Following the overview are detailed findings, highlights, and lessons learned.

Program Description

Per Decision 18-05-040, SCE's Charge Ready Transport program provides infrastructure for fleet electrification at a low cost or at no cost to participants who procure or convert at least two medium- or heavy-duty (MDHD) EVs. SCE launched the Charge Ready Transport program in May 2019 to accelerate the adoption of MDHD EVs by lowering the TCO for fleets, assist businesses in reducing emissions, and offer an avenue for customers to take advantage of current incentives.[44] Charge Ready Transport has an approved budget of $342.6 million.[45] Though the program originally targeted 870 sites supporting 8,490 EVs procured or converted to electric, the site goal was reduced in 2023 in Resolution E-5257 to 500 sites.

Charge Ready Transport Program Design Goal

Accelerate the adoption of MDHD EVs by lowering the TCO for fleets, assisting businesses in reducing emissions, and offering an avenue for customers to take advantage of current incentives.

Through the Charge Ready Transport program, SCE covers the cost of most or all of the distribution charging infrastructure needed up to the first point of connection with a participant's charging stations. Participants can choose Utility ownership or customer ownership of BTM infrastructure. If SCE owns both the Utility-side and customer-side of the meter infrastructure, then SCE pays to design, construct, own, and maintain all infrastructure up to the EV charging stations. The participant will then pay to install, own, and maintain the charging stations. If the participant decides to own the BTM infrastructure, SCE will pay to design, construct, own, and maintain all TTM infrastructure, and the participant will pay to design, construct, own, and maintain all BTM infrastructure and receive a rebate for up to 80% of what it would have cost SCE to perform the BTM work or for the participant's actual installation costs, whichever amount is lower. Additional charger

Original Program Target

Achieve a minimum of 870 sites with 8,490 MDHD EVs procured or converted.

Revised Program Target

Achieve a minimum of 500 sites with 8,490 MDHD EVs procured or converted.

44 Southern California Edison. Accessed April 2022. "Charge Ready Transport Program."

45 This amount does not include the budget for the evaluation.

rebates are available for transit and school bus deployments and for fleets that are located in DACs and not operated by Fortune 1000 companies.

To participate in the Charge Ready Transport program, fleets must meet specific criteria. The program requires participating customers to lease, purchase, or convert at least two MDHD EVs. MDHD EVs include various categories of eligible vehicle and transportation equipment: airport GSE, forklift, heavy-duty vehicle, medium-duty vehicle, port cargo truck, school bus, transit bus, and TRU, among others. Program-eligible vehicles include commercial PHEVs approved by SCE for use in the outlined market sectors, on-road vehicles with a GVWR exceeding 8,500 pounds (Class 2b through Class 8), and non-road vehicles. Additionally, fleets must own or lease the property, operate and maintain the infrastructure for 10 years, provide monthly data related to EV usage for five years, and use approved vendors for the EVSE, among other requirements. Pursuant to the SB 350 Decision, the Charge Ready Transport program's infrastructure budget should spend a minimum of 15% for transit agencies, a maximum of 10% for forklifts, and a minimum of 25% for ports and warehouses in SCE's territory. A minimum of 40% of the infrastructure should result in installations in DACs in SCE's territory.

SCE offers EV-specific TOU rates to support commercial EV fleet customers (TOU-EV-7, TOU-EV-8, and TOU-EV-9), which include demand charge relief.[46] In Decision 22-08-001, SCE received approval for an extension of the demand charge holiday for TOU-EV-8 and TOU-EV-9. The specific charge paid by the customer includes a monthly fixed customer charge, an energy charge (per kilowatt-hour), and a demand charge, calculated using the highest recorded demand during each monthly billing period.

Implementation

Figure 35 details the key steps in the Charge Ready Transport program implementation process. SCE implemented several changes to improve the program in 2023, particularly to enhance program readiness ahead of application submission. As Figure 35 shows, SCE now conducts EV Readiness assessments for program applicants that may need additional support before applying. SCE has also added an environmental questionnaire to the application, so site planning can consider unique, site-specific designs and accessibility considerations.

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46 Southern California Edison. 2018. "Business Rate Basics: Rate Schedules TOU-EV-7, TOU-EV-8, TOU-EV-9 for Business Customers Charging Electric Vehicles." https://www.sce.com/sites/default/files/inline-files/TOU-EV-7_8_9_Rate_Fact_Sheet_WCAG.pdf

Figure 35. SCE Charge Ready Transport Program Implementation Process

EV READINESS AND FUNDING REQUEST

1. Customer expresses interest in the program to SCE
2. SCE coordinates with customer to determine EV readiness
3. SCE provides guidance as needed, including conducting an EV Readiness Study
4. If the customer expects to meet the port and vehicle program requirements, customer submits program enrollment applications and EV acquisition plans to SCE

RESERVE FUNDING

1. SCE screens and prioritizes applications
2. SCE conducts a site evaluation
3. SCE and customer develop conceptual infrastructure design
4. SCE conducts cost analysis to ensure that applications do not exceed cost thresholds
5. Parties sign program participation agreement

PRE-CONSTRUCTION COMMITMENTS

1. Customer provides proof of EV acquisition
2. Customer provides proof of charging equipment acquisition
3. SCE assigns rebate

DESIGN AND BUILD

1. SCE or customer performs detailed site design work
2. Customer grants final easement
3. SCE or customer requests and secures permits
4. SCE or customer constructs infrastructure
5. Customer installs charging equipment

ISSUE REBATES

1. SCE verifies charging equipment installation
2. SCE reviews documentation and issues rebates
3. Customer completes program survey

VERIFY COMPLIANCE

1. Customer completes planned EV acquisition
2. Customer complies with five-year port-level data sharing commitment
3. Customer complies with 10-year operation of charging equipment

Program Performance Metrics

The Evaluation Team reviewed the participating sites in SCE's Charge Ready Transport program and organized them by program status. Table 24 displays the number of sites in the program by completion status as of December 31, 2023.

Table 24. SCE Charge Ready Transport Program Complete Site Count by Status

Site Status	EY2023	Program to Date
Utility Construction Complete	23	65
Activated	16	55
Operational	15	54
Closed Out	13	29

In EY2023, SCE's Charge Ready Transport program received 46 additional applications, signed contracts with 50 sites, and activated 16 sites that supported 459 vehicles across five market sectors. This increased the total number of applications received to date by SCE's Charge Ready Transport program to 226 and the total number of contracts executed to date to 156.[47] As shown in Table 25, 75% of sites activated in 2023 (12 of 16) and 69% of activated sites to date (38 of 55) are located within a disadvantaged community (DAC).

Table 25. SCE Charge Ready Transport Program Activated Sites by Market Sector in EY2023 and Program to Date

Market Sector	EY2023		Program to Date	
	Number of Sites in DAC	Number of Sites in Non-DAC	Number of Sites in DAC	Number of Sites in Non-DAC
Heavy-Duty Vehicle	7	–	12	–
Medium-Duty Vehicle	1	–	1	4
School Bus	2	2	17	10
Transit Bus	1	1	5	2
TRU	1	1	3	1
Total	**12**	**4**	**38**	**17**

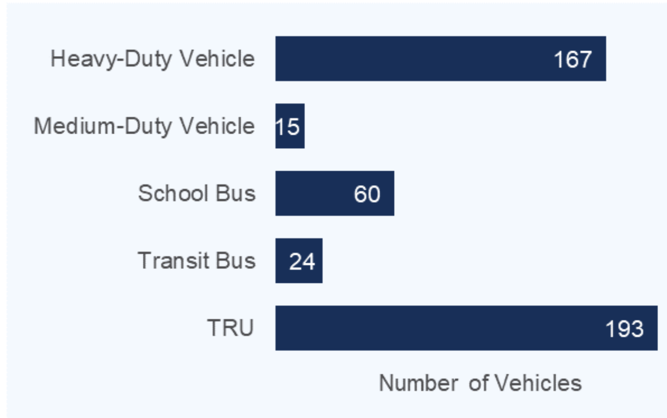
In EY2023, the highest participation rate in the SCE Charge Ready Transport program came from heavy-duty vehicles, which account for 44% of EY2023 activated sites. The school bus market sector accounted for the second most sites, with 25% of EY2023 activated sites, followed by the transit bus and TRU market sectors, each with 12% of EY2023 activated sites. The medium-duty vehicle market sector was the least represented sector, with one activated site in EY2023.

To date in SCE's Charge Ready Transport program, school bus fleets represent nearly 50% of all activated sites. Heavy-duty vehicle and transit bus sites are the next most common market sectors, accounting for 22% and 13% of activated sites to date, respectively, followed by the medium-duty vehicle market sector, which represents 9% of all activated sites. The TRU market sector accounts for 7% of activated sites to date and is the least represented in the program.

[47] The application and contract totals do not include applications that were withdrawn, rejected, or put on hold.

SCE installed charging infrastructure to support 459 MDHD vehicles across five market sectors in EY2023 based on 10-year VAPs submitted by customers at the time of application. This brings the total number of MDHD vehicles electrified in the Charge Ready Transport program to 1,206. As shown in Figure 36, the TRU market sector is the largest sector of MDHD vehicles electrified (193, or 42%) in EY2023, followed by heavy-duty vehicle (167, or 36%) and school bus fleets (60, or 13%). The least commonly electrified MDHD sectors in EY2023 are transit bus fleets (24, or 5%), and medium-duty vehicle sites (15, or 3%).

Figure 36. SCE Charge Ready Transport Program Vehicles Supported by Market Sector, EY2023 Sites



As shown in Table 26, by the end of EY2023, the SCE Charge Ready Transport program had 55 activated sites to support the electrification of 1,206 MDHD vehicles per customers' VAPs. The 156 contracts signed meet 31% of the program's *per se reasonableness* goal of 500 sites and could support 3,337 MDHD vehicles meeting 39% of the program's *per se reasonableness* goal of 8,490 additional vehicles electrified. The total 226 customer applications could satisfy approximately 45% of the program's site goal and would support more than 5,300 MDHD vehicles, which could satisfy 62% of the program's electrified vehicles goal.

Table 26. SCE Charge Ready Transport Program *Per se Reasonableness* Site and Vehicle Goal Progress

Program Metric	*Per se Reasonableness* Goal	Program to Date
Activated Sites	500	55
MDHD EVs	8,490	1,206

The 16 sites activated in EY2023 installed 430 charging ports to support the 459 electrified MDHD vehicles. L2 ports accounted for 216 of these, with 214 direct current fast charging (DCFC) ports making up the remainder. In SCE's Charge Ready Transport program to date, 1,019 L2 and DCFC ports have been installed at activated sites to support charging of 1,206 MDHD EVs, equating to roughly 1.2 vehicles per charging port.

The CPUC established six phases in the program timeline per the SB 350 reporting template. As presented in Table 27, at the end of 2023 more than half (52%) customer applications were either in the Activation or the Design and Permitting phase. Of the remaining applications, the majority were in the Site Assessment and Contract Issuance phases. Roughly equal numbers of applications were in the Application Review and Construction Complete phases of the program.

Table 27. SCE Charge Ready Transport Program Sites, Vehicles, and Ports by Program Phase, as of December 31, 2023

CPUC Program Phase	Number of Sites	Total Number of EVs Supported	Total Number of Ports
Application Review	19	571	135
Site Assessment	40	1,785	953
Contract Issuance	29	867	434
Design and Permitting	62	1,687	1,016
Construction Complete	20	498	363
Activation	55	1,206	1,019

Table 28 shows the median durations per program phase (measured in calendar days) for EY2023 and PTD activated sites. The column labeled EY2023 refers to sites activated in 2023. The Program to Date column refers to all sites activated from the initiation of the program through December 31, 2023.

Values in Table 28 provide insight into program phase length trends over time. Note that sites in each column did not necessarily pass through each phase in the same calendar year. For example, EY2023 activated sites may have passed through Contract Issuance in 2021 while others passed through in 2022 or 2023. Across all program phases, Contract Issuance and Activation have the shortest median durations, while Design and Permitting has the longest median duration.

Table 28. SCE Charge Ready Transport Program Median Calendar Days per Phase for EY2023 and PTD Sites

CPUC Program Phase	Median Calendar Days	
	EY2023	Program to Date
Application Review	96	75
Site Assessment	40	35
Contract Issuance	43	20
Design and Permitting	293	215
Construction Complete	129	133
Activation	20	33

Median durations vary by market sector. For instance, for heavy-duty vehicle sites activated in EY2023, the median calendar days for Design and Permitting was 222 days; however, transit bus applications took a median of 558 days to pass through this program phase. Overall, the median durations per program phase in EY2023 were similar to their PTD counterparts.

Figure 37 expands the analysis of program phase duration by displaying the average number of calendar days per phase (denoted by X), calendar day median (middle line inside box), first quartile (bottom of box), third quartile (top of box), minimum (bottom tail), maximum (top tail), and outliers (dots). Program applications experienced the most variation in completion time within the Design and Permitting phase, which involves an external review and substantial back-and-forth with applicants to finalize site layout, design, easements, and conveyances, if required. This was followed by Construction Complete, which requires coordination among contractors and supply chain vendors. Application Review also had a high degree of variation in completion time, most likely a result of the amount of communication program administrators had with customers to solidify the site scope and ensure that they had completed the required documentation. Customer applications in the Site Assessment and Contract Issuance phases experienced the lowest mean and variance in calendar days among all the program phases, despite a few outliers.

Figure 37. SCE Charge Ready Transport Program Calendar Days per Phase for EY2023 Sites

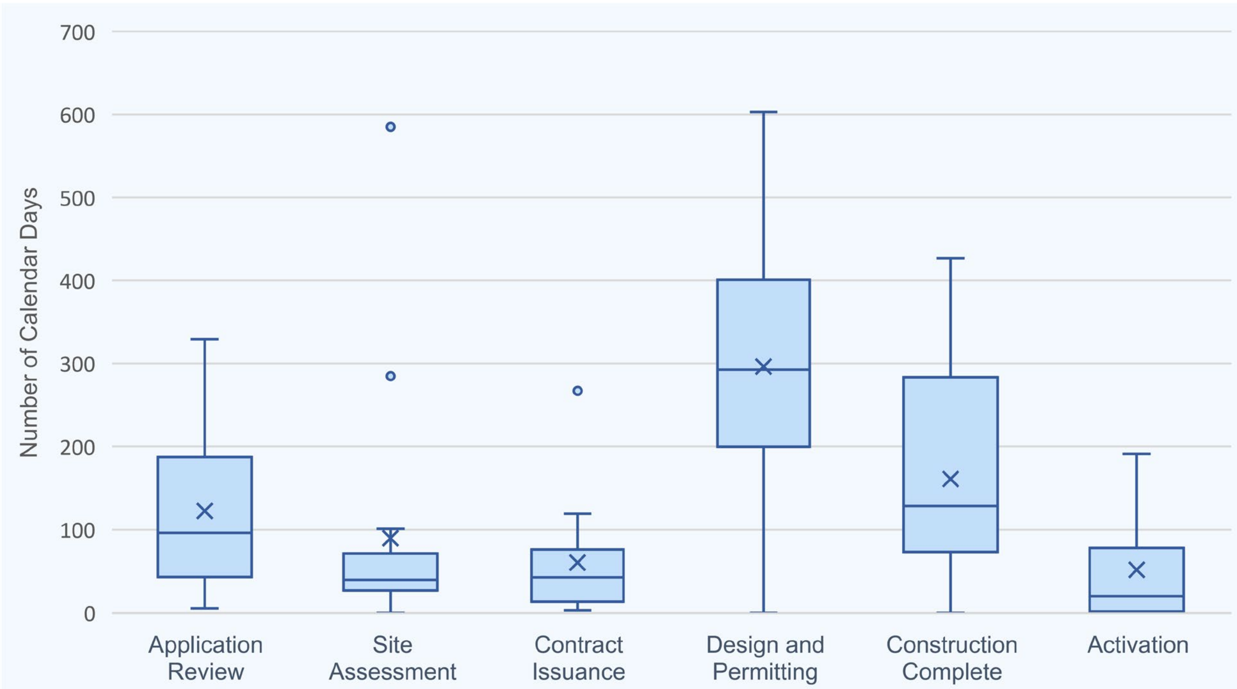


Table 29 displays the median number of calendar days that Charge Ready Transport program participants took from program start to finish (Application Review to Activation) for 16 activated sites across five market sectors in EY2023 and the median for the program to date. The overall median start-to-finish timeline for site activation for EY2023 sites was 960 calendar days, up 119 days from the median in EY2022 (841 days) which was also an increase from EY2021 (669 days). As displayed in Table 29, median start-to-finish durations varied widely across market sectors from two years (728 days) to nearly four years (1,440 days) in EY2023. The 55 activated sites to date had an overall median start-to-activation duration of 728 days, ranging from 666 calendar days for school bus applications to 919 days for TRU applications.

Table 29. SCE Charge Ready Transport Program Median Duration for Site Activation by Market Sector for EY2023 and PTD Sites

Market Sector	EY2023		Program to Date	
	Median Duration Start-to-Finish (Calendar Days)	Number of Activated Sites	Median Duration Start-to-Finish (Calendar Days)	Number of Activated Sites
Heavy-Duty Vehicle	852	7	709	12
Medium-Duty Vehicle	728	1	728	5
School Bus	800	4	666	27
Transit Bus	1,440	2	863	7
TRU	1,073	2	919	4
All Market Sectors	**960**	**16**	**728**	**55**

Program Materials Summary

This section highlights findings from the review of program materials and marketing, education, and outreach (ME&O) activities SCE conducted in 2023. Throughout 2023, SCE staff sent 25 separate email blasts to potential participants through multiple campaigns that not only promoted the program (such as through highlighting successful sites) or upcoming webinars, but also provided educational tips and resources on key TE topics such as state regulations and grid preparation. In addition to these traditional marketing efforts, SCE staff conducted outreach, education, and support for Charge Ready Transport program customers through multiple marketing strategies to expand outreach in 2023:

- **Industry Working Groups/Webinars.** The program staff hosted industry working groups in February, June, and September 2023 to discuss the impact of new regulations on fleets and program offerings. The webinars provided specific updates on grid preparation for EV adoption and highlighted the importance of a separate EV meter for sites. For example, one session focused on SCE's Power Site Search tool, a GIS tool that provides public access to SCE distribution circuits and substations to help customers understand what infrastructure is available and what might need to be upgraded before EV chargers can be installed.
- **Ride and Drive Events.** In March 2023, SCE staff held Ride and Drive events to engage potential participants in a hands-on, interactive experience with EVs. Through partnership with 24 other organizations such as EV manufacturers, previous participants, and other EV stakeholders, this event was an opportunity for interested customers to both experience driving MDHD EVs and learn more about the technology and funding opportunities.
- **Grant Writing and Grant Package Review Assistance.** Starting in 2022, through the Transportation Electrification Advisory Services (TEAS) program, SCE began providing grant writing assistance virtually and grant package review support to help small and mid-sized fleets access funding for purchasing electric MDHD vehicles (SCE also provides grant package review services for large fleet customers as needed). Staff expanded this offering in 2023 with the addition of SCE's first in-person grant writing assistance event. Staff noted that the grant assistance has helped fleet owners understand the eligibility and compliance requirements for the various grant funding opportunities to avoid confusion down the road about compliance issues such scrappage requirements for

conventional vehicles being replaced. SCE's TEAS website advertises its grant writing webinars for fleets, grant writing assistance program, and grant package review assistance service.

- **Help Navigating EV Funding Opportunities.** In addition to grant writing assistance, through TEAS, SCE staff continued to provide outreach, education, and information on other EV funding nuances and opportunities such as rebates, tax incentives, and stackable incentives via fact sheets, case studies (Figure 38), and webinars on EV topics. Overall, SCE staff hosted or participated in 55 events in 2023, reaching an estimated average of 700 people per month.

Figure 38. SCE Charge Ready Transport Program One-Page Case Study Example (Prologis)

EDISON

Case Study: Prologis, Southern California

CHARGE READY TRANSPORT: SCE AND PROLOGIS PARTNER TO ELECTRIFY FREIGHT OPERATIONS

Prologis supports Performance Team's Electric Vehicle Growth

Prologis is a leader in logistics real estate headquartered in San Francisco, California, with global operations in 19 countries. Prologis owns 5,495 warehouse locations from which medium- and heavy-duty fleets operate. As a result, Prologis has a significant opportunity to assist the logistics industry in electrifying truck fleets by outfitting its properties with the necessary infrastructure.

In 2022, Prologis' Mobility Team installed Electric Vehicle (EV) charging at two distribution centers that are leased by Performance Team, a national logistics company that operates third-party distribution, short-haul inland transportation, and logistics programs for customers. These charging sites, located in Santa Fe Springs (a non-Prologis-owned logistics facility) and at the City of Commerce Transport Center (a Prologis-owned logistics facility), currently power 38 Volvo VNR Electric Class 8 battery-electric trucks that perform short-haul inland transportation.

One of the largest barriers to heavy-duty electric vehicle (EV) adoption is access to real-time insights on vehicle status, location, charging ecosystem, and energy management opportunities. Prologis provides a Mobility Software suite that ensures their fleet customers can seamlessly integrate e-mobility into their existing operations. In the case of Performance Team, this software allows an electric fleet to operate two shifts per day, in some cases logging 20 hours on the road, which is an extreme use case for heavy-duty EVs. In addition, the implementation of this solution ensures that the customer is fully able to realize all the benefits of zero-emission transportation, associated technology, and overall system optimization.

Prologis Mobility: Future Sustainable Operations

Prologis Mobility was launched in 2021 to help its customers make the transition to alternative fuel trucks, including EVs. The program supports Prologis' commitment to reach net zero across its value stream (scope 1, 2, and 3 emissions) by 2040. Prologis' investment in charging infrastructure provides commercial fleets with access to a low-risk turnkey solution and assists customers with permitting, utility relationships, design, and installation coordination as well as providing software to manage the fleets.

SCE Provides Critical Support

Southern California Edison (SCE) supported Prologis Mobility through the Charge Ready Transport (CRT) program, which provided design, installation, and funding support to both projects. The CRT program reduced Prologis' costs for the construction and installation of electrical panels, conduit and trenching, and the necessary transformer upgrades. Prologis Mobility reported that, *"The SCE team was very responsive, and once we were able to build understanding around goals and working within the confines of the program, [they were] extremely helpful."*

The Prologis Mobility team also stated that the CRT program benefits were "extremely valuable" as they enabled the delivery of a dedicated EV service within Performance Team's required timeline and allowed Prologis to mitigate costly risks like temporary power outages and interruptions to customer operations.

Prologis recommends that other facility and fleet owners transitioning to electric technology begin the infrastructure planning early and connect with their utility more than 12 months before they expect to break ground. The company also suggests that fleet operators evaluate the duty cycle of their planned electric vehicles to understand the total demand and cost of electricity. This evaluation will uncover opportunities to manage risks through solar, storage, and energy management. Prologis recommends fleet operators work with a trusted third-party provider to acquire and manage charging infrastructure on an as-a-service basis to reduce risk and costs.

Key Takeaways

- Short-haul inland transportation is well suited to be performed by today's EV trucks.
- SCE's Charge Ready Transport (CRT) program provides design, installation, and financial support to fleet operators' EV charging infrastructure projects. The CRT program also offers rebates on charging stations to its fleet customers.
- Third-party providers, like Prologis, can offer fleet owners a simplified, low-risk opportunity to transition to electric vehicles without owning or operating the charging infrastructure

Logistics companies can follow the lead of Prologis through SCE's Charge Ready Transport program. Under the program, SCE builds out charging infrastructure for customers deploying two or more electric vehicle trucks, buses, or other medium or heavy-duty vehicles. Learn more at **www.sce.com/crt**.

sce.com/CRT

Figure 38 shows a case study of a 2023 activated SCE Charge Ready Transport program site. The Prologis Case Study, which was distributed via email, highlights how participating in programs like Charge Ready Transport can change the charging ecosystem for warehouse locations where heavy-duty vehicle fleets operate.

Budget Summary

As shown in Figure 39, from program inception in 2019 through December 31, 2023, SCE spent $34.8 million[48] of $342.6 million (constant dollars) of the approved Charge Ready Transport program budget. In 2023, program spending was $12.8 million.

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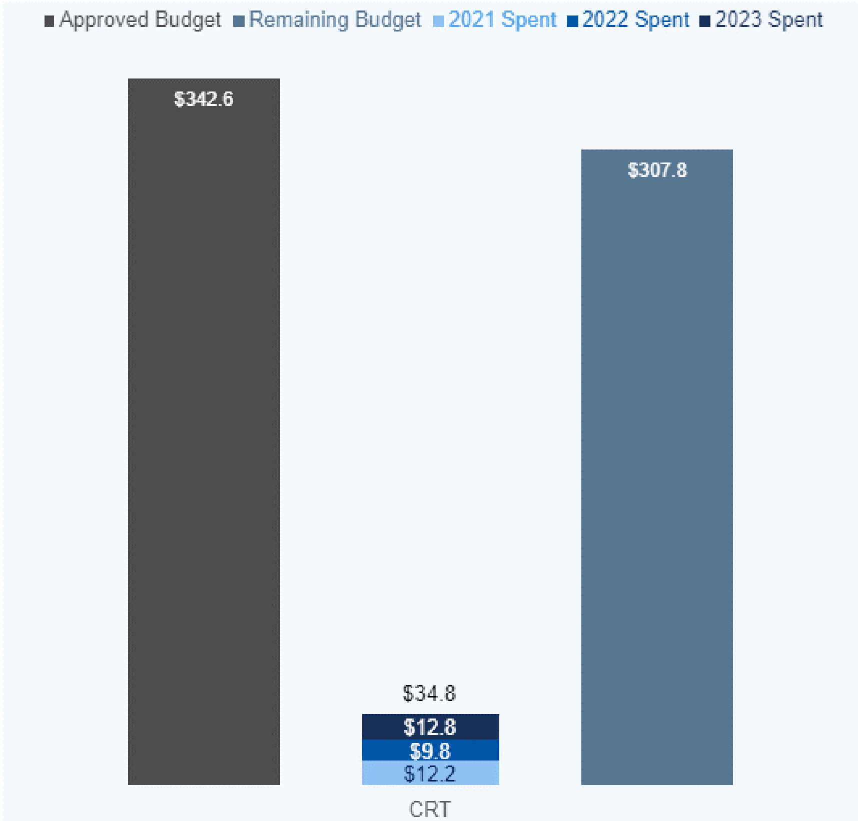
48 This amount accounts for sites that have been fully financially closed out and for administration and marketing costs incurred through the end of 2023. Costs are considered spent/recorded as incurred after a site is fully complete and invoiced, including the payment of rebates that require the customer to submit paperwork.

Figure 39. SCE Charge Ready Transport Program Spend Compared to Program Budget (Million USD) as of December 31, 2023

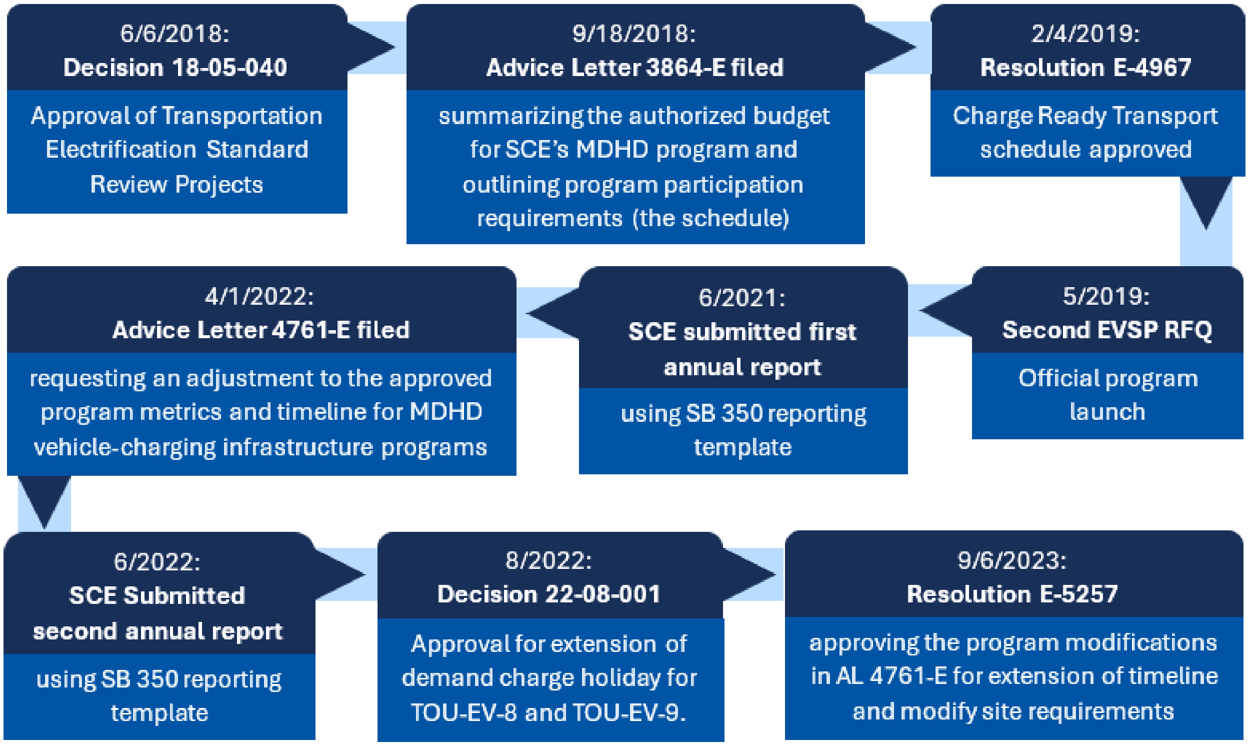


Timeline

Since the beginning of the program SCE has filed two Advice Letters. In 2022, SCE filed AL 4761 jointly with PG&E, requesting to adjust some program metrics and timeline. Specifically, AL 4761 requested an adjustment in site count from 800 to a range between 470 and 870 sites, an extension of the program timeline, and a modification of the vehicle purchase or conversion requirements for public charging sites for MDHD vehicles. In August 2023, Resolution E-5257 approved the site count adjustment to a minimum of 500 sites and granted the program extension but denied the request to modify vehicle purchase or conversion requirements for public charging sites for MDHD vehicles.

Figure 40 shows all major milestones since the beginning of the program.

Figure 40. SCE Charge Ready Transport Program Key Milestones



4.1.2. Findings

The following sections provide findings from the Utility staff interviews, as well as from surveys, site visits, and deep dive sites. The Evaluation Team also provides insights from the co-benefits and co-costs analysis, site costs, as well as the grid impacts, petroleum displacement, GHG and criteria pollutant reductions, health, and net impacts.

Table 30 summarizes key impact parameters for EY2023 sites as well as for the program to date. Annual estimates of impacts are provided for metrics calculated as part of the impact evaluation. Additionally, the table provides estimates of impacts across all sites included in the program population through the end of 2023.

Table 30. SCE Charge Ready Transport Program Impacts Summary

Impact Parameter	EY2021 Sites[a]	EY2022 Sites[a]	EY2023 Sites[a]	EY2023 Sites Percentage in DAC	PTD Sites Actual	PTD Sites Actual Percentage in DAC
Population of Activated Sites (#)	24	15	16	75%	55	69%
Sites Included in Analysis (#)	16	15	15	80%	54	70%
Ports Installed in Analyzed Sites (#)	63	432	420	74%	1,009	77%
EVs Supported (#) [b]	184	456	449	73%	1,206	73%
Electric Energy Consumption (MWh)	1,029	2,432	13,874	88%	17,742	69%
Petroleum Displacement (DGE)	99,699	208,972	937,186	84%	1,527,157	64%

Impact Parameter	EY2021 Sites[a]	EY2022 Sites[a]	EY2023 Sites[a]	EY2023 Sites Percentage in DAC	PTD Sites Actual	PTD Sites Actual Percentage in DAC
GHG Emission Reduction (MT GHG) [c]	723	1,739	7,246	84%	11,497	66%
NO_x Reduction (kg)	278	2,114	8,336	97%	9,362	98%
PM_{10} Reduction (kg)	1.32	16.0	75.6	96%	83.8	91%
$PM_{2.5}$ Reduction (kg)	1.25	14.9	72.2	96%	79.0	91%
ROG Reduction (kg)	14.2	656	289	93%	2,300.1	95%
CO Reduction (kg)	7,055	36,191	5,166	54%	77,533.2	49%

[a] Energy consumption, petroleum displacement, and emissions reductions are based on annualized data. PTD results in the table are based on actual data (see *Appendix A* for more details).

[b] The Evaluation Team derived the EVs supported value from applicants' VAPs. This value represents the maximum number of vehicles expected to be supported by the charging infrastructure.

[c] GHGs include CO_2, CH_4, and N_2O multiplied by their respective GWPs as defined by IPCC AR5 (see *Appendix A* for more details).

Utility Staff Insights

In addition to monthly check-in calls with key SCE staff to discuss the status of the Charge Ready Transport program, the Evaluation Team conducted a close-out interview with staff in February 2024 to review overall Program challenges and successes in 2023. Staff identified several program challenges:

- **Vehicle Procurement Costs.** The cost of EV procurement is significant and continues to be one of the largest factors in a customer's decision to electrify their fleet. Specifically, staff said MDHD EVs continue to have higher up-front costs than comparable diesel, gasoline, and natural gas vehicles. Since the Charge Ready Transport program requires program participants to demonstrate a commitment to acquiring vehicles, fleets lacking capital cannot participate. Furthermore, staff indicated that inflation in 2023 is a key concern among customers.
- **Site Construction Costs and Delays.** As in prior evaluation years, SCE staff continue to report site construction costs are higher than anticipated than in the original decision due to several factors such as labor constraints, material costs, supply chain delays and shortages (which were prominent for switchgears in particular), and lengthy wait times for permits and easements to be processed. Additionally, staff noted that inflation has increased labor and equipment costs higher than average years in 2023. The program's original target cost thresholds were determined in 2018, which means higher-than-expected costs may reduce the number of potentially eligible sites. SCE staff expect to adjust cost thresholds in 2024 to better align with market conditions and the program *per se reasonableness* criteria from the Decision.
- **Legislation and Compliance.** Staff note that legislation plays a large role in driving the EV market. Without clarity on regulation enforcement timing, SCE is not able to adequately prepare for changes and respond to the current EV market. In 2023, this impacted the program in two key ways:
  - *Uncertainty around potential interest***.** While program staff anticipate an influx in applications once new regulations go into effect, there is uncertainty surrounding if and when new

regulations, such as ACF[49] will be enforced. Some potential applicants have stated that they are delaying their electrification plans until regulations like ACF are enforced.

  - *Changes mid-implementation*. Program staff confirmed with the CPUC in 2023 that the program is held to International Organization for Standardization (ISO)-15118, which outlines standards for communication between EVs and charging stations. Specifically, staff noted that ISO-15118 requires interoperability between different EVs and charging systems. These standards were designed to enable smart charging capabilities between EVs, EVSE, and the grid to support VGI. This new requirement, which was not part of the original decision approving the program, has several implications. First, staff must determine what noncompliance means for sites that were completed during the compliance period and what, if any, corrective action needs to be taken. Second, staff are concerned about potential ongoing effects of compliance, such as limited customer choice of equipment options available, which may reduce participation and impact progress towards achievement of program goals.

- **Ownership Model Preferences.** SCE staff observed in 2023 that customers are often interested in either owning their own infrastructure or assessing the feasibility of using existing public infrastructure to support their electrification. In the evolving market, the program's offering of utility-owned infrastructure may become less compelling, while interest in trusted, in-depth guidance in EV readiness from utilities to customers increases. To meet this need, SCE has developed other educational programs such as TEAS to support its customers and has added EV Readiness steps ahead of the Charge Ready Transport program application process as noted in the successes detailed below.

SCE staff also reported notable successes in 2023:

- **Strategic Partnerships.** In 2023, staff adjusted the outreach process to put more focus on identifying organizations that fleets trust for electrification information. SCE staff prioritized partnering with those organizations, such as dealers that sell vehicles, to get in front of customers that are near-term prospects for electrification. Through this strategic outreach in 2023, SCE staff found that raising awareness of the program beyond targeted customers can help create connections to potential participants who are ready to adopt EVs.
- **Ensuring Customer Readiness and Education.** SCE staff, particularly the business development team, took additional efforts to prepare fleet customers for electrification. In 2023, the business development team hosted meetings with potential participants in the year leading up to their application submissions. Ultimately, this allows SCE to reduce time spent in each phase of the application process by helping customers do much of the work up front for draft site plans, connections, cost analyses, and charging equipment selections. SCE focuses on pre-pipeline decisions to move the application process more quickly, such as making sure all charging equipment is finalized before filing an application. By focusing on up-front education and decision-making, SCE

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49 The ACF Regulation from the California Air Resources Board (CARB) is designed to accelerate zero-emissions technology with targeted policies such as manufacturer sales mandates and purchase mandates for high-priority fleets.

staff have seen an increase in quality applicants, and more sites are going into agreement and construction than in previous program years.

- **Process Design Enhancements.** SCE staff implemented changes to improve the program processes in 2023. The application process now has an environmental questionnaire to anticipate barriers at an early stage of the application process as part of the initial high-level review of the site. SCE also assigned staff to a procurement team to preempt material shortages causing bottlenecks in program implementation, such as switchgear delays, to help alleviate the impact of these long lead times on upcoming sites. With these process adjustments, SCE staff expect to identify cost-effective sites and execute sites with less delay than in previous program years.

Highlights

- Site development costs are higher on average compared to the original per site target cost thresholds estimated at the inception of the program.
- Program staff continue to implement changes to improve program processes, such as including an environmental questionnaire as part of the initial high-level review of the site, explaining to customers that no redlines or changes are accepted on the Participation Agreement or easements,[50] assigning staff to preempt material shortages causing bottlenecks in program implementation such as switchgear delays in previous years, and focusing on up-front education and decision-making to increase quality applicants.
- SCE is strengthening strategic partnerships to expand and diversify the program's participating customer base.
- Policy uncertainty continues to impact utility planning, program participation, and customer choices in the EV market.

Survey Results

The Evaluation Team surveyed fleet managers who participated in the Charge Ready Transport program about their motivations for and barriers to electrification, satisfaction with and awareness of the program, experience with EVs and charging infrastructure, views about the impact of the program on fleet electrification, and perspective on the industry. Table 31 shows the distribution of responding fleet managers by sector.

Table 31. SCE Charge Ready Transport Program Fleet Manager Survey Sample for EY2023 Sites

Survey Type	Sector	Number of Surveys Sent	Number of Partial Surveys	Number of Completed Surveys
Participating Fleet Managers	Heavy-Duty Vehicle	4	–	1
	Medium-Duty Vehicle	1	–	–
	School Bus	7	1	3
	Transit Bus	2	1	–

[50] SCE requires participants to share easement language with the property owner to avoid problems during the construction requirements phase when the easements are distributed for approval.

Survey Type	Sector	Number of Surveys Sent	Number of Partial Surveys	Number of Completed Surveys
	TRU	2	–	1
Total Fleet Manager Participants	–	**16**	**2**	**5**
Withdrawn Fleet Managers	–	25[a]	–	–

In some cases, the number of responses to a question is greater or less than five (the number of completed surveys). This is due to the inclusion of partial participants (those who answered some questions but did not complete the survey) and cases where not all respondents answered a question.

[a] Two emails were returned as undeliverable from the original sample (27).

Despite the Evaluation Team's efforts to improve the response rate through multiple rounds of outreach and the available survey incentives, the fleet manager survey did not reach the target response number, which limits the insights that can be gleaned from a smaller sample size. In addition, although the evaluation team attempted to complete surveys with fleet managers who withdrew from the program (known as withdrawn fleet managers), none of the contacts responded to the multiple survey requests.

Electrification Motivators and Barriers

The Evaluation Team asked fleet managers about their motivations for transitioning to EVs. As shown in Figure 41, six of seven managers mentioned rebates and incentives for EVs and EV charging infrastructure, while five mentioned environmental benefits and four mentioned expected fuel cost savings. One school bus fleet manager expanded by stating they were motivated by "Student, driver, and community health and welfare benefits."

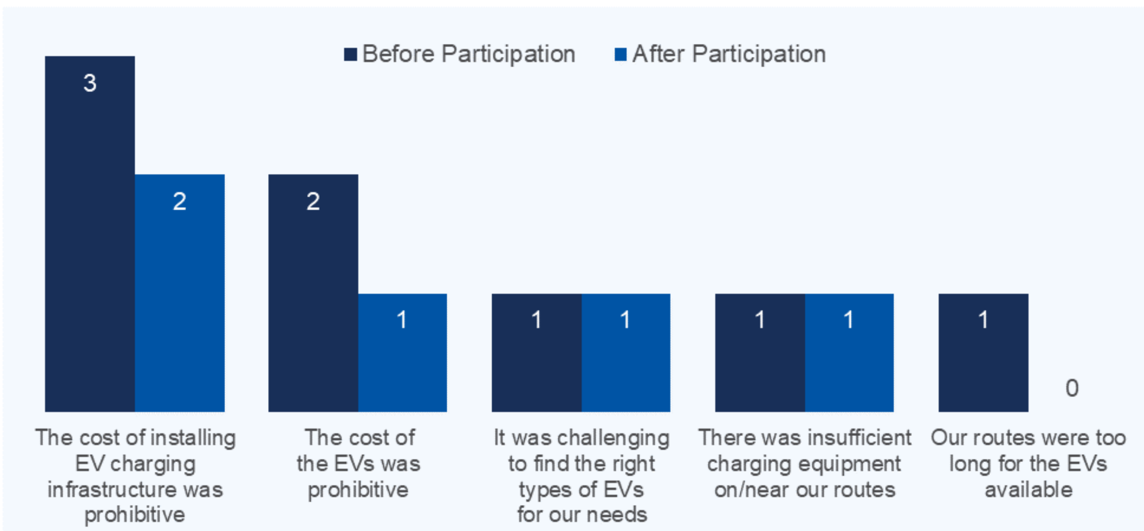
Figure 41. SCE Charge Ready Transport Program Participant Motivators for Transitioning to EVs in EY2023

Source: Fleet Manager Survey Question C1. "Why did your fleet decide to transition to EVs? Select all that apply." (n=7; multiple responses allowed)

The Evaluation Team asked fleet managers which barriers to electrification their fleets faced before participation in the Charge Ready Transport program and which remained after participation. As shown in Figure 42, three fleet managers (two school bus sites and one TRU site) said the top barrier prior to electrification was the cost of installing EV charging infrastructure, with the cost of EVs as the second most common response (two school bus fleet managers).

The largest remaining barrier reported by fleet managers after participating in the program continued to be the cost of installing EV charging infrastructure (one school bus site and one TRU site). Respondents also cited the cost of EVs (one school bus site), finding the right types of EVs for participant needs (one heavy-duty vehicle site), and insufficient charging equipment on or near participant routes (one school bus site) as remaining barriers.

Figure 42. SCE Charge Ready Transport Program Barriers to Electrification Before and After Program Participation in EY2023



Source: Fleet Manager Survey Questions F3 and F4. "Which of the following barriers to electrification did your fleet face before participating in the Charge Ready Transport program?" (n=7; multiple responses allowed) and "You mentioned that the following were barriers to electrification before participating in the Charge Ready Transport program. Do any of these barriers still exist after you participated in the program?" (n=7; multiple responses allowed) Note: No respondents provided a rating of "Finding qualified drivers or "maintenance technicians for EVs."

Program Satisfaction

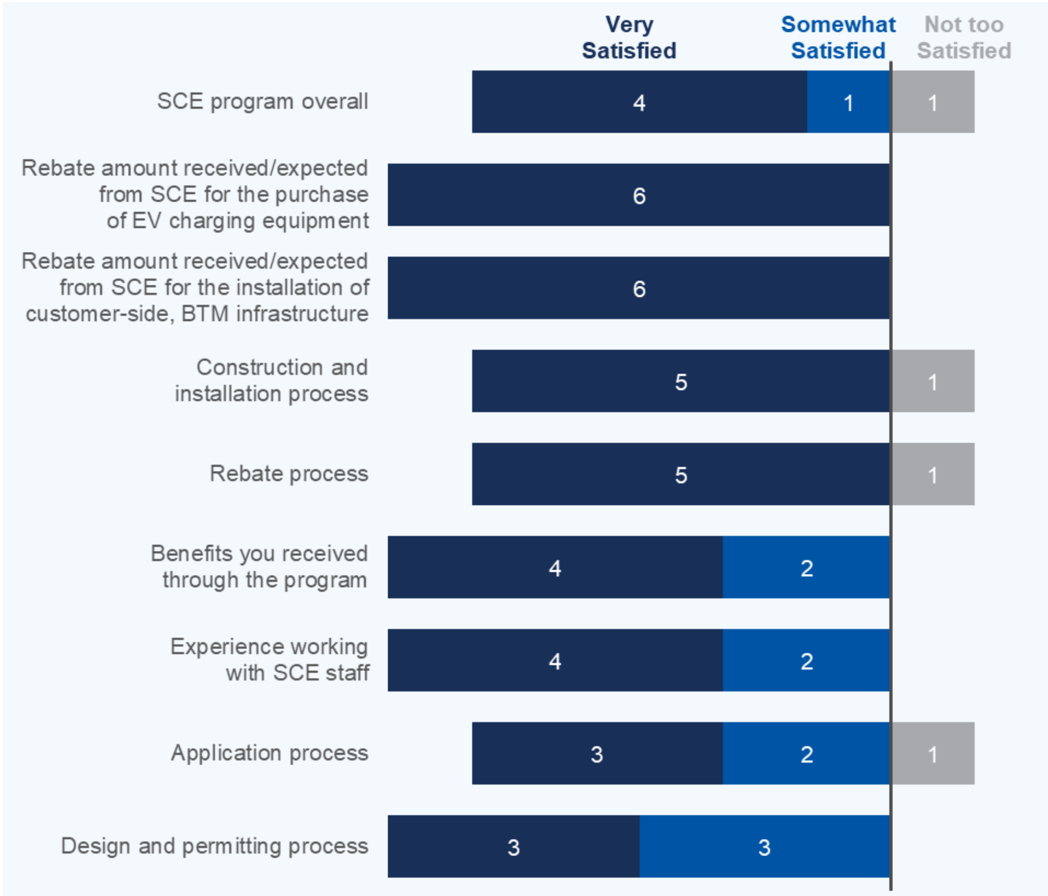
When asked to rank the likelihood of recommending the Charge Ready Transport program on a scale of 0 to 10, with 10 meaning they had already recommended the program, five of six fleet managers indicated they had already recommended the program. One fleet manager indicated a 7 out of 10 likelihood. Together, these ratings led to a net promoter score (NPS) of +83.[51]

As shown in Figure 43, four fleet managers rated themselves as *very satisfied* with the program overall (two school bus, one heavy-duty vehicle, and one TRU fleet manager), one chose *somewhat satisfied* (school bus), and one gave a rating of *not too satisfied* (school bus) (n=6). The later respondent also rated their experience with the rebate and application process as *not too satisfied*. For comparison, in EY2022 four of four fleet managers rated their overall program experience as *very satisfied* (three school bus and one medium-duty vehicle fleet manager). All six responding fleet managers were pleased with the rebate amount for the purchase of EV charging equipment, and rebate amount for installation of

[51] The Evaluation Team calculated the NPS by subtracting program detractors (those who rated their likelihood to recommend the program to others as a 0 through 6) from the program promoters (those who rated their likelihood to recommend the program as a 9 or 10). The fleet manager who gave a rating of 7 is labeled as passive, and their rating did not impact the score.

customer side, BTM infrastructure. The rebate process and the construction and installation process also earned high satisfaction ratings (five respondents).

Figure 43. SCE Charge Ready Transport Program Satisfaction with Program Elements in EY2023



Source: Fleet Manager Survey Question B1. "Thinking about your experience with the Charge Ready Transport program, how satisfied are you with the following?" (n=6)
Note: No respondents provided a rating of *not at all satisfied* for any element.

When asked about aspects of the program they were particularly satisfied with, four fleet managers provided the following comments:

- "The user-friendly portal, **support staff** and the whole project was great." (School bus sector)
- "Providing customer and SCE build options is fantastic. **Financial infrastructure assistance**…is essential to transitioning to electric school buses. **The knowledge from SCE** was…much needed throughout the project." (School bus sector)
- "**The people we worked with** did what they could to make it as easy as possible for our team on site to continue their daily operations. Everything was communicated well and understood." (Heavy-duty vehicle sector)
- "The administration process to participate in the program was very easy, and **the SCE team** guiding the project were great to work with." (TRU sector)

When asked about aspects of the program fleet managers were particularly dissatisfied with, two fleet managers provided the following comments:

- "The **application process is and continues to be slow**, clunky, and much more difficult than it needs to be. Throughout my project there were numerous personnel changes and as a result **miscommunications** and frustrations with the project. One project manager should be assigned to each project, be involved more frequently, and focus on the customer's needs as the project moves through completion." (School bus sector fleet manager who rated their experience with the program overall as *not too satisfied*)
- "The charging station options for the TRUs…only work with electric standby trailers currently. **Technology** on fully electric trailers was **not compatible**…In addition, the final inspection process to close the project out **could have been coordinated better**…Possibly, an end of construction meeting or document with to-dos." (TRU sector)

Two fleet managers shared what they would have done differently if they were to go through the program again. One of these fleet managers responded that they would have installed more fast chargers, and the other said they would have incorporated a microgrid with additional solar and a backup battery with the capability to charge buses up to 48 hours in the event of a blackout.

Program Awareness

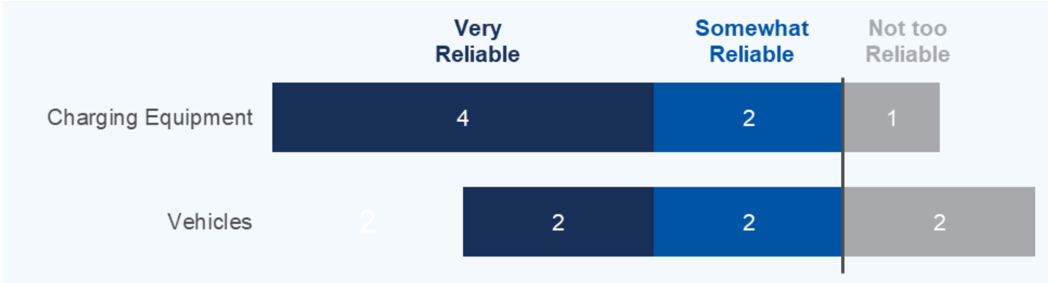
The Evaluation Team asked fleet managers how they learned about the Charge Ready Transport program. Four of six fleet managers learned about the program from SCE, while two learned about it from an EV manufacturer or an EVSE manufacturer. Prior to joining the program, three of the six fleet managers did not know that they needed to upgrade the electrical infrastructure from the Utility grid to their meter to charge EVs at their site; the remaining three fleet managers understood what was needed.

Experience with EVs and Charging Infrastructure

When asked to rate the reliability and ease of using EVs and EV charging equipment, two fleet managers reported finding the EVs *very reliable*, and four found the EV charging equipment *very reliable*. As shown in Figure 44, two fleet managers each found the EVs and EV charging equipment *somewhat reliable*, and two rated the EVs and one rating the EV charging equipment as *not too reliable*.

Additionally, six of six fleet managers rated the charging equipment as *very easy to use*.

Figure 44. SCE Charge Ready Transport Program Reliability of Vehicles and Charging Equipment in EY2023



Source: Fleet Manager Survey Questions C3 and C4. "How would you rate the reliability of the electric vehicles that are part of your fleet?" (n=6) and "How would you rate the reliability of the electric vehicle charging equipment?" (n=7)
Note: No respondents provided a rating of not at all reliable.

Impact of Program on Fleet Electrification

When asked if they plan to accelerate the procurement of EVs and EV-related equipment because of their experience with the program, four fleet managers said their rate of procurement would remain unchanged. However, three fleet managers said they have plans to accelerate procurement. When asked what aspects of the program have impacted their decision, one responded that regulations and their company's sustainability goals are driving acceleration, and the other cited the initial funding assistance and developing partnership.

Table 32 shows the number and type of EVs fleet managers plan to acquire in 5 and 10 years by sector.

Table 32. SCE Charge Ready Transport Program EV Acquisition Projection by Vehicle Type in EY2023

Respondent and Market Sector	Current EV Fleet Size	EV Type								
		School Bus 5 yrs.	Med-Duty 5 yrs.	Heavy-Duty 5 yrs.	Other: Refrig Trailers[a] 5 yrs.	School Bus 10 yrs.	Med-Duty 10 yrs.	Heavy-Duty 10 yrs.	Forklift 10 yrs.	Other: Refrig Trailers* 10 yrs.
School Bus	19	–	5	1	–	–	10	1	1	–
School Bus	11	1	–	–	–	1	–	–	–	–
School Bus	42	75	–	–	–	–	–	–	–	–
School Bus	12	5	–	–	–	5	–	–	–	–
Heavy-Duty Vehicle	2	–	–	3	–	–	–	6	–	–
TRU	–	–	–	3	102	–	–	7	–	32
Total	**–**	**81**	**5**	**7**	**102**	**6**	**10**	**14**	**1**	**32**

Source: Fleet Manager Survey Question A3. "Please specify the number of electric vehicles/equipment that you plan to acquire in the next 5 years and in the next 10 years." (n=6)
[a]Electric standby, not fully electric

When asked how participating in the program changed the number of EVs they planned to acquire, three fleet managers provided the following comments:

- "This program played an important role in transitioning our school bus fleet to electric. The **partnership with SCE was critical**…The feedback and suggestions that we have received…has been appreciated and assisted us successfully transitioning nearly half of our school bus fleet to zero emission! We replaced all our 46 diesel powered school buses with electric and now have an entire fleet of near zero to zero-emission buses…This has been a project that took four years from conception to a successful working model." (School bus sector)
- "We have 102 new refrigerated trailers coming…equipped with Carrier 8700 systems, and electric standby. While not fully electric…this **will allow for fully electric use** while idle on site. We are currently in talks with vendors to test fully electric TRUs and fully electric yard trucks." (TRU sector)

Industry Perspective

The Evaluation Team asked fleet managers how well their industry or sector is positioned for electrification. As shown in Table 33, the five responding fleet managers each had a different perspective of their industry, and four provided comments with insights about their response, with a focus on technology constraints:

- One heavy-duty vehicle fleet manager selected *somewhat well-positioned* and said, "We are **just starting out with electrifying** some of the larger gear that is now available in electric power. More and more will happen as technology adjusts."
- One school bus fleet manager selected *somewhat well-positioned* and said "More effort needs to be placed on **equipment compatibility** in the school bus sector. There are chargers that are not compatible with certain school buses and that is going to be a big challenge to overcome as more electric buses are put in service."
- Another school bus fleet manager selected *not too well-positioned* and said, "**Range** is a huge concern as well as limited or **nonexistent commercial charging** in the public."
- One TRU fleet manager who responded *not too well-positioned* cited **cost and technology** as reasons for their response.

Table 33. SCE Charge Ready Transport Program Industry Positioning for Electrification among Program Participants in EY2023

Market Sector	*Extremely Well-Positioned*	*Somewhat Well-Positioned*	*Neutral*	*Not Too Well-Positioned*	*Not at All Well-Positioned*
Heavy-Duty Vehicle (n=1)	–	1	–	–	–
School Bus (n=3)	–	1	–	2	–
TRU (n=1)	–	–	–	1	–

Source: Fleet Manager Survey Question F1. "How well-positioned do you think your industry/sector is for electrification?" (n=5) No respondents provided a rating of *extremely well-positioned*, *neutral*, or *not at all well-positioned*.

When asked about the availability of EV options in their sector, two of six fleet managers in the school bus sector said they were satisfied with the EV options available, while four in other sectors were not satisfied. Four fleet managers provided additional feedback regarding the limitations of current EV options in their sector:

- "This is moving at a rate that is difficult to keep up with. The funding…caused a rush to market, often with products that are not as advertised. We did our homework and the efforts paid off for our District; however, many are struggling with reliability and **compatibility** of equipment." (School bus sector)
- "Cost, **range**, **compatibility** of charging/standby type." (TRU sector)
- "Only a couple manufacturers on the market with electric rigs." (Heavy-duty vehicle sector)
- "**Range** and charging stations." (School bus sector)

The Evaluation Team asked fleet managers whether, given what they know or believe about requirements for fleets to purchase zero-emissions MDHD vehicles, electric or diesel vehicles seem like a riskier purchase in the next three years and in the next 10 years. Two fleet managers in the school bus and heavy-duty vehicle sectors said that diesel vehicles seem like a riskier purchasing decision than EVs in the next three years, while three fleet managers in the school bus and TRU sectors said EVs seem riskier in that time span. One TRU fleet manager's perspective shifted in the 10-year horizon, with three fleet managers saying that diesel vehicles seem like a riskier purchasing decision than EVs, while two fleet managers in the school bus sector said EVs seem riskier.

Highlights

- Fleet managers were motivated primarily by rebates/incentives (six of six fleet managers), environmental benefits (five of six fleet managers), and expected fuel cost savings (four of six fleet managers).
- Four of six fleet managers rated themselves as very satisfied with the Charge Ready Transport program overall and five said they had already recommended the program to others.
- Four of six respondent fleet managers became aware of the Charge Ready Transport program directly from SCE.
- Four of seven fleet managers rated the EV charging equipment as very reliable, and six of six fleet managers rated the charging equipment as very easy to use.
- The primary barriers for fleet managers both before and after participation were the cost of installing charging infrastructure (three before; two after) and the cost of EVs (two before; one after).
- Three fleet managers plan to accelerate procurement of EVs because of their experience with the program.
- Two of five fleet managers consider their industry to be somewhat well-positioned for electrification.

Site Visit Findings

In EY2023, the Evaluation Team completed 15 site visits (n=15) in the SCE territory across several market sectors: heavy-duty, medium-duty, port cargo (drayage), school bus, transit bus, and TRU. During the site visits, the Team collected qualitative and quantitative information that provided the Team with an understanding of fleet composition and operations. We used site visits to verify aspects about sites such as the number of installed chargers, EVSPs the fleet uses, types of EVs in use or scheduled for delivery, and physical influences on construction designs.

Table 34 provides a summary of charging site characteristics by market sector, including number of site locations visited, number of L2 and DCFC charging ports, and total charging capacity. In total, the SCE Charge Ready Transport program added 216 L2 ports, and 188 DCFC ports with nearly 25 megawatts (MW) of EV charging capacity in EY2023. The TRU count includes 15 ports for forklifts because one site hosted both types (but predominantly TRUs). Figure 45 presents a summary of charging port and charging capacity of Charge Ready Transport program site visit locations by market sector for evaluation year 2023 and for the program to date.

Table 34. SCE Charge Ready Transport Program Site Visit Summary by Market Sector (Quantity of Ports by Type and Installed Capacity)

Market Sector	EY2023 Sites Visited	EY2023 Sites Ports	EY2023 Sites Capacity (kW)	PTD Sites Visited	PTD Sites Ports	PTD Sites Capacity (kW)
Heavy-Duty Vehicle	4	76	11,070	7	109	13,373
Medium-Duty Vehicle	1	15	450	4	59	1,762
Port Cargo Truck (drayage)	2	35	5,955	2	35	5,955
School Bus	4	51	1,211	23	185	4,041
Transit Bus	2	24	2,375	4	54	4,125
TRU	2	192	2,786	4	480	6,873
Total	15	393	23,847	44	922	36,129

Figure 45. SCE Charge Ready Transport Program Site Visit Ports and Capacity, EY2023 and PTD Sites

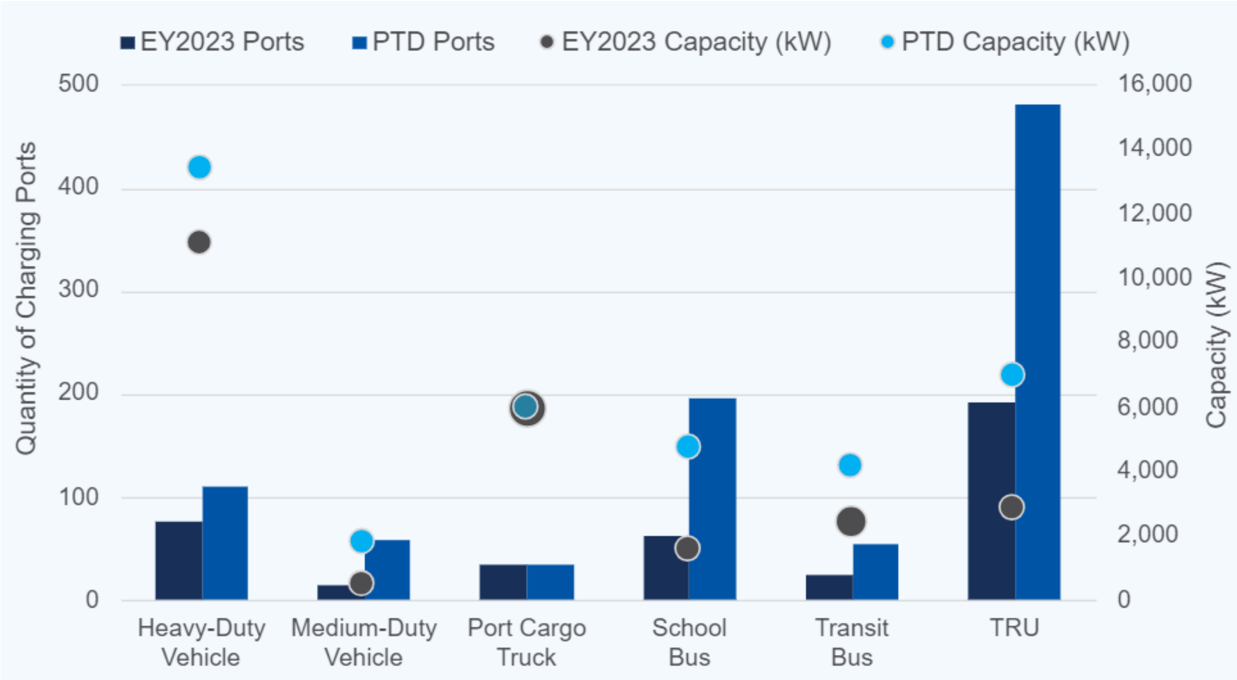
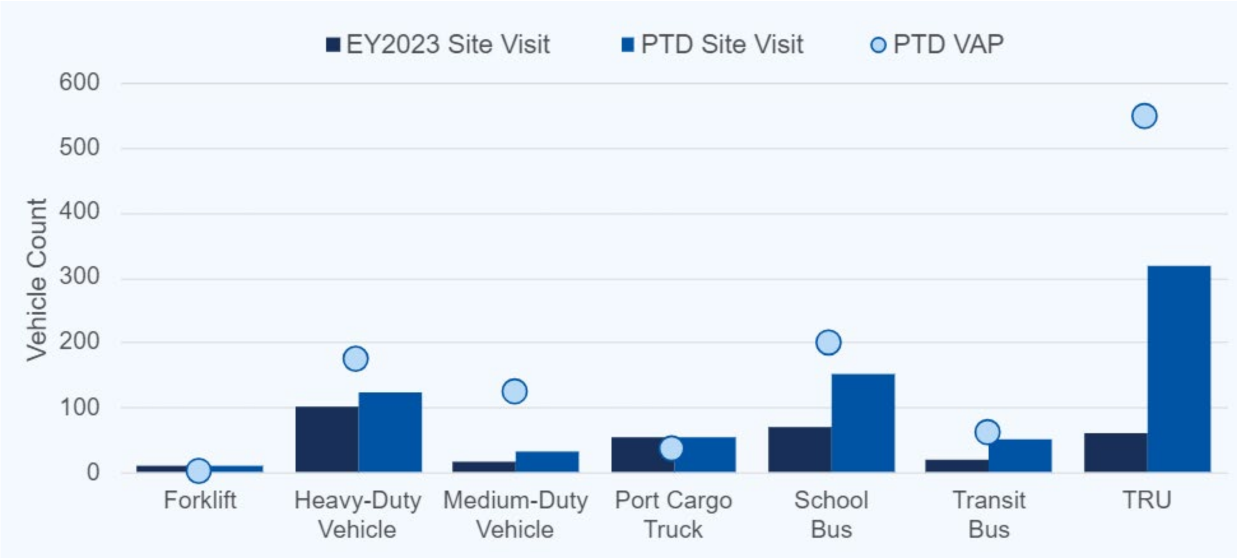


Figure 46 shows the counts of vehicles noted through site visits compared with long-term VAPs. Although not shown in the figure, a comparison was also made to the VAP for vehicles anticipated through the end of 2023. Sites are not included that have not been completed even if their VAP lists prior years. The figure and analysis suggest that vehicle deliveries are not running on schedule and therefore most of the fleets have not yet acquired the vehicles per their agreement with SCE. Market sectors closest to plan include port cargo trucks, forklifts, and transit buses. The TRU and medium-duty vehicle market sectors appear to have the largest gap between vehicles on site versus anticipated. The lone site exhibiting forklifts was predominantly another market sector, TRU, and was counted in that category in Figure 45 and Table 34.

Figure 46. SCE Charge Ready Transport Program Comparison of Verified Vehicles to Long-Term VAP



During site visits, the Evaluation Team reviewed charge management capabilities and electrical infrastructure, discussed future vehicle/equipment replacement plans (including future vehicle adoption) and public funding sources, and investigated whether fleets had an interest in on-site solar and/or battery storage. Site visits allowed the Evaluation Team to obtain direct feedback from the individuals involved with operations and to identify EVSP points of contact to obtain charging session data.

The Evaluation Team monitors site charging behavior over time and found that one site has not logged significant charging on its Charge Ready Transport program chargers since September 2022. The site had communicated dissatisfaction with its charging network service provider (NSP) because of reliability issues and concerns that load management might interfere with vehicles' ability to complete their routes. At the time of the site visit, the Evaluation Team noted that the site had preexisting, non-networked EVSE tied to a building meter. In the interest of reliability, the fleet may have elected to use these charging stations rather than the Charge Ready Transport program stations, which would influence the energy and demand trends discussed in the Grid Impacts section.

The following sections provide a summary of key observations and data collected during site visits, organized by market sector.

Figure 47. eTRU Connector

Transportation Refrigeration Unit

In EY2023, the Evaluation Team conducted site visits to two TRU sites (Figure 47 shows an example of a typical connection set up at these sites). The TRU sector represents over 50% of the total ports at sites the Evaluation Team visited in EY2023, possibly because TRU sites are larger on average than other market sector sites. One of the sites the Evaluation Team visited accounted for 100 ports, while the other accounted for 92 ports, 15 of which were for charging forklifts. TRU sites tend to be large projects, with long trenching runs likely contributing to high site costs and creating operational disruptions due to extended construction time. However, infrastructure deployed at these sites tend to have low costs per vehicle due to the scale and large number of ports. These sites also commonly include other elements such as a forklift deployment and make-ready infrastructure for future charging deployments. Few of the eTRUs had actually been delivered when the Evaluation Team conducted site visits.

School Bus

The Evaluation Team visited four school bus sites in EY2023, with a total of 38 DCFC and 24 L2 ports. In a continuation of trends observed in EY2022, three sites installed only L2 charging ports while one site installed 38 DCFC and no L2 chargers.

All the schools the Evaluation Team visited reported issues with vehicle reliability and components. For these reasons three out of four sites had removed significant portions of their EV fleet from service for extended periods of time to address issues. During the Evaluation Team's interviews, representatives from school districts repeatedly stated that their EVs could not currently support nonstandard operations such as field trips because of limitations on vehicle range and inadequate public charging infrastructure along those routes. However, one site reported already acquiring second-generation EVs that were better able to meet the range requirements for longer routes. Procuring additional vehicles depends on securing additional funding, which multiple school districts were actively pursuing. Three out of five sites were unfamiliar with Utility tariffs and were therefore unaware of the value (and concept) of load management. Three out of four school sites were not yet using load management at the time of site visits and as a result they consume roughly 35% to 50% of their energy unnecessarily during the peak period (from 4 p.m. to 9 p.m.) at four to five times the cost of other times. The larger site with DCFCs has implemented load management through their NSP.

Transit Bus

The transit bus market sector uses some of the largest EV batteries and maintains the longest routes of the market sectors, which results in a significant continuous load on charging equipment. In EY2023, the

Evaluation Team conducted two transit bus site visits, encompassing 24 DCFC ports and 2.38 MW of installed charging capacity.

Neither of the two sites has placed its electric buses in regular operation. One site had several-year delays with site completion for various reasons. Initial delays were partially because the site was one of the first in the program and therefore a test case for many program processes. Additional significant delays were caused by supply chain challenges with switchgear and transformers among other equipment. Finally, once the Utility had completed site construction, the charger installation vendor was unable to finish installation as some of the dispensers were corroded due to storage over a two-year period with exposure to the elements. As a result, replacement dispensers had to be procured at $10,000 apiece through an additional RFP process.

Due to the very long process of deploying electric charging infrastructure at this site, it is examining adding hydrogen FCEVs to the fleet, as these vehicles can cover approximately 80% of routes, compared to the 20% the current battery-electric buses can cover. Additionally, the site's battery-electric buses have had significant issues effectively communicating with SRP-installed DCFC chargers, forcing the vehicles to use chargers on site from a previous project that were designed to support the site's LDVs. This fleet has four additional locations, each with a significant number of transit buses that will need to be replaced with ZEVs based on California's ICT regulations.

Load management is more important for the transit bus sector than the other sectors given the vehicles' electricity demand and consumption. One site did not have immediate plans to use load management but was aware of TOU electricity rates. The other had recently powered up its infrastructure prior to the site visit and was planning to start commissioning electric buses in revenue service. This site has been operating other EVs for several years, which suggests it will readily adapt to these vehicles and load-management practices.

Medium-Duty Vehicle

In EY2023, the Evaluation Team visited the single completed medium-duty vehicle site. This site currently serves 15 cargo vans and has installed 15 DCFC ports, totaling 450 kW of charging capacity. The site operates all its EVs as regional delivery vehicles and plans to acquire heavy-duty vehicles. The site's chargers are unique in that they appear to connect to the building's main meter, which may make it difficult to isolate AMI usage from the sitewide load. This is the only site that used the customer-owned BTM program option.

The fleet managers highlighted that the EVs have adequate range and can fulfill their duty cycles, but also spoke about general reliability issues with the EVs, with one or two vehicles out of service at any given time during their operations period. At the time of the site visit, fleet managers could not provide detailed information or impressions about vehicle operations and suitability, because all the responsible parties were new to the site and did not have significant experience working with these EVs.

Heavy-Duty and Drayage Vehicles

The Evaluation Team visited six heavy-duty vehicle sites in EY2023. These sites had a total of 111 DCFC ports completed in EY2023, providing 17 MW of installed capacity.

One heavy-duty truck that the Evaluation Team observed at several sites in 2023 has two onboard charging ports that can be used concurrently to maximize total charging power (Figure 48). The vehicle's design is such that vehicle port A can take a maximum of 120 kW, while port B can take a maximum of 60 kW—for 180 kW in total.

Figure 48. Heavy-Duty Truck with Two Ports

One of the sites operating this truck opted to use a dual-port charger that splits power at 90 kW per port which means the 60 kW inlet acts a bottleneck. This could in theory reduce the site's maximum power needs while still providing adequate charge given the vehicles' duty cycles.

One drayage site operates both 350 kW and 175 kW chargers, of which the fleet manager reported observing drivers using the higher power and therefore faster chargers when available. This reduces vehicle charging time but increases the site's potential demand costs, perhaps unnecessarily.

Two of the sites that used Class 8 electric trucks with DCFC with a plug-and-charge authentication protocol experienced challenges with sessions either not commencing or terminating early. Given these challenges these fleets were hesitant to test and implement load management which could potentially significantly reduce monthly charging costs.

Another site recently began operations covering what it considers small routes. Based on data the fleet acquired so far, the fleet manager says the EVs can be charged every other day to help avoid installing more charging equipment, leaving midday charging capacity available for expanding the EV fleet with on-road and off-road vehicles while the delivery fleet is out. Load management continues to be an important factor for this market sector and one they seem to pay attention to more than other sectors.

Cargo-Handling Vehicle

The Evaluation Team could not conduct an in-person site visit to the single cargo-handling site energized during EY2023 because of the end of the year site completion and restricted site access at the Port of Long Beach, which limited the information available for reporting. However, the Evaluation Team was able to coordinate a call with the operator, which proved informative. The operator noted the spatial constraints of the operation and said that to alleviate this issue in the future, the site will use charging hardware with one-piece power cabinets and dispensers. The site operator is taking a slow approach to commissioning vehicles as opposed to attempting to commission the entire fleet of nearly three dozen yard tractors and has not established energy trends or intentions around load management. The site has a custom one-off vehicle with an automated charging connection, both of which have unproven reliability in this application and therefore at this point, the site operator does not expect to add this setup to any of its other sites.

Common Site Visit Findings

Across market sectors, the Evaluation Team did not observe radio frequency identification (RFID) cards in use to enable charging or instances of vehicles being reliably assigned to specific parking spaces. As a result, fuel economy, fuel cost, and charging demand data are available only at the aggregate fleet level and not at the vehicle- or route-specific level.

During site visits, three fleet operators discussed interest in distributed generation, including solar and energy storage. Operators also expressed interest in offsetting utility billing costs and/or enhancing resiliency in the event of wildfires or other emergencies. Some operators, in hindsight of their organization having selected SCE BTM work initially, realized they were subject to limitations on distributed generation in the course of completing their projects. Specifically, one site reported that it would be unable to tie into the Utility-owned BTM infrastructure to install solar and battery storage, which it could privately finance. However, sites are informed early in the process about this restriction and the program terms required for Utility-constructed BTM infrastructure. Projects constructed without Utility-owned BTM infrastructure do not face the same restrictions.

Highlights

- Most fleet managers expressed little knowledge of load management and were instead focused on EV operational readiness. Two heavy-duty vehicle and one school bus site using DCFC chargers planned to implement load management. Approaches varied from automated NSP software scheduling and power management to manual controls.
- Several fleet managers suggested that highlighting EVSE/NSP/EV pairings from the Approved Products List would minimize the risk of service disruptions for the fleets. The Utilities do not make any recommendations beyond publishing and maintaining the Approved Product List for EVSE and NSPs. Additionally, there does not seem to be any information readily available on the interoperability testing between vehicles and chargers or validation of NSPs' load management capabilities. Fleets transitioning to electrification, especially smaller ones with fewer resources (staffing, funding, and EV knowledge), could benefit from a resource that would include such information to support load management adoption, especially if provided by a trusted source like a Utility.
- Across participating fleets, issues with maintenance, service, and reliability were recurring issues among both nascent and established manufacturers of vehicles and charging equipment.
- All four school bus sites reported issues with vehicle reliability and components. Three out of four sites had removed significant portions of their EV fleet from service for extended periods of time to address these issues. The current EV range is inadequate for field trips and there is insufficient public charging infrastructure along those routes.
- Three fleet operators expressed interest in distributed generation, including solar and energy storage, to reduce costs and/or enhance resiliency, but were unable to add it given their selection of Utility-owned BTM infrastructure. Specifically, one site reported that they would be unable to tie into the Utility-owned BTM infrastructure to install solar and battery storage, which they would privately finance. Had they selected customer owned BTM infrastructure they would be able to install distributed generation but would have to take on more responsibility for design, construction and maintenance of BTM infrastructure.[52]

Deep Dives

The Evaluation Team conducted deep dives for two Charge Ready Transport program sites in EY2023. The Team selected sites for deep dives based on several criteria. We considered sites with significant demand, energy consumption, and/or installed charging capacity; sites that had an ability to expand EV infrastructure; and/or sites with load management, unique vehicles and/or charging equipment, a large fleet size, and importantly a fleet manager who was willing to participate in the deep dive process.

For EY2023, the Evaluation Team examined two sites completed in 2022 in SCE territory, both of which are school districts operating Type D school buses. Type D school buses carry up to 90 passengers and have the passenger door ahead of the front wheels. The Team conducted in-depth fleet manager

[52] SCE clarified with The Evaluation Team that because of the need to clearly delineate SCE-owned equipment and infrastructure from customer-owned electrically connected equipment and infrastructure, customers cannot incorporate customer-owned equipment into SCE-built projects.

interviews, analysis of AMI and EVSP data, and fleet driver surveys, but only one of the two fleets participated in the driver surveys.

Findings presented in this section reflect results of the interviews, the data analysis, and driver survey feedback, where available. *Appendix B* presents detailed case studies on each of these fleets.

School Bus Fleet 1

The Evaluation Team selected a school bus fleet that operated Type D buses for a deep dive analysis because of its deployment of two different models of school bus, its V2G-enabled bidirectional chargers, and its potential for load management.

The site charges its buses using 15 bidirectional L2 stations and follows a two-shift charging schedule. This schedule involves plugging in when a bus returns from its morning routes around 8:30 a.m. and again when a bus returns from its afternoon routes around 5 p.m., though evening charging is automatically delayed by management software until after 9 p.m. This results in an extremely low percentage of monthly energy consumed during the 4 p.m. to 9 p.m. peak period (approximately 6%), which tends to be the most expensive time of the day to use electricity.

The site has encountered issues with vehicle reliability, with all of its EV school buses experiencing electrical problems that have required temporary removal from service to address the issues. However, when operating, the vehicles generally have sufficient range and charge to fulfill their duty cycles.

Even though the EV school bus ranges are shorter than equivalent ICE vehicles, the fleet manager observed marked improvement in drivers' confidence in completing their routes with their second-generation EVs. The fleet manager indicated that EV fleet driver training is a potential area for improvement, noting that drivers tend to require significantly more training to adapt to EV charging and operation (for example, regenerative braking, torque, and charging indicator lights). Despite these hurdles, the fleet manager reported having an excellent experience with SCE Charge Ready Transport program staff and processes and looking forward to claiming LCFS credits as soon as possible. This fleet is also participating in a second Charge Ready Transport program site to add additional charging infrastructure.

School Bus Fleet 2

The Evaluation Team selected a second school bus fleet operating six Type D school buses for a deep dive. This selection was the result of several considerations, including the site's usage of 50 kW DCFC ports with load management, the site's vehicle telematics data, and a known responsive fleet manager.

On average, charging power demand at the site ramps up sharply at around 9 a.m., peaks at approximately 10 a.m., and tapers off at 2 p.m. Before load management was instituted, a second charging peak began at 4 p.m., peaked at 6:30 p.m., and tapered off through 10 p.m. The fleet manager's interest in reducing electrical load on the site led to the introduction of load management. This shifted the second charging peak to much later in the day, with a sharp demand increase at 9 p.m. and tapering off through 11 p.m., with some minor additional charging between midnight and 4 a.m.

This site initially did not have load management implemented on its chargers and was consuming between 35% and 55% of its total monthly energy between 4 p.m. and 9 p.m. After the team conducted a site visit, the fleet manager implemented the chargers' ability to delay charging between specified hours. This ultimately resulted in a 25% decrease in the monthly energy consumed between 4 p.m. and 9 p.m. on average over the remainder of the 10-month data collection period.

The site has experienced issues with vehicle reliability and the fleet manager expressed concern about the speed of repairs to vehicles and the expiration of the manufacturer's warranty. Ongoing and recurring problems that necessitated towing are no longer covered by the manufacturer, which resulted in the fleet covering these expenses out-of-pocket. The manufacturer has since sold off its assets to other vendors, raising questions around further vehicle service coverage and maintenance. The site is currently transitioning the management of its EV buses to a third-party service to help maintain a base level of vehicle operation and utilization.

Fleet Driver Surveys

As part of the deep dives, the Evaluation Team surveyed 19 fleet drivers who participated in SCE's Charge Ready Transport program about their experience driving an EV and using the associated charging infrastructure. Three drivers began operating EV equipment for their organization in 2024, eight in 2023, five in 2022, two in 2021, and one in 2020.

Training

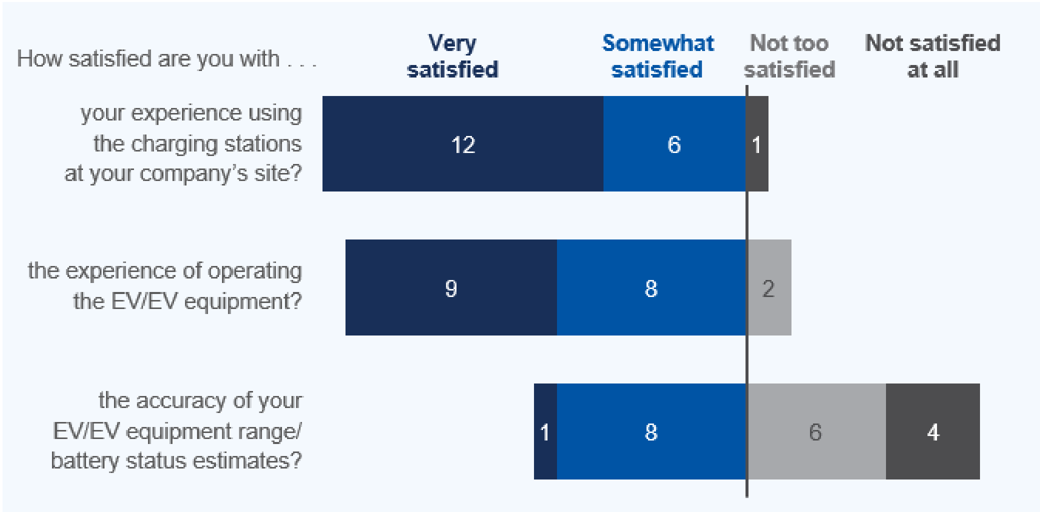
All 19 drivers received training to operate the vehicle/equipment, with 17 drivers surveyed receiving on-site training on operating and charging the EVs and equipment. Nine received a training manual to operate the EVs and five received a training manual on EV charging. One respondent also received classroom training.

All but one of the 18 drivers received training from their company. One also received training from the EV distributor/supplier and two also received training from the charging station provider. Sixteen drivers rated the training as *very helpful* and three drivers said it was *somewhat helpful*.

Operational Experience

Driver satisfaction with their EV and charging equipment is shown below in Figure 49. A majority of respondents reported being *very satisfied* or *somewhat satisfied* with the charging stations and operating equipment. Opinions were more mixed regarding the accuracy of the EV range and battery status estimates, with about half of respondents reporting being *not too satisfied* or *not satisfied at all*.

Figure 49. SCE Charge Ready Transport Program Fleet Driver EV/EV Equipment Experience

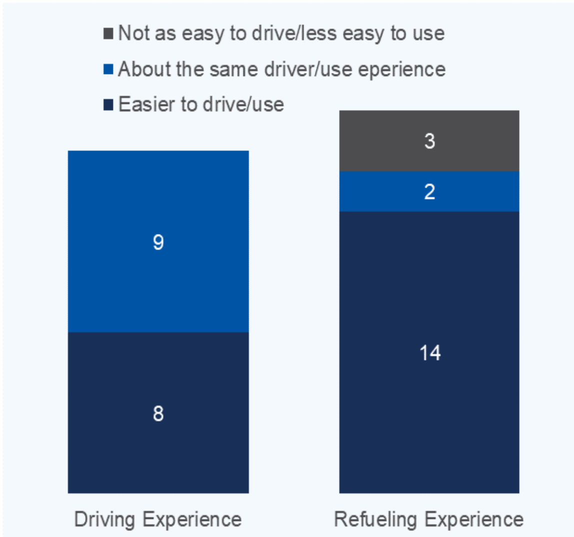


Source: Fleet driver survey question B1, "How satisfied are you with the experience of operating the EV/EV equipment?", B3. "How satisfied are you with the accuracy of your EV's/EV equipment's range/battery status estimates?", and B4. "How satisfied are you with your experience using the charging stations at your company's site?"(n=19)

Fleet drivers provided reasons for the satisfaction ratings in Figure 49:

- **Experience operating EV/EV equipment**: Of the nine drivers who were *very satisfied* with operating the EV equipment, three commented on how the buses offer a smoother drive than compressed natural gas (CNG) or diesel-powered buses (citing the acceleration), two drivers expressed appreciation for the noise reduction and quiet ride the EVs provide, and two drivers mentioned that the equipment is comfortable to operate. One of these drivers said, "The vehicle driver experience is great overall. Smooth vehicle ride with great options for operator comfort." Three of the eight drivers who were *somewhat satisfied* similarly appreciated how the equipment offers a smooth drive. However, four of these eight drivers commented on the equipment's limited range due to the inability of the bus to hold a charge for long distances and two drivers mentioned the compartment space being too small. The two drivers who were not too satisfied similarly called attention to the equipment's poor range per charge, with one stating, "the dashboard gauge is easy to operate and drive[s] smooth[ly], but the electric range is not too satisfying."
- **Experience using the charging stations**: Eight of the 12 drivers who were *very satisfied* appreciated the EV's simplicity and ease of charging, saying they simply "plug in and go," and three drivers mentioned that the charging stations are reliable and dependable. Among the six somewhat satisfied drivers, four similarly liked how easy the charging stations were to operate; however, three drivers cited issues with charging, stating that charging can be inconsistent (for example, the equipment sometimes depletes instead of charging) or slow or that there are not enough charging stations available. The one driver who reported being *not too satisfied* similarly mentioned the slow pace of charging: "Charging is too slow, rendering the bus useless for the afternoon. Many times, charges back 10 mile of range per hour."

Figure 50. SCE Charge Ready Transport Program Fleet Driver Comparison of EVs to ICEs



Source: Fleet driver survey question B8, “Compared to operating a vehicle/equipment with an internal combustion engine, would you say operating the EV/EV equipment is overall?” and B9. “Compared to refueling a vehicle/equipment with an internal combustion engine, would you say using the charging stations for the EV/EV equipment is overall?” (n=17-19)

In their responses to questions about EV/EV equipment reliability, four fleet drivers said the EV/EV equipment was *very reliable*, eleven said it was *somewhat reliable*, three said it was *not too reliable* and one said it was *not reliable at all*. When asked why they gave a specific reliability rating, four fleet drivers cited software malfunctions, three mentioned warning lights activating in the absence of a real issue, and three commented on the restrictions in driving range.

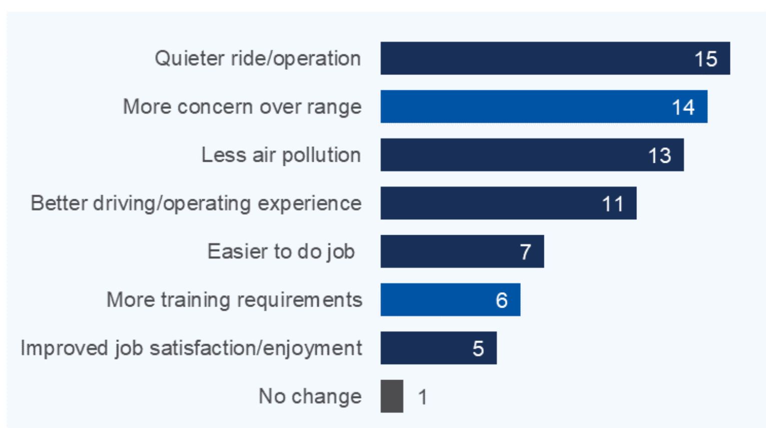
Most surveyed fleet drivers said that charging an EV is easier than refueling an ICE vehicle, with 14 of 19 stating that EVs were *easier to use*. When asked to compare driving EVs to operating ICE buses, there was less agreement: eight drivers said EVs are easier and nine said they were about the same (Figure 50).

When fleet drivers were asked how their job has changed now that they are driving/operating EV/EV equipment (Figure 51), they most frequently mentioned quieter ride/operation (15 of 19) and less air pollution (13 of 19), while most (14 of 19) cited more concern over range. Only one respondent reported no changes to their jobs.

Desired Improvements

When asked to provide any additional thoughts on their experience with EVs, 9 of 16 drivers echoed concerns about the limited EV range due to the battery capacity, which according to one driver can “sometimes [be] an obstacle to completion of all driving assignments.” Two drivers also drew attention to the need for faster and more reliable charging stations at every school site, with one stating, “The only thing I would change on the EV buses [would be the presence of] better chargers, so the battery [charge] will last longer.”

Figure 51. SCE Charge Ready Transport Program Changes to Fleet Drivers’ Jobs Since Operative EVs



Source: Fleet driver survey question D3, “How, if at all, has your job changed now that you are driving/operating an EV/EV equipment?” (multiple responses allowed; n=19)

Highlights

- Both deep dive sites experienced frequent electrical issues with their vehicles, requiring multiple units to be taken out of service for extended periods of time. One fleet opted to transfer maintenance and operations of its vehicles to a third-party operator after the vehicle manufacturer support expired.
- Both sites have taken advantage of their operational patterns to shift charging loads to avoid charging between 4 p.m. and 9 p.m. One fleet consistently keeps its monthly peak period energy consumption below 10% of total monthly consumption; the other site was able to reduce peak energy consumption from around 40% to roughly 15% of monthly energy consumption.
- Fleet drivers were satisfied with their vehicles' performance when EVs were operational but had concerns about the vehicles' short range and overall reliability.

Co-Benefits and Co-Costs

Through fleet manager surveys, deep dive fleet manager interviews, deep dive fleet driver surveys, and site visits, the Evaluation Team identified several co-benefits and co-costs associated with the Charge Ready Transport program's vehicle electrification sites.

Fleet Manager Surveys

The fleet manager surveys used both aided (asking fleet managers if they have noticed a specific co-benefit or co-cost) and unaided (open-ended) questions to assess co-benefits and co-costs.[53]

Table 35 shows that six of six fleet managers expected to realize benefits for their community or fleet because of electrifying. This is consistent with EY2022, when four of four fleet managers expected benefits. Four of the six fleet managers expected *significant benefits* because of electrifying, such as improved air quality and health, improved driver comfort and convenience, and reduced noise pollution. Fleet managers were more divided on whether electrification increased fleet flexibility and about their inclination to encourage other individuals and fleets to convert to EVs.

Table 35. SCE Charge Ready Transport Program Benefits Fleet Managers Reported from Electrification in EY2023

Electrification Benefit	*Significant Benefits*	*Some Benefits*	*No Benefits*
Improved air quality/health	4	2	–
Improved driver comfort/convenience	4	2	–
Reduction in noise pollution	4	2	–
Encourages other individuals/fleets to convert to EVs	1	1	3
Increased fleet flexibility	2	3	1

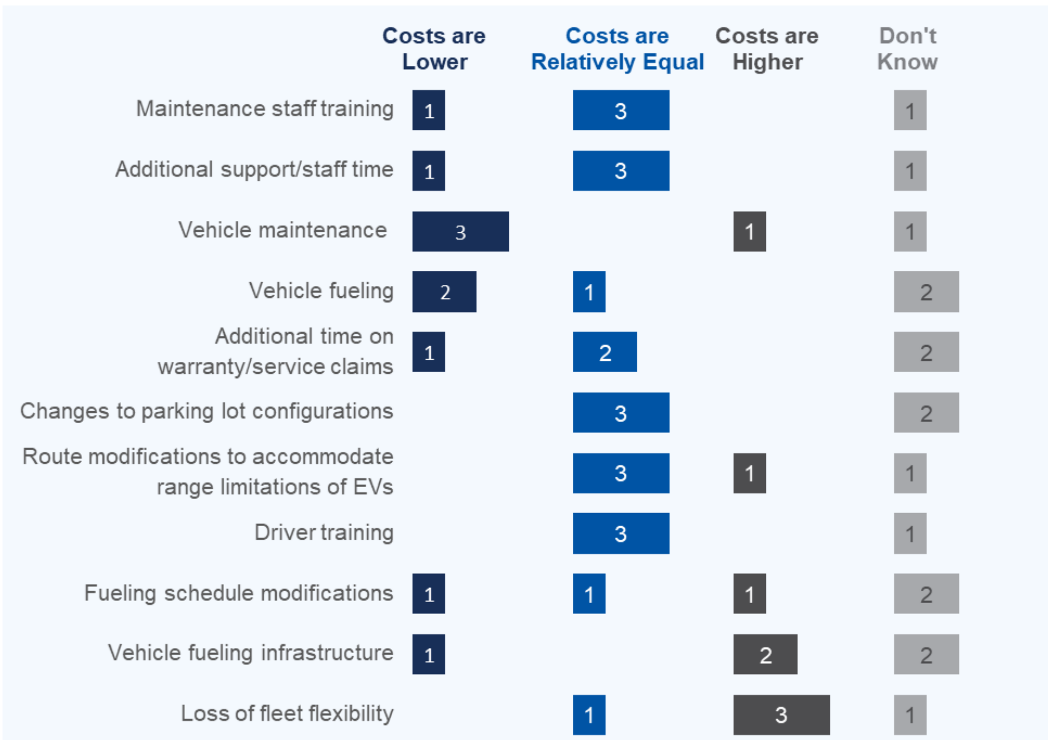
Source: Fleet Manager Survey Question D1. "What ancillary benefits do you think will be realized for your community/fleet as a result of electrifying?" (n=6)

[53] The Evaluation Team received responses from seven fleet managers, but the sample size (n) denoted in the following tables and charts may differ because fleet managers could skip questions and response options.

When we asked fleet managers what other benefits their community fleet would realize as a result of electrifying, one fleet manager mentioned that their company "will benefit by contributing to our goal of fleet electrification," and that electrifying would "show our community and customers we care about our environmental impact and are doing what we can to help reduce our carbon footprint." Another fleet manager provided feedback that "students with autism have responded positively to the new equipment due to the reduction in noise within the electric school buses" and "the reliability of the equipment selected far exceeded my initial expectations."

Figure 52 shows the surveyed managers' responses to questions on the observed costs associated with operating and maintaining EV fleets.

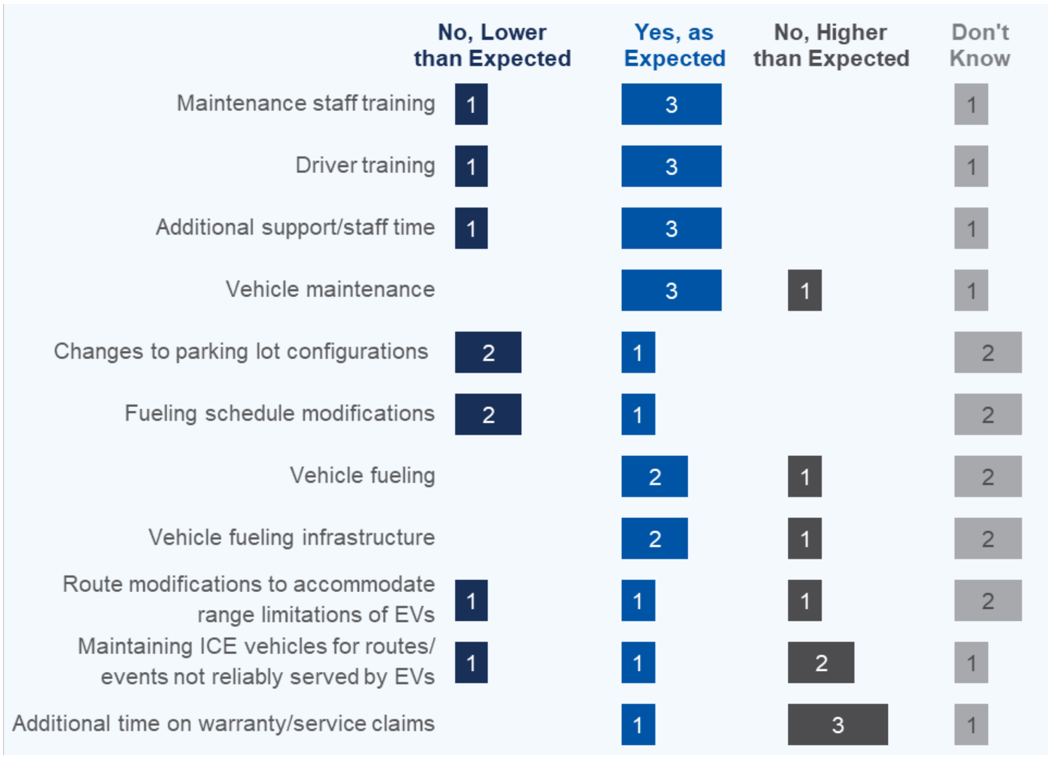
Figure 52. SCE Charge Ready Transport Program Observed Cost Changes since Electrification in EY2023



Source: Fleet Manager Survey Question E1. "Please think about all the costs associated with operating and maintaining your fleet. For each cost type, please estimate how much the cost has changed since transitioning your fleet to EVs." (n=4-5)

The Evaluation Team also asked fleet managers about changes in operational and maintenance costs. As shown in Figure 53, two of six managers reported *lower than expected* costs for fuel schedule modifications and changes to parking lot configurations. Three of four fleet managers indicated costs were *as expected* for vehicle maintenance, additional support/staff time, maintenance staff training, and driver training. For other cost categories, three of five reported *higher than expected* costs for additional time on warranty/service of claims, and two reported *higher than expected* costs for the need to maintain ICE vehicles for operations not reliably served by EVs.

Figure 53. SCE Charge Ready Transport Program Differences between Electrification Expectations and Costs in EY2023



Source: Fleet Manager Survey Question E2. "Have these operational and maintenance costs been what you expected?" (n=5)

When we asked fleet managers if there have been any other impacts or costs incurred as a result of electrifying, one fleet manager said there was a "large increase in tire cost/replacement, and challenges with our TOU and 500 kW utilization cap. The difficulty is the scheduled charging and remote charging sessions as it relates to the developer and software updates."

Deep Dive Fleet Manager Interviews

The Evaluation Team conducted deep dive interviews with two participating fleet managers to assess the co-costs and co-benefits of TE for fleets and fleet drivers. During the interviews, fleet managers noted several costs:

- **Range and duty limitations.** One fleet manager noted that EVs could run only certain routes because of the low range of early-generation models, but that the second generation of the same models largely ameliorated that issue. The other fleet manager noted that while few routes caused concern about EV range, the fleet had encountered issues with its EVs seating fewer students than their equivalent diesel counterparts, limiting the routes they could run.

- **EV reliability.** Both fleet managers reported encountering problems keeping their current fleet of EVs fully operational, because of a combination of software, electrical, and hardware issues. One fleet found that vehicle warranties generally covered repairs, but the time required for repairs occasionally removed buses from service for more than a month. The other found that specific problems continued through warranty coverage into the post-warranty period, requiring the fleet to cover the cost of repairs.
- **Staff training.** Fleet managers also discussed their staff's level of comfort with and training required to operate the vehicles. One manager noted that it took longer than expected to train the staff on the buses and charging methods—approximately twice as long as for diesel or CNG.

Both fleet managers expressed an overall positive experience with their charging hardware, with one specifically noting the proactive and responsive nature of their EVSP, and the other highlighting good collaboration and active load management under theirs. One fleet manager noted that hiring a third-party entity to manage their buses remedied some of their operational difficulties.

Fleet Driver Surveys

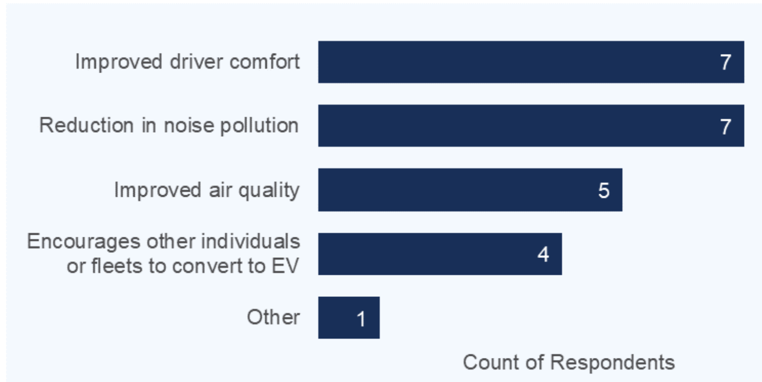
The Evaluation Team fielded surveys with participating fleet drivers to examine co-costs and co-benefits as part of the deep dive effort and received 19 responses from one fleet. Drivers reported a **quieter ride/operation** (n=15), **less air pollution** (n=13), a **better operating experience** (n=11), improved ease in doing their job (n=7), and improved job satisfaction (n=5). However, 14 drivers had **concerns over range**, and 6 noted additional training requirements.

Additional Insights from Site Visits

To inform co-costs and co-benefits findings, the Evaluation Team analyzed qualitative insights from the 21 SCE Charge Ready Transport activated sites visited as part of EY2023 reporting. This cohort includes sites activated across EY2021 and EY2023 that were not previously visited or reported on in prior evaluation reports. Some fleet site contacts were unable to determine co-benefits and co-costs during site visits because their fleets had only recently been electrified.

As shown in Figure 54, the most frequently reported co-benefits included improved driver comfort and reduction in noise pollution (seven sites each). Five fleet site contacts reported improved air quality, while an additional four contacts reported that their fleet electrification encourages other individuals and fleets to convert. One site contact reported *other* co-benefits and indicated that they were pleased with the lower fuel costs resulting from fleet electrification.

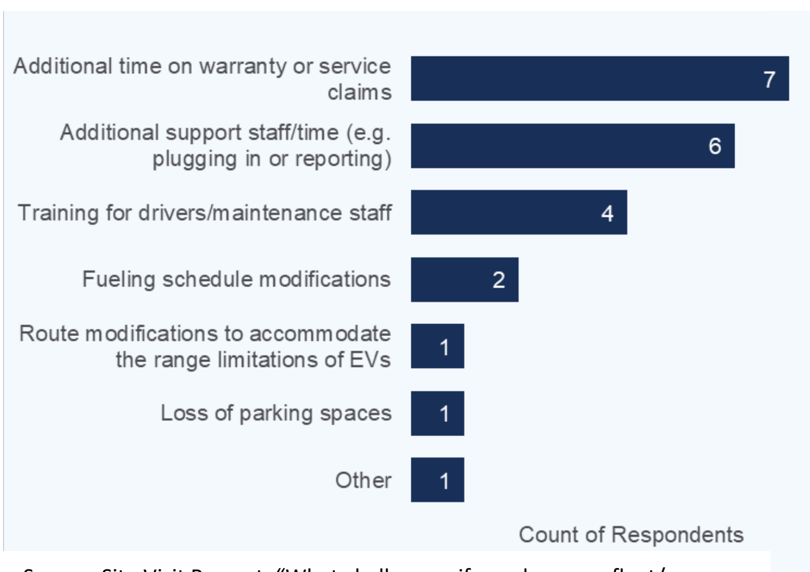
Figure 54. SCE Charge Ready Transport Program Co-Benefits Identified during Site Visits



Source: Site Visit Prompt. “What ancillary benefits have been realized for your fleet/community as a result of electrifying?” (n=9)

Figure 55 displays the rate at which co-costs were reported during site visits. The most frequently reported co-cost was additional time spent on warranty or service claims (seven sites), with two sites specifying that they encountered issues with charging network software and delays in switchgear delivery. Six fleet site contacts reported needing additional support staff and/or time following their fleet’s electrification. Four site contacts reported that their drivers and/or maintenance staff required additional training, while another two contacts reported making modifications to their fueling schedule. Only a single site contact reported either modifying their route to accommodate EV range limitation, the loss of parking spaces, or an *other* co-cost, who mentioned challenging logistics with SCE.

Figure 55. SCE Charge Ready Transport Program Co-Costs Identified during Site Visits



Source: Site Visit Prompt. “What challenges, if any, has your fleet/community experienced as a result of electrifying?” (n=9)

Highlights

- All six interviewed fleet managers anticipated benefits for their community or fleet through the transition to electrification.
- Four of six fleet managers expected *significant benefits* from improved air quality and health, improved driver comfort and convenience, and reduced noise pollution.
- Three fleet managers reported *lower costs* for vehicle maintenance since electrification, and two also reported *lower* costs for vehicle fueling. Three fleet managers reported *higher costs* from loss of fleet flexibility, and two reported *higher costs* from vehicle fueling infrastructure.
- Two of six managers reported *lower than expected* costs for fuel schedule modifications and changes to parking lot configurations. Three of five reported *higher than expected* costs for additional time on warranty/service of claims, and two reported *higher than expected* costs from maintaining ICE vehicles for operations not well served by EVs.
- Fleet managers improved comfort and reduction in noise as key benefits (seven) and the commonly reported co-cost was the additional time on warranty or service claims (seven), followed by additional required staff time (seven).

Site Costs

The Evaluation Team conducted an analysis on the 29 sites with fully closed out finances as of December 31, 2023, including EY2021, EY2022, and EY2023 activated sites. The set of fully closed out sites is smaller than the set of activated sites because of the time lag involved in performing activities such as collecting receipts, paying invoices, and obtaining administrative approvals. Cost estimates presented here are in nominal dollars.

The 29 sites had a mix of L2 and DCFC ports, with an average of 411 kW installed capacity and 12 ports. The 29 sites included 15 school bus sites, 6 transit bus sites, 3 medium-duty vehicle sites, 3 heavy-duty vehicle sites, and 2 TRU sites. Of the 29 sites, only two sites had customer-owned BTM. All other sites had Utility-owned BTM. Market sectors are presented together to meet customer confidentiality requirements. While this aggregation impedes findings for given market sectors, it still provides insights on relative magnitudes of costs faced by MDHD fleets. In future evaluation years, the Evaluation Team expects to have sufficient data points to disaggregate certain market sectors.

Figure 56 shows the distribution of site-level costs for the 29 sites. The horizontal lines of the boxes show the 25th, 50th, and 75th percentile of sites; the “x” represents the mean site cost; and the three panels are defined as follows:

- **Utility Infrastructure Costs**. Site costs borne by the Utility for TTM and BTM.[54]
- **Ratepayer-Funded Costs**. All site costs paid for by the Utility, including TTM, BTM (or BTM incentive if infrastructure is customer owned), and EVSE rebate.

[54] Utility Infrastructure Costs are the same as the Ratepayer-Funded Costs, except they do not include the EVSE rebates.

- **Estimated All-in Costs.** The total estimated cost of installing the site, including capital and labor costs for the Utility and the customer. The value is calculated by summing 100% of TTM,[55] BTM,[56] and EVSE costs.[57]

Figure 56. SCE Charge Ready Transport Program Per-Site Costs Organized by Three Perspectives, Across 29 Closed-out PTD Sites

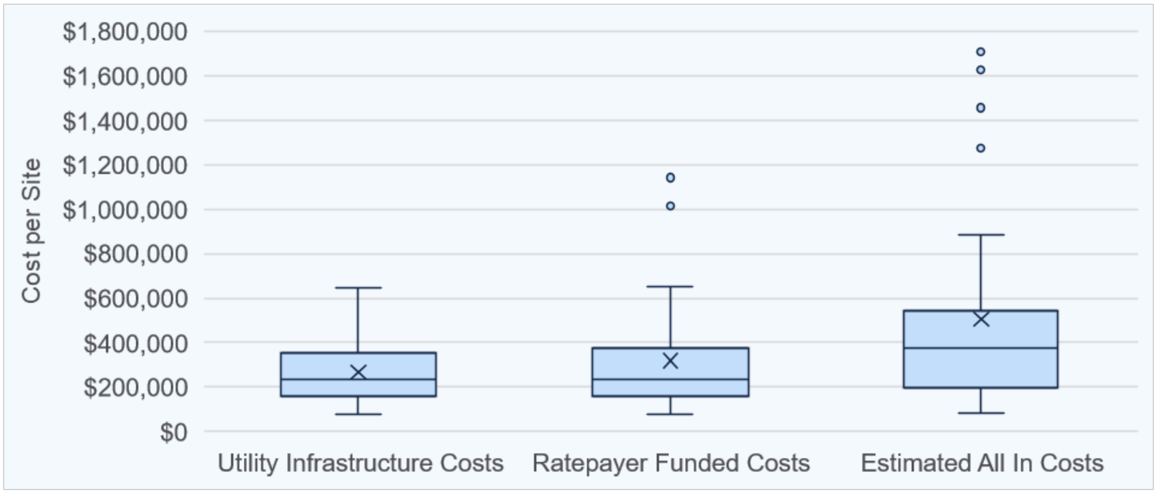


Figure 57 shows average all-in costs for the 29 sites. BTM is the largest cost across the sites, followed by EVSE, then TTM. Together, the average all-in TTM, BTM, and EVSE cost is $504,275.[58]

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55 The Utility pays 100% of the TTM costs and therefore reports actual TTM costs to the Evaluation Team.

56 The Evaluation Team receives actual BTM costs for sites with Utility-owned BTM. In total, 27 of 29 sites with fully closed out financials have utility-owned BTM. For the two customer-sponsored BTM sites, the BTM cost is estimated using the following equations: for DCFC ports, the BTM cost per kilowatt is $\$11{,}6133 * Installed\ kW^{-0.541}$. For L2 ports, the cost per kilowatt is $\$42{,}975 * Installed\ kW^{-0.705}$. These equations are best fit curves of other utility-owned BTM.

57 Because actual EVSE costs are not known by the Utility, The Evaluation Team estimates EVSE equipment costs using an assumption of $3,000 per port for L2 ports.

58 Calculated by summing all TTM, BTM, and EVSE costs borne by SCE and the customer and dividing by 29 sites.

Figure 58 shows the distribution of utility infrastructure costs (corresponding to the far-left panel in Figure 56) presented per site, per vehicle, and per kilowatt. The average utility infrastructure cost, including TTM and BTM borne by SCE, was $304,057 per site, $41,395 per vehicle, and $1,356 per kilowatt of installed charging capacity. Although not shown, forty-four percent of SCE Charge Ready Transport program spending on infrastructure for financially closed out sites to date has been on DAC sites, exceeding the 40% program target.

Figure 57. SCE Charge Ready Transport Program Average Estimated All-In Costs across 29 Closed-out PTD Sites

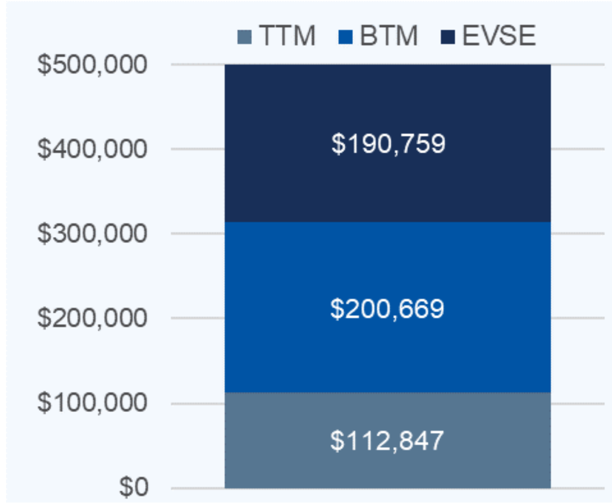
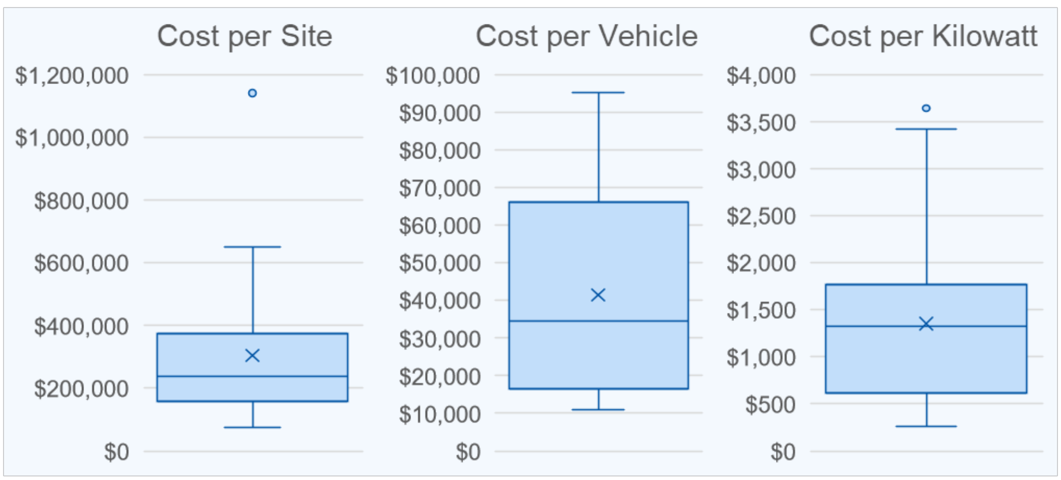


Figure 58. SCE Charge Ready Transport Program, Utility Infrastructure Cost per Site, per Vehicle, and per Kilowatt for 29 Closed Out PTD Sites



Highlights

- Estimated all-in costs paid by the customer and SCE vary widely between sites, with an average of $504,275 per site. On average, EVSE was the largest cost across the sites, followed by BTM and TTM costs.
- The average utility infrastructure cost, including TTM and BTM borne by SCE, was $304,057 per site, $41,395 per vehicle, and $1,356 per kilowatt.
- Forty-four percent of SCE Charge Ready Transport program spending on infrastructure for financially closed out sites to date has been on DAC sites, exceeding the 40% program target.

Grid Impacts

This section describes grid impacts for the Charge Ready Transport program based on an analysis of energy consumed and customer bills by operational charging stations installed through the program in EY2023.

Data Sources

The primary data source for the analyses detailed in this section is the energy usage–related data provided in regular 15-minute intervals from the AMI. Other data sources include customer bills, LCFS program information, and charging session–specific data provided by NSPs. There are several important differences between AMI and NSP data. While AMI data includes only energy usage, NSP data includes session start and stop time, the duration of a vehicle's connection to a charging port, the duration of a vehicle actively pulling power, and the specific port used for a session. AMI meters track standing loads (such as those the EVSE uses for communications, cooling, active power converters, solenoids, and screens), which NSPs typically cannot do. For cases in which AMI data is missing from the dataset, the Evaluation Team used NSP data to fill in the gaps.

Summary of Grid Impacts

Table 36 presents the estimated Charge Ready Transport program grid impacts.

Table 36. SCE Charge Ready Transport Program Grid Impacts

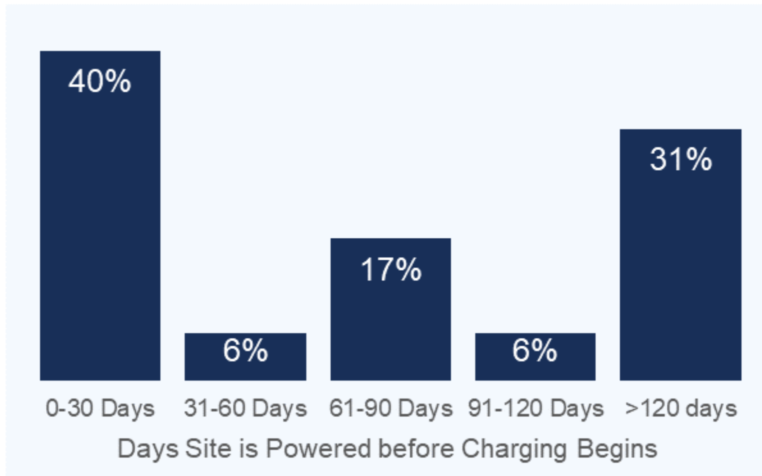
Impact Parameter	2023 Actual	PTD Actual	10-Year Projection
Operational Sites	54	54	54
Installed Charging Capacity, kW	24,455	36,737	36,737
Electric Energy Consumption, MWh	12,753	17,742	194,774
On-Peak (4 p.m. to 9 p.m.) MWh (percentage of total)	3,517 (28%)	4,785 (27%)	N/A
Maximum Demand, kW (date and time)	5,950 (9/28/23: 10:45 p.m.)	5,950 (9/28/23: 10:45 p.m.)	N/A
Maximum On-Peak Demand, kW (date and time)	5,620 (10/25/23: 6 p.m.)	5,620 (10/25/23: 6 p.m.)	N/A

Energy Trends

Site Startup

The Evaluation Team examined the duration between Charge Ready Transport site activation and operation to illustrate the timing relationship between readiness of charging infrastructure and actual vehicle charging. AMI data demonstrates that 63% of sites had significant operations within 90 days of activation, as illustrated in Figure 59. However, as seen in the final column of Figure 59, almost a third of sites were not in use for at least four months after activation. Based on discussions during site visits, the primary cause of delays in operation was a delay in vehicle delivery. Additionally, transit operators often took several months to commission vehicles.

Figure 59. SCE Charge Ready Transport Program Percentage of Sites by Days between Activation and Operation for PTD Sites



Consumption and Maximum Demand

Figure 60 depicts the growth of SCE's monthly energy consumption and maximum demand for all operational sites in the Charge Ready Transport program to date. In EY2023 both consumption and maximum demand increased as new sites became operational.

Charge Ready Transport program sites collectively reached 5.95 MW of maximum demand at the end of 2023, with an installed capacity of approximately 42 MW. As detailed throughout the Site Visits section, the low demand relative to the installed capacity can be attributed to several factors including fleet operators still gaining experience with the new vehicles, waiting for delivery of vehicles, or not having commissioned all vehicles yet, leading to slow growth in utilization. Part of this is also due to less-than-perfect reliability, in which case not all vehicles operate regularly. Comparing the early 2023 demand of nearly 2.5 MW to the peak demand of nearly 6 MW in late 2023 shows that demand for Charge Ready Transport program sites more than doubled in EY2023. Figure 60 shows that the energy consumption in November and December 2023 more than doubled the monthly consumption for the months in the first half of 2023.

Figure 60. SCE Charge Ready Transport Program Monthly Energy Consumption and Maximum Demand for PTD Sites

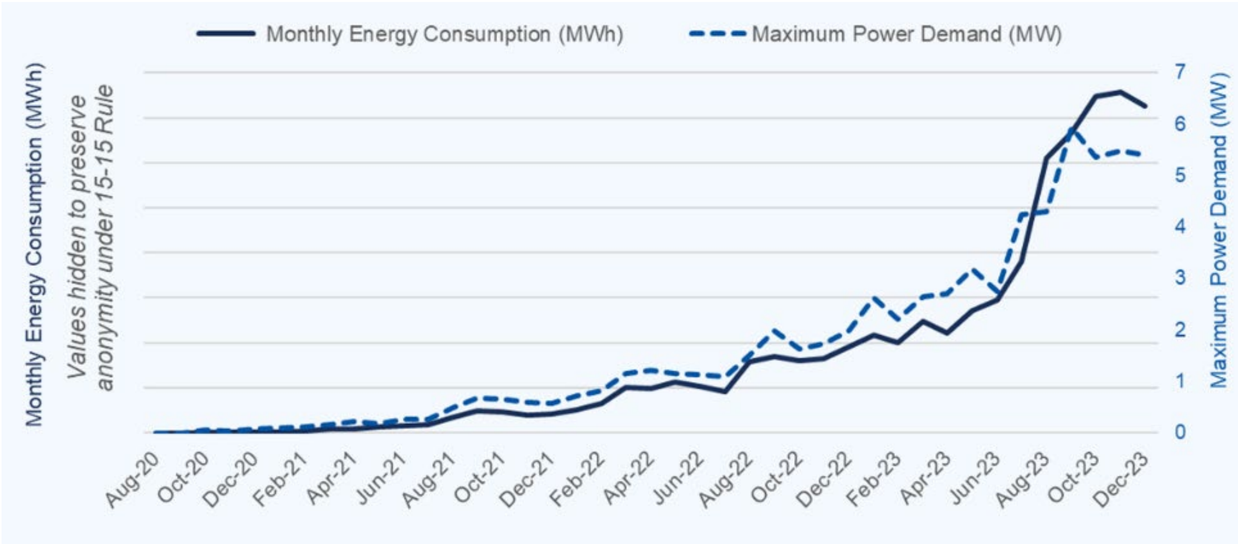


Figure 61 provides insight into monthly energy consumption trends of activated sites by program reporting year. Sites activated in 2021 reach a point of consistent consumption by the end of 2022 that continues throughout 2023. On the other hand, energy consumption of sites activated in 2022 level off more quickly—by late 2022. Sites activated in 2023 appear to be on an upward trajectory at the end of 2023 with a much higher rate of consumption than sites activated in 2021 or 2022. Despite having similar total numbers of activated sites in 2021, 2022, and 2023, the sites activated in 2023 have more ports and higher installed charging capacity.

Figure 61. SCE Charge Ready Transport Program Monthly Energy Consumption of Activated Sites Grouped by Initial Reporting Year for PTD Sites

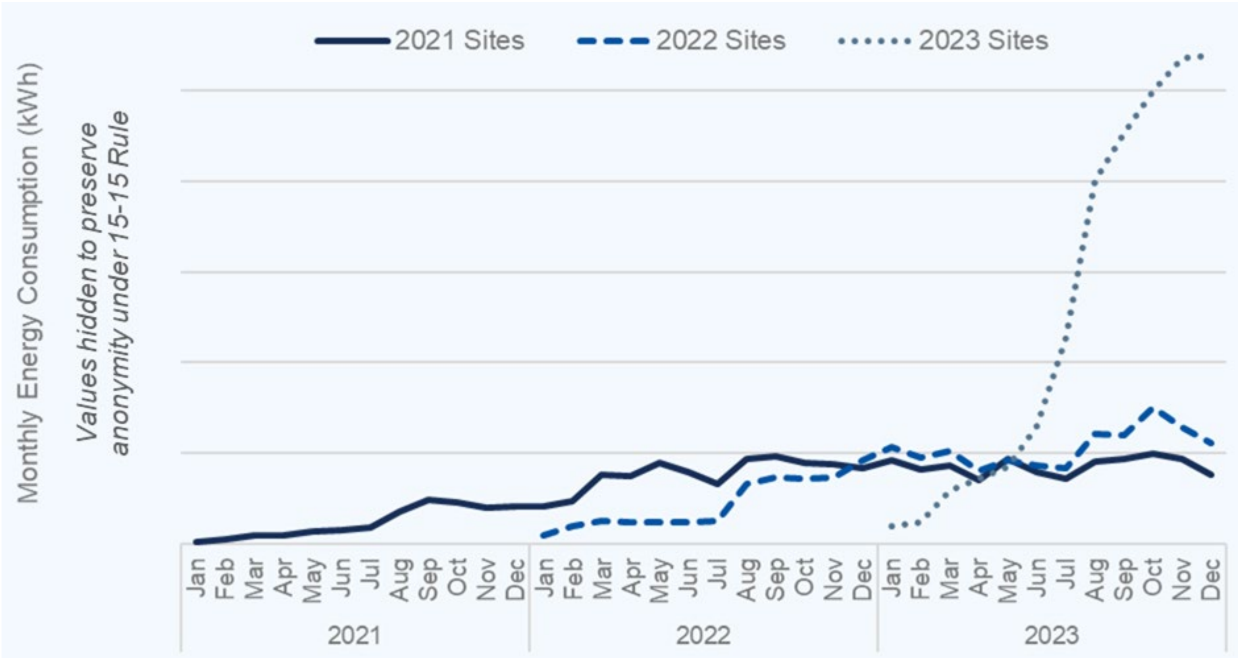


Figure 62 shows wide variations in daily consumption between weekdays and weekends. The high marks typically represent weekday operation, while the low marks typically represent weekend operation. In the final months of 2023, weekday energy uptake typically fluctuated from 50 MWh to 70 MWh, Saturday energy consumption ranged from 25 MWh to 35 MWh, and Sundays ranged from 15 MWh to 20 MWh. Figure 63 shows daily fluctuations in the maximum demand during the same period.

Figure 62. SCE Charge Ready Transport Program Daily Energy Consumption for PTD Sites

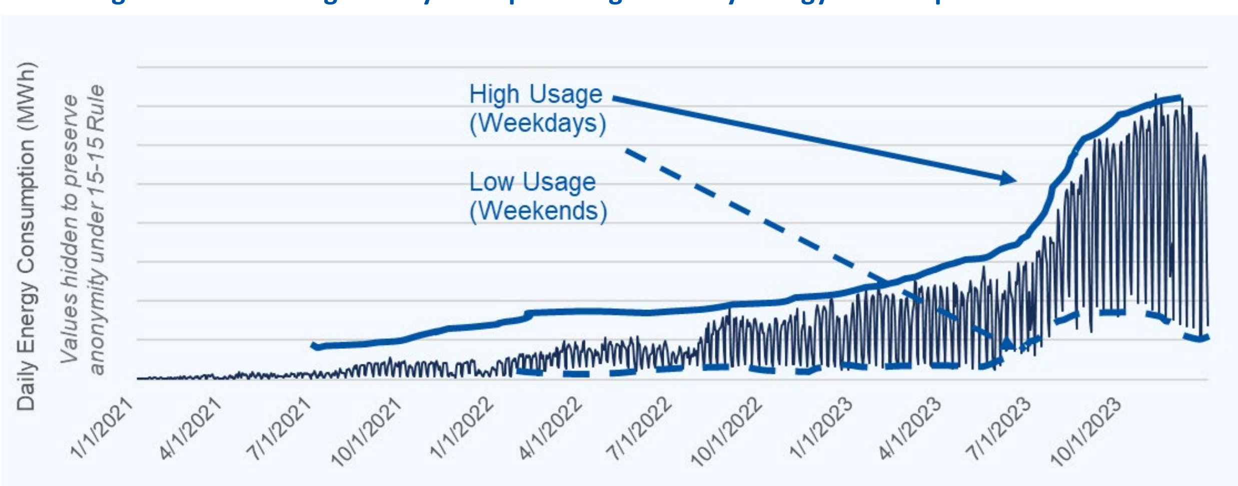
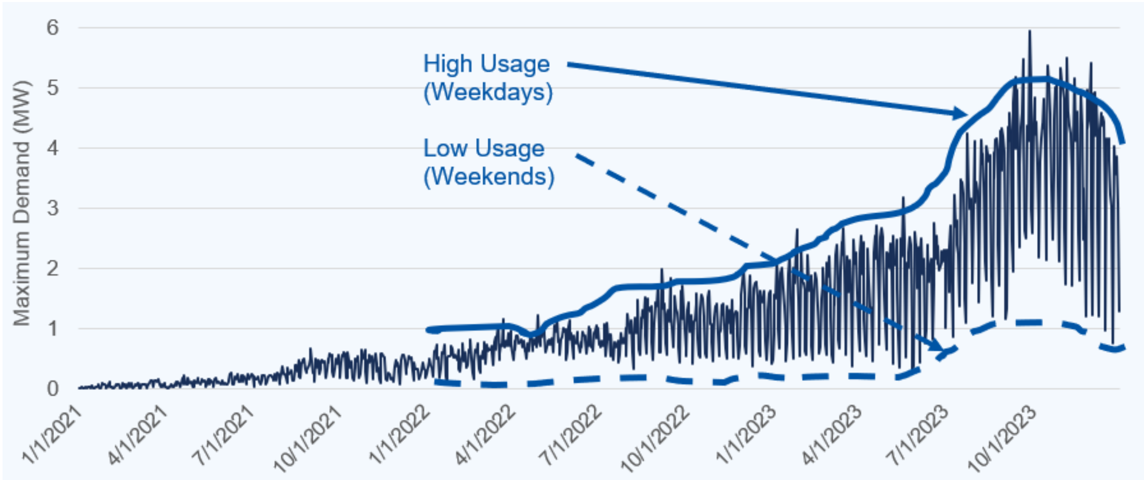
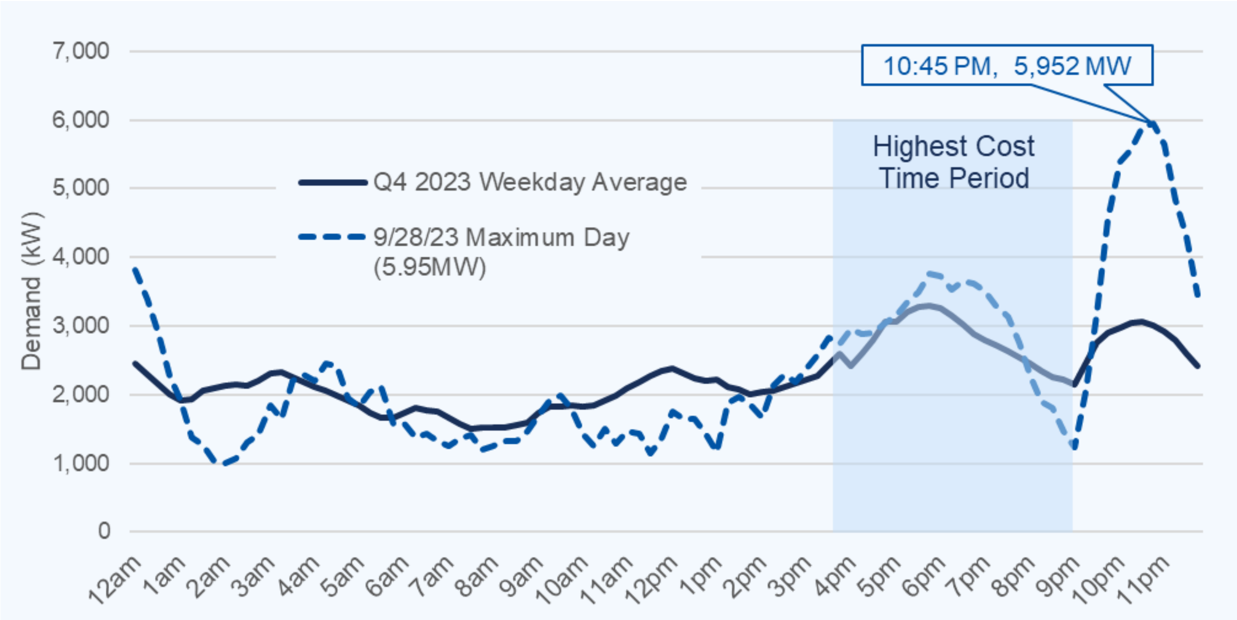


Figure 63. SCE Charge Ready Transport Program Daily Maximum Demand for PTD Sites



The final quarter of 2023 exhibited the most-consistent consumption (and demand) of the year at approximately 2,500 kW monthly. Figure 64 compares the day of highest demand (September 28, 2023) to the average weekday during that quarter. Both curves show increases at around 5 p.m. (when many fleets return to base) and at 9 p.m. (when fleets that are using load management start to charge). The prominence of the 9 p.m. peak typically varies throughout the week. Notably the demand at 9 p.m. on the day with the maximum demand is double that of an average day after 9 p.m. and shows significant curtailment from 7 p.m. to 9 p.m., with over 2 MW of demand shifting to after 9 p.m. This indicates that significant load has shifted from periods of peak demand and high energy prices (4 p.m. to 9 p.m.) to off-peak periods, likely through the implementation of load management practices on days with the highest overall demand.

Figure 64. SCE Charge Ready Transport Program
Highest Demand Day (9/28/23) and Q4 2023 Weekday Average Demand



Load Management and Charging Flexibility Analysis

This section describes analyses around load management and load flexibility. Load-managed sites are those that adopt techniques to avoid charging vehicles during periods of peak energy prices. The analyses consider sites to be load managed if they exhibited consistent load management regardless of when load management was implemented during the year; otherwise, they are labeled as non-load-managed.

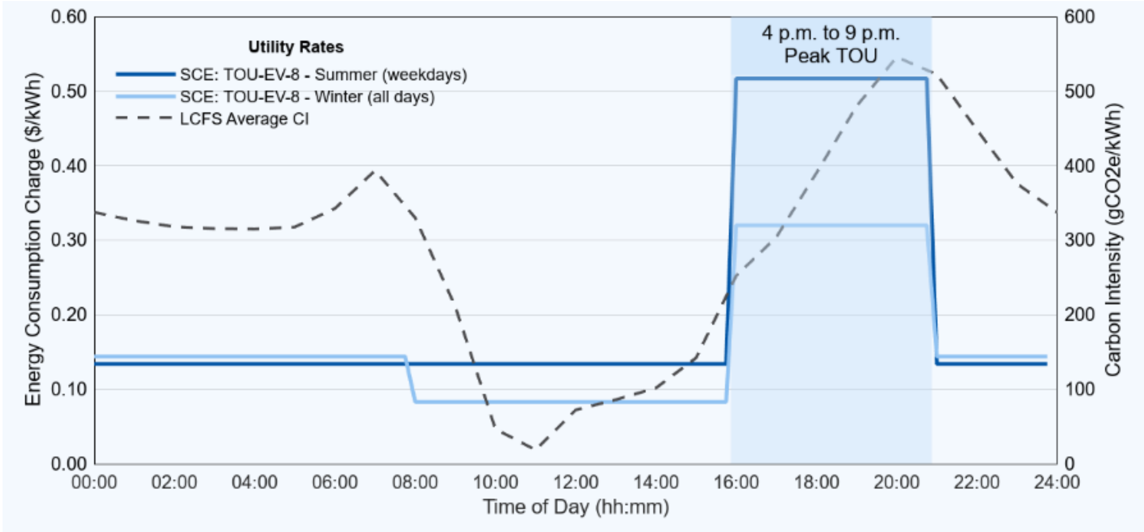
The peak TOU period (daily from 4 p.m. to 9 p.m.) for TOU-EV-8 and TOU EV-9 rate structures (20 kW to 500 kW and >500 kW demand respectively) in 2023 for SCE's Charge Ready Transport program, provides energy at costs ranging from $0.07 to $0.52 per kilowatt-hour depending on the season and time of day. Figure 65 displays these TOU rates for summer and winter weekdays. In many cases, lower-cost TOU periods correlate with lower carbon intensity of the grid, as indicated by the dashed line, which shows the 2023 annual hourly average carbon intensity (expressed as an hourly average across Q1–Q4 values) for generating credits using the LCFS Smart Charging mechanism with grid electricity in California.

What is Load Management?

Load Management is an effort to control vehicle charging for several purposes:

- Mitigation of electricity costs
- Participation in special programs (Demand Response or California Low Carbon Fuel Standard)
- Compensation for limited electrical capacity

Figure 65. SCE Charge Ready Transport Program Hourly TOU Electricity Rates and Average Carbon Intensity Used for Generating LCFS Credits in 2023



The Evaluation Team periodically reviews data on a site-by-site basis throughout the year to identify load-managed sites. Visiting sites in person and speaking to fleet managers also provides context around load management intent. SCE is different from the other Utilities in that its EV tariff does not currently include demand-related costs.

Of the 39 operational sites at the beginning of 2023, four sites appear to be using load management; another five sites began this practice in 2023, with two of the five starting near the end of the year (54 sites were operational at the end of 2023). This was evident in two ways:

- Load spiked quickly around 9 p.m.
- The proportion of total monthly energy consumption that was used between 4 p.m. and 9 p.m. was often below 10%.

The Evaluation Team assessed consumption trends for sites that had implemented load management and those that had not. Load-managed sites are sites that adopt techniques to avoid charging vehicles during periods of peak energy prices (4 p.m. to 9 p.m.). Figure 66 compares the average load curves of load-managed sites, non-load-managed sites, and overall site averages. The load-managed sites show an increasing proportion of consumption between 4 p.m. and 9 p.m. that peaks near the middle of both 2022 and 2023, likely representing new sites coming online. From mid-year on, these sites appear to have begun load management, resulting in a downward trend entering the latter part of both years. Notably, load from 4 p.m. to 9 p.m. grew from an average of 800 kW in 2022 to an average of 3,200 kW in 2023 (not shown in the figure).

Figure 66. SCE Charge Ready Transport Program Percentage of Monthly Consumption between 4 p.m. and 9 p.m. for PTD Sites

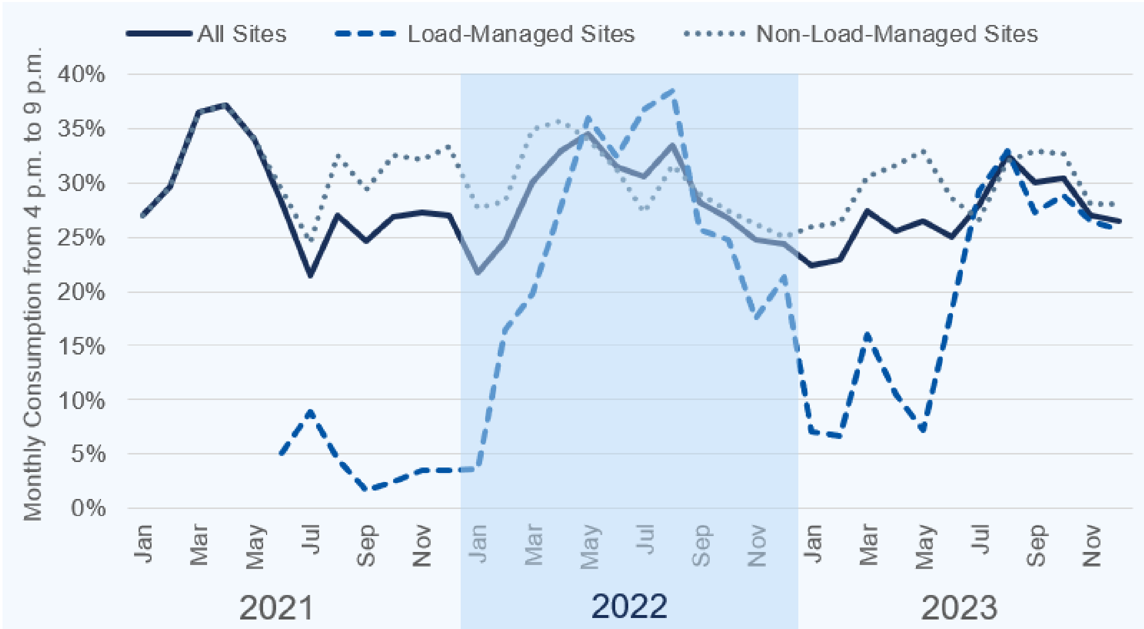


Figure 67 illustrates the differences in peak demand between load-managed and non-load-managed sites (determined using consumption data). Because few sites are currently using load management, the chart compares shapes rather than amplitudes. Figure 67 uses the months of August through October when load is highest. While the curve for the load-managed sites shows slightly increased demand from 4 p.m. to 9 p.m., it also clearly shows a peak after 9 p.m., indicating demand was avoided during the earlier period. Conversely, the curve for the non-load-managed sites spikes around 5 p.m., coincident with many fleet vehicles returning to base. Sites identified as using load management based on consumption trends are included in the EY2023 analysis as load-managed sites regardless of when its load management practice began. For example, if a site transitioned to load management in September, non-managed load for this site in August would impact the overall load curve for load-managed sites.

Figure 67. SCE Charge Ready Transport Program Load-Managed and Non-Load-Managed Site Demand, August 2023 through October 2023 (High Consumption and Demand Months), PTD Sites

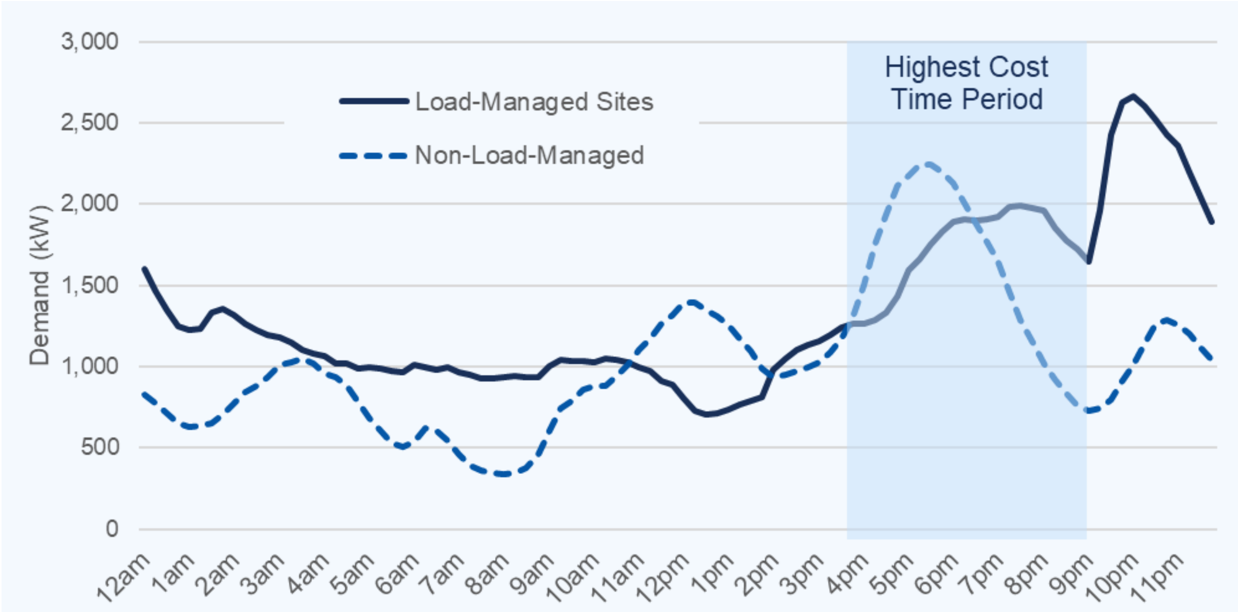
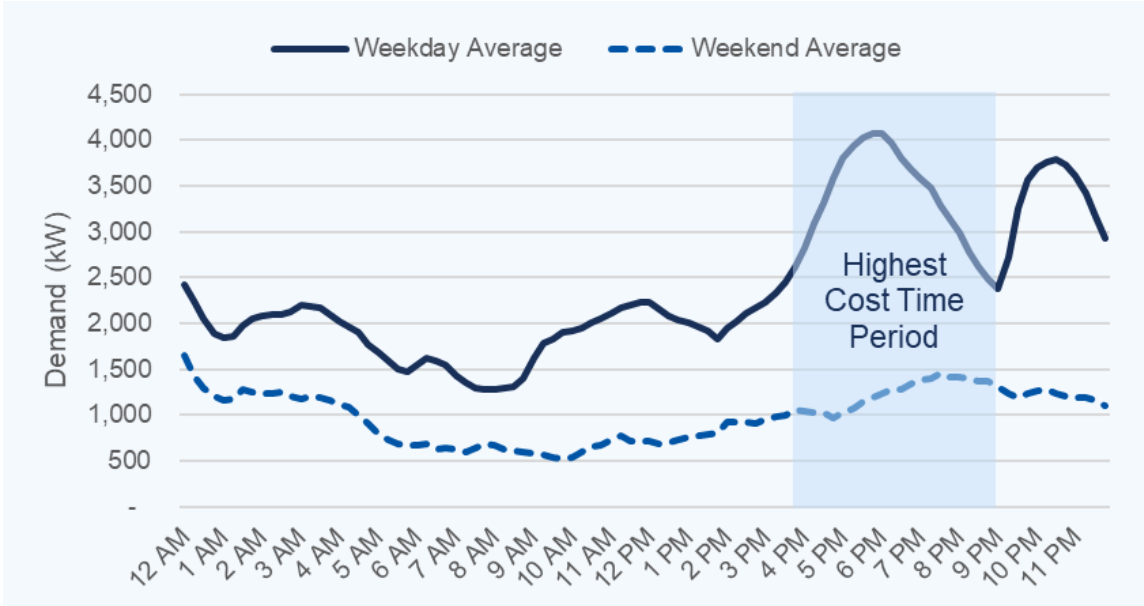


Figure 68 shows the average weekday and weekend daily load across all sites in the Charge Ready Transport program for the months of September through November, which have the highest demand. Most fleets exhibit higher consumption and demand on weekdays than on weekends because most fleets such as school buses and delivery trucks have little to no activity during weekends. However, some fleets such as transit buses may also operate on weekends, creating more consistent demand. Energy prices on both weekdays and weekends are highest during the period from 4 p.m. to 9 p.m.

Figure 68. SCE Charge Ready Transport Program Weekday and Weekend Daily Average Loads for PTD Sites from September 2023 to November 2023



This figure clearly shows a significant increase in demand starting at 9 p.m. for weekday operations, after the highest-cost and highest-demand time period has passed, indicating a portion of program sites are employing load management. At the same time, the lack of a demand peak after 9 p.m. on weekends suggests that most weekend operators are not currently using load management.

Charging Flexibility

The Evaluation Team used site charging data to determine the amount of time vehicles are connected to a charging port but not actively consuming energy. This allowed the Team to assess charging flexibility, or the ability for a vehicle to shift charging from periods of high-cost electricity to low-cost electricity without impacting vehicle operations. In addition, site visits allowed the Evaluation Team to confirm vehicles' make, model, and battery size, all of which affect charging flexibility. For instance, many school bus charging sessions use less than half of the vehicle's battery capacity. Providing feedback to operators about historical usage trends like charging session size in relation to battery size and available time to charge may help inform charging plans.

Figure 69 shows the relative charging flexibility of school bus and non-school bus fleets which represents the number of hours that fleet vehicles are connected to a charging port but not consuming electricity. Figure 69 uses only charging sessions that took place partially or entirely during periods of highest cost electricity and omits charging sessions that did not overlap with the period between 4 p.m. and 9 p.m.

Figure 69. SCE Charge Ready Transport Program Flexible Charging Availability for PTD Sites in Sessions Overlapping the Time Period Between 4 p.m. and 9 p.m.

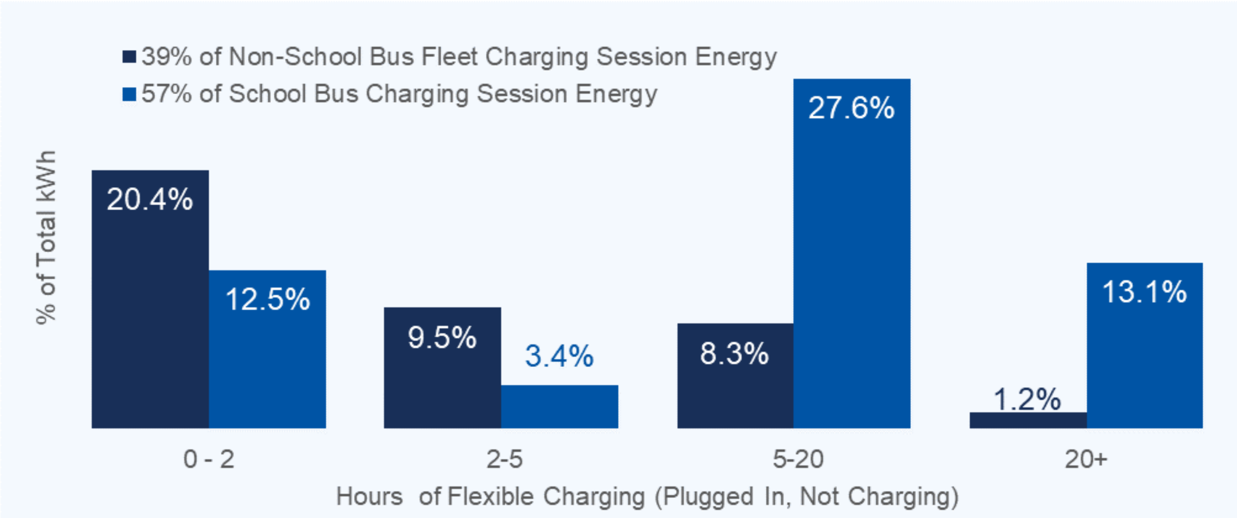


Figure 69 shows that 39% of non-school bus sessions and 57% of school bus sessions either started before and extended past 4 p.m. or started between 4 p.m. and 9 p.m. Some of these operators use load management, so their vehicles did not charge during that period; however, these sessions are relevant to the analysis of how much time a vehicle was connected but not drawing power.

Figure 69 also shows that a high proportion of energy from school bus charging sessions are from vehicles with enough flexibility to entirely avoid the highest-cost time period. As the period of highest-cost electricity lasts for five hours (4 p.m. to 9 p.m.), a vehicle with a charging period longer than five hours would need at least five hours of charging flexibility to fully shift consumption from on-peak to off-peak periods. However, vehicles with less than five hours of charging flexibility will benefit from adopting load management by shifting a portion of demand to periods of lower-cost electricity.

Although non-school bus fleets have less charging flexibility, they can benefit from charging management based on these results:

- Approximately 10% of all sessions have over five hours of flexibility, which is enough to avoid the high-cost time period.
- Portions of 30% of the non-school bus sessions have some flexibility to shift energy use.

Fleets operating a single shift are usually able to benefit the most from load management, while fleets operating multiple daily shifts face the most challenges to leveraging load management. However, those with more shifts often have significant energy consumption at all times of day, which somewhat reduces the proportion of charging during 4 p.m. to 9 p.m., resulting in comparatively lower average energy costs.

Costs and Billing

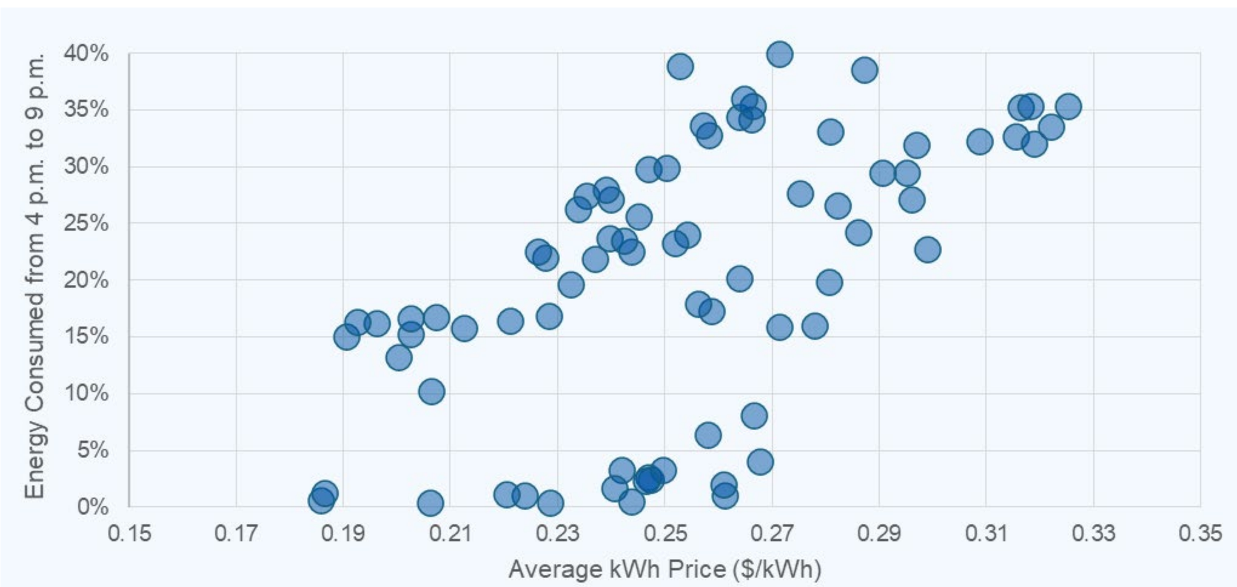
Previous sections have focused on energy trends and on charging flexibility that hints at how those trends could change in the future. The following sections discuss billing cost trends and to what extent those may improve based on charging flexibility. The Evaluation Team's review of billing data focuses on the average unit cost of a kilowatt-hour for a given site-billing month compared to the TOU-based tariff cost of energy.

NSPs' load management capabilities and fleets' adoption rate of load management impact costs and energy trends. Nearly every NSP involved in the Charge Ready Transport program provided reliable data; however, not all of these NSPs offered load management as a service on their platform as of the end of 2023. When provided, load management may be a base offering or tiered-cost package. Interoperability between hardware, software, and vehicles presents challenges that can make load management impractical or difficult to achieve.

Many fleet operators remain unaware of their energy use and charging costs even though most EVSPs make this data available. Often a site host's finance office will receive utility bills but will not share information with fleet operators that would enable them to compare energy costs with other fuel types in their fleets. The Evaluation Team uses energy trends as discussion points during site visits if operations have started. Many fleet operators said they had not seen these data trends prior to the evaluation site visits.

Figure 70 illustrates the positive relationship between percentage of on-peak energy consumption and the average monthly customer bills for sites billing more than 20 MWh (each dot represents a month) and highlights the potential financial opportunity to use load management to reduce costs.

Figure 70. SCE Charge Ready Transport Program Percentage of Monthly Energy Consumed from 4 p.m. to 9 p.m. vs. Average Energy Price for High Consumption Billing Months (>20 MWh) for PTD Sites



Billing months for fleets that consumed between 5 MWh and 20 MWh in a month also show a strong positive correlation between energy consumption from 4 p.m. to 9 p.m. and average unit pricing (Figure 71). This should provide further encouragement for fleets to focus on improving their load-management efforts. Many of these customers' bills show an average of $0.20 to $0.30 per kilowatt-hour, so cost savings of 30% for users averaging $0.40 or more per kilowatt-hour are likely achievable.

Figure 71. SCE Charge Ready Transport Program Percentage of Monthly Energy Consumed from 4 p.m. to 9 p.m. vs. Average Energy Price for Medium Consumption Billing Months (5 to 20 MWh) for PTD Sites

Fleets that used less than 5 MWh per month show a greater correlation between average unit pricing and overall monthly consumption. Figure 72 illustrates that sites with the lowest monthly energy consumption often have the highest electricity costs per kilowatt-hour. This can be attributed to fixed fees, which are spread across the total kilowatt-hours consumed and therefore have a greater impact on sites with lower total consumption. Figure 73 also shows a correlation between the proportion of consumption from 4 p.m. to 9 p.m. and average energy price as occurs with higher-energy users, highlighting the opportunity for low-energy users to reduce costs by using load management.

Figure 72. SCE Charge Ready Transport Program Monthly Kilowatt-Hours Consumed from 4 p.m. to 9 p.m. vs. Average Energy Price for Low-Consumption Billing Months (<5 MWh) for PTD Sites

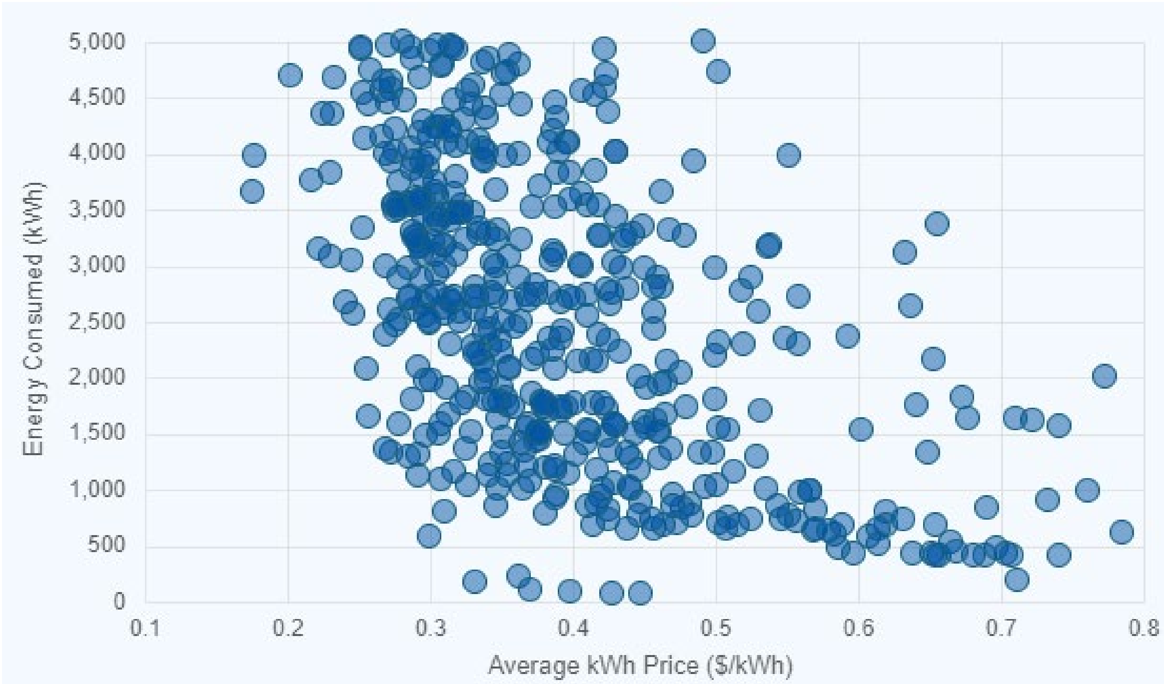
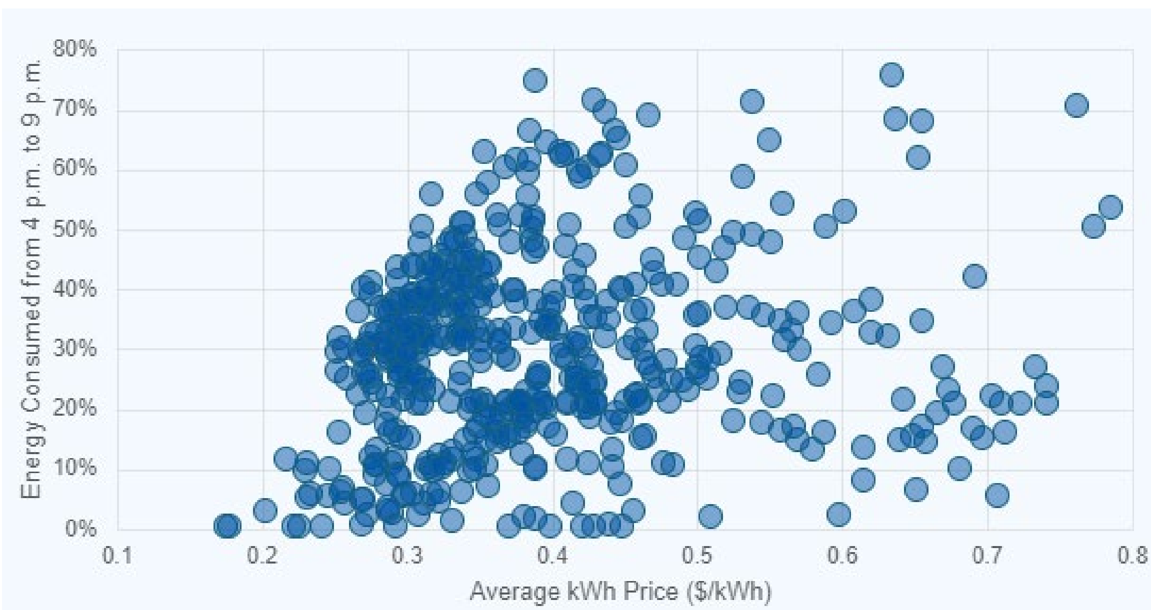


Figure 73. SCE Charge Ready Transport Program Percentage of Monthly Energy Consumed from 4 p.m. to 9 p.m. vs. Average Energy Price for Low Consumption Billing Months (<5 MWh) for PTD Sites



Electricity Cost and Emissions Optimization Analysis

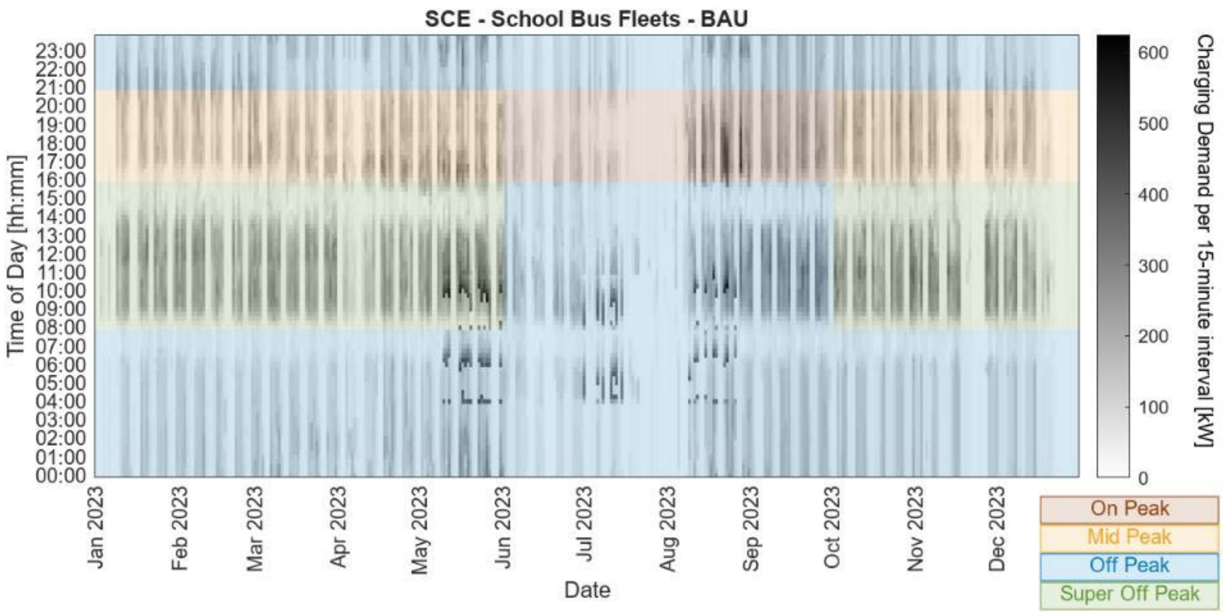
This section builds upon the grid impact findings above to include an analysis of hypothetical customer bills and emissions under an optimal load management scenario, assuming perfect load management across all sites. While real-world constraints—such as technology, operations, and education—currently prevent ideal load management, the findings shed light on the long-term potential of load management. To quantify the potential benefits of using load management, the Evaluation Team analyzed observed outcomes of sites with and without existing load management practices and conducted a load-shifting optimization exercise to estimate the total potential cost savings and emissions reductions. This analysis primarily uses NSP data to assess charging flexibility. Future efforts will extend this analysis to fleets without NSPs. *Appendix A* provides additional methodological notes.

Load Management Outcomes Observed in EY2023

The Evaluation Team assessed a subset of all PTD sites that had the necessary AMI and NSP data—a total of 33 Charge Ready Transport program sites. This analysis does not use data for all 54 operational sites in the Charge Ready Transport program to date, but only for those sites with AMI and NSP data that met analysis requirements. Of these 33 sites, 20 were school bus sites and 13 were from other market sectors, including transit bus, medium-duty vehicle, and heavy-duty vehicle.

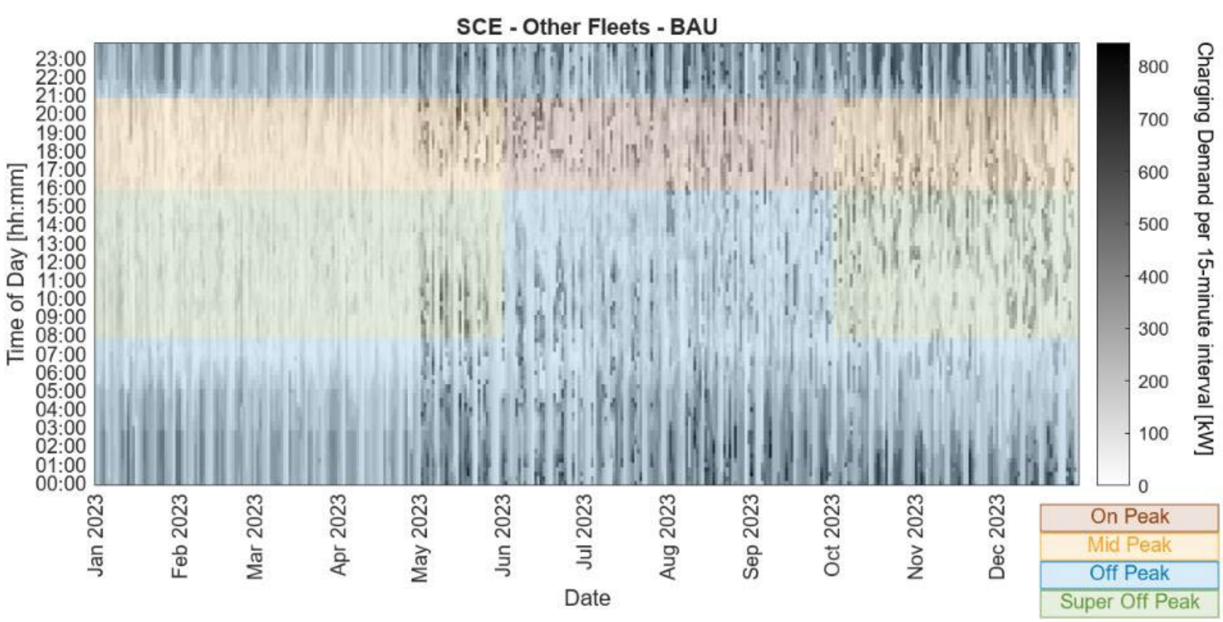
Figure 74 and
Figure 75 depict the business-as-usual (BAU) historical energy consumption of school bus and non-school bus fleets in aggregate during 2023. BAU is the current charging behavior of the 33 sites represented in this analysis. In Figure 74 and
Figure 75, the areas with darker shading area indicate those times of day (y-axis) and days throughout the year (x-axis) when charging demand is the highest. Areas with no shading represent no energy demand. School bus fleets show a relatively consistent trend of charging twice per day: first during the school day, then again once school is out for the day and buses complete afternoon runs. This spread generally coincides with higher TOU rates. Demand is visibly lower during the winter holiday, spring break, and summer vacation periods, when many schools are not in session.

Figure 74. SCE Charge Ready Transport Program Heatmap of the Collective BAU Charging Demand for All SCE School Bus Fleets in 2023



Dark shading intensity indicates average charging demand (kW) per 15-minute interval.
Colored regions indicate TOU periods.

Figure 75. SCE Charge Ready Transport Program Heatmap of the Collective BAU Charging Demand for All SCE Non-School Bus Fleets in 2023

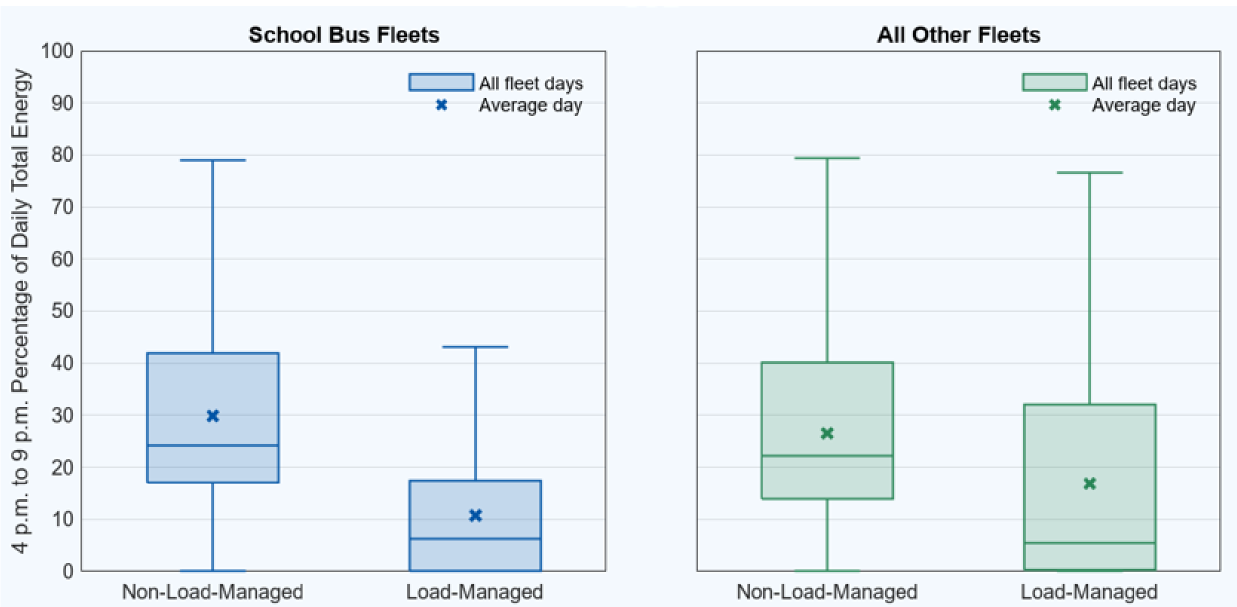


Dark shading intensity indicates average charging demand (kW) per 15-minute interval.
Colored regions indicate TOU periods.

The Evaluation Team compared NSP sessions under load management strategies to non-load-managed sessions for the school bus and non-school bus fleets in this analysis. This helps to identify how effective existing load management strategies are at shifting energy use away from 4 p.m. to 9 p.m.

Figure 76 shows the percentage of each day's energy consumption occurring during the peak TOU period. Non-load-managed school buses average 30% of consumption between 4 p.m. and 9 p.m. On the average load-managed day, average consumption drops significantly to 10% of overall consumption. For other market sectors (shown on the right), the average non-load-managed day has over 25% of consumption during the peak TOU period, compared to just over 15% for load-managed days. These comparisons help guide the Team's estimates of how much energy from non-load-managed days (and fleets) can shift to potentially save money and emissions.

Figure 76. SCE Charge Ready Transport Program Distribution of the Fraction of Daily EV Charging Load Occurring in the Peak TOU Period



The box and whisker plot represents the distribution of daily total energy consumed from 4 p.m. to 9 p.m. across one operating day by group, and diamonds indicate the average value for all operating days per group.

This analysis suggests that existing load management programs reduce the fraction of energy consumed between 4 p.m. and 9 p.m. and by that reduce the energy costs. However, outcomes vary substantially across sites (both load-managed and non-load-managed), suggesting that the value of load management depends on each site's operating patterns, charging flexibility, and chosen implementation of load management controls.

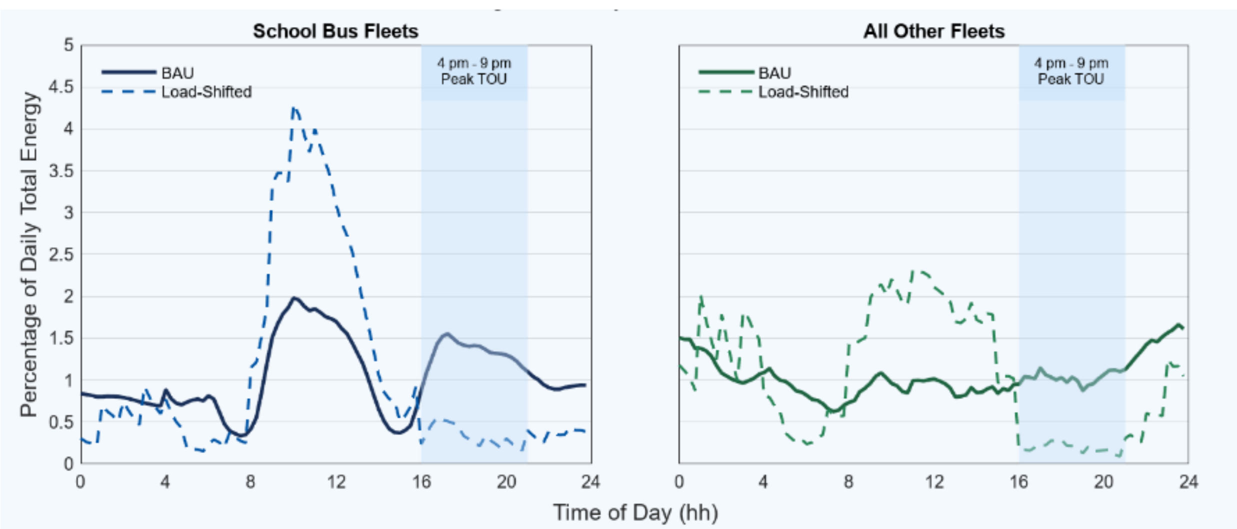
Potential Benefits of Optimal Load Management

The Evaluation Team analyzed AMI and NSP data to estimate the potential value of optimal load management, considering each site's observed operating patterns and potential ability to shift vehicle charging loads. This analysis included only days with energy consumption recorded in NSP charging session data. On average, each SCE school bus site had 224 such days, while SCE sites in other market sectors had 214 such days (reflecting that vehicle fleets operate only on certain days and that some sites had only partial-year data).

The Evaluation Team developed and executed an optimization routine for each included operating day. This optimization shifted each site's energy consumption from the peak time period from 4 p.m. to 9 p.m. into the lowest-cost hours of the day whenever there was both unused charging capacity and vehicle charging availability during those hours. For hours in the same TOU rate period, the Team used emissions intensity (measured as CARB LCFS carbon intensity factors for smart charging programs) and BAU charging load as tiebreakers to determine vehicle charging priorities. The Evaluation Team used NSP charging session data to ascertain how many vehicles were plugged in and how many kilowatt-hours of energy could be shifted during each time period.

Figure 77 illustrates how optimally shifted loads differ from BAU loads, averaged across EY2023. For both school bus and other market sector sites, the average day's load can be almost completely shifted out of the high-cost 4 p.m. to 9 p.m. window and into midday charging (8 a.m. to 4 p.m.). This time period offers the lowest energy consumption costs (off-peak during summer months, super-off-peak during winter months) and roughly corresponds to the lowest average carbon intensity of grid electricity.

Figure 77. SCE Charge Ready Transport Program Fraction of Daily EV Charging Load Occurring at Each 15-Minute Interval for the Average Day in this Analysis



Note: Line color indicates site market sector and dashed versus solid lines indicate whether the load is BAU or shifted.

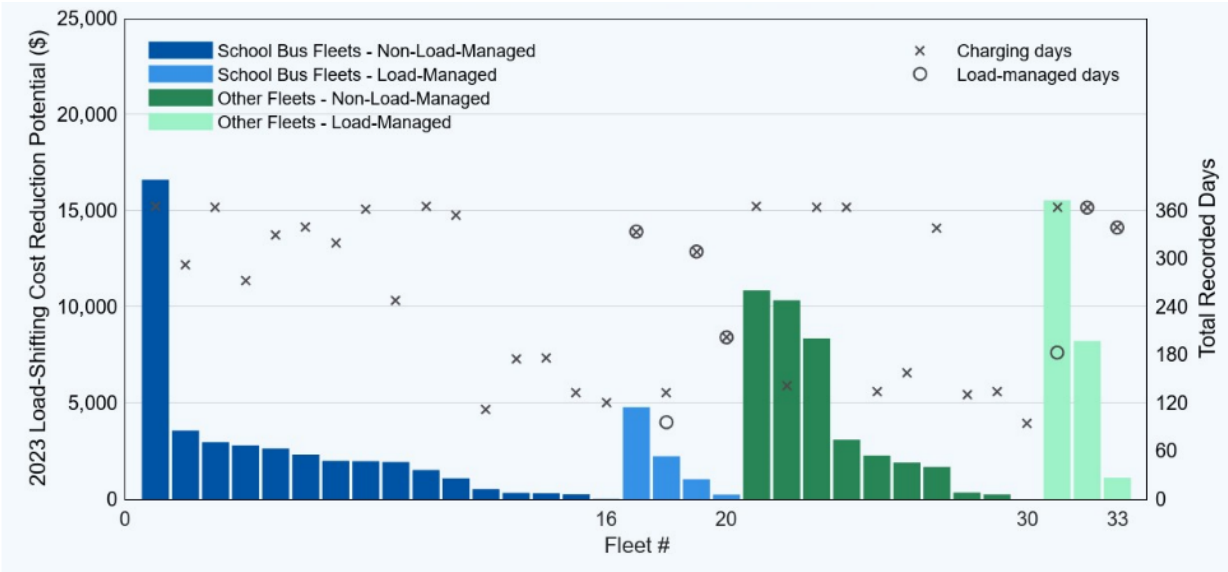
The Evaluation Team estimated the cost reduction potential of this daily load shifting, within the following context:

- This analysis considers only the volumetric (cost per kilowatt-hour) component of each site's electricity costs. Optimal load management has the potential to also reduce demand charge subscriptions, which could impact costs especially in lower-volume months. The cost-minimization approach developed in this analysis ensures that peak demand does not increase but does not yet consider potential cost savings resulting from demand reduction.

- These results reflect only the portion of the year in which each fleet operated and provided charging data; annualized projections of these cost reductions could be substantially higher for fleets that have less than a full year of charging data included in this analysis or that have not yet reached mature operations.
- These results reflect only the portion of each site's vehicle fleet that it electrified in EY2023. A fully electrified vehicle fleet would see higher cost reduction potential from load management.
- This analysis considers the cost-saving potential of load management, but it does not consider the potential of load management to generate revenue via LCFS Smart Charging credits.
- This analysis examined the actual charging behavior at each site (using actual recorded plug-in and unplug times) to determine charging opportunities and does not account for other operational or scheduling improvements for charging electrified fleets, which could enable more-effective load management, resulting in higher potential cost reduction.

Figure 78 shows the cost reduction potential for each site in total dollars per year. Potential reductions in annual energy costs are as high as $16,700 for non-load-managed school bus sites and as high as $10,900 for non-load-managed sites in other market sectors. Sites with load management still have cost reduction potential ranging from $200 to $4,800 in the school bus market sector and from $1,100 to $15,500 in other market sectors. This unrealized potential may reflect inconsistent use of load management controls by fleets, variation in effectiveness of load management controls across vendors, or risk-averse preferences of fleet managers to charge as soon as possible upon each vehicle's return to base. This analysis suggests room for improvement in realizing the full benefits of smart charge management. A total of 33 sites (as opposed to all PTD sites) had enough NSP data to be considered for this particular analysis.

Figure 78. SCE Charge Ready Transport Program 2023 Load Shifting Cost Reduction Potential of Each Site if it Used Optimal Load Management



Each bar represents one site. Bar colors indicate the site's market sector and whether it uses load management.

Because lower-cost TOU periods often correspond to periods with relatively low carbon intensity estimates for grid electricity, optimizing load management for energy cost savings can have a secondary effect of reducing the resulting carbon emissions. Figure 79 shows estimated cost reductions and corresponding GHG emissions reductions for each site resulting from a cost-minimizing load-management strategy (considering carbon intensity only as a tiebreaking factor when there is sufficient charging flexibility). In general, across sites, shifting charging load to reduce costs shows the potential to reduce GHG emissions by an even greater percentage than costs.
Table 37 aggregates these results across the included sites. Overall, optimal load shifting could reduce school bus sites' collective energy consumption costs by 32.7% and attributed electricity grid GHG emissions by 54.1%; for other market sectors, it could reduce energy consumption costs by 23.9% and attributed electricity grid GHG emissions by 33.2%.

Figure 79. SCE Charge Ready Transport Program Potential Percentage Cost Reduction and Attributed GHG Emissions Reduction of Optimal Load Management

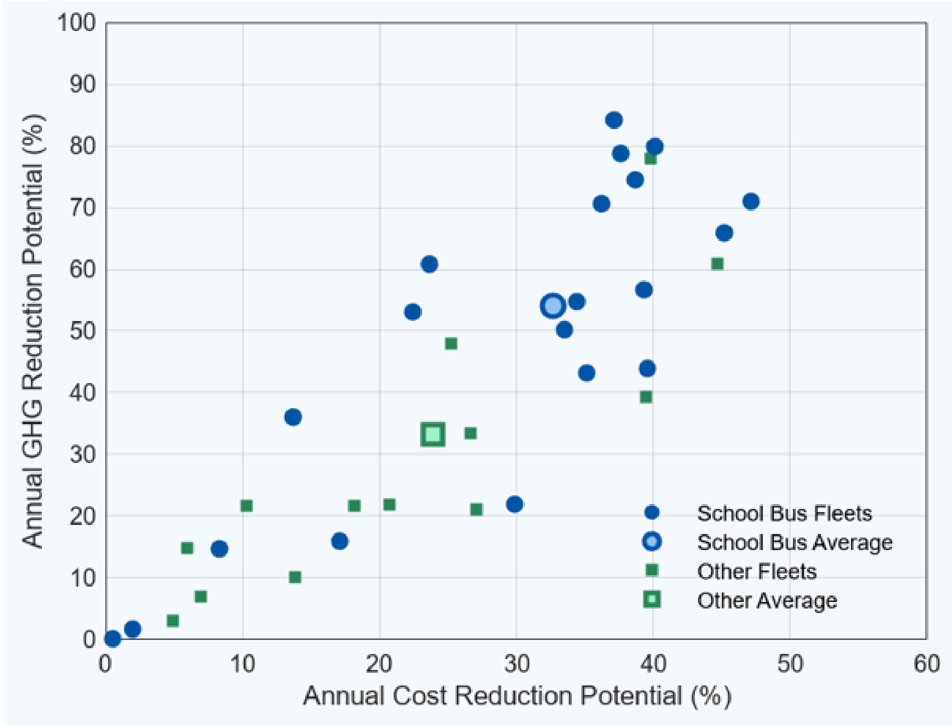


Table 37. SCE Charge Ready Transport Program Summary of Potential Cost and Attributed GHG Emissions Reductions, Aggregated across All Included Fleets

SCE	School Bus Fleets	All Other Fleets	All Fleets Combined
Total number of fleets	20	13	33
Total count of 2023 operating days	5,307	3,291	8,598
Cost Reduction Potential (%)	32.7%	23.9%	27.1%
GHG Reduction Potential (%)	54.1%	33.2%	39.7%

Highlights

- Charging data indicates that there is significant opportunity for most fleets to shift their charging energy use to lower-cost time periods.
- Sites activated in EY2021 have displayed consistent operations in 2022 and 2023, possibly showing maturity in their operations.
- Newly operational sites in EY2023 increased overall demand by over 250% from EY2022.
- Interoperability between hardware, software, and vehicles presents a significant challenge to load management in addition to the lack of education and awareness.
- Nearly 60% of school bus charging sessions overlapped the 4 p.m. through 9 p.m. peak-cost period but have enough flexibility to delay charging to lower-cost time periods with effective load management. Other market sectors also show significant opportunity for load shifting.
- The number of load-managed sites grew from 4 in EY2022 to 9 in EY2023 out of 55 PTD activated sites.
- Although 40% of sites began vehicle charging within 30 days of power availability, more than 30% took over 120 days, often driven by supply chain issues.

Petroleum Displacement

The Evaluation Team estimated the petroleum displacement attributable to vehicle electrification enabled by SCE's Charge Ready Transport program. The Team used DGE for reporting purposes. However, as the transit bus market sector primarily uses CNG fuel, the Team needed to convert transit bus natural gas consumption into DGE units based on the CNG fuel's energy content.

Table 38 presents petroleum displacement impacts for the Charge Ready Transport program through 2023, including estimated actual impacts for 2023, actual impacts for PTD sites, and a 10-year forecast for PTD sites. The results include the five market sectors represented in the program, with the majority of vehicles in the heavy-duty vehicle sector followed by the transit bus sector. The PTD usage is over 9.5 million electric miles, estimated based on electricity consumption of nearly 18,000 kWh. This translates into the displacement of over 1.5 million DGE.

Table 38. SCE Charge Ready Transport Program Petroleum Displacement Summary

Market Sector	Usage (n=54)				Petroleum Displacement (DGE)		
	2023 Actual[a] kWh	PTD Actual[b] kWh	2023 Actual Use	PTD Actual Use	2023 Actual	PTD Actual	10-Year Projection
Forklift					327	327	4,931
Heavy-Duty Vehicle					489,261	526,760	8,968,444
Medium-Duty Vehicle					212,390	333,353	1,203,022
School Bus		2,771,146		2,148,099 miles	141,729	235,596	1,399,432
Transit Bus					173,771	340,205	1,415,489
TRU					49,948	90,917	267,732
Total	**12,904,543**	**17,742,352**	**6,925,554 miles 67,812 hours**	**9,632,226 miles 123,175 hours**	**1,067,426**	**1,527,157**	**13,259,050**

Market Sector	Usage (n=54)				Petroleum Displacement (DGE)		
	2023 Actual[a] kWh	PTD Actual[b] kWh	2023 Actual Use	PTD Actual Use	2023 Actual	PTD Actual	10-Year Projection

[a] "2023 Actual" represents the data from all activated sites from program inception for the calendar year 2023.

[b] "PTD Actual" represents the data from all activated sites from program inception for all program years.

Highlights

- All operational sites in 2023 collectively achieved a PTD impact of over 1.5 million gallons of petroleum displaced.
- The heavy-duty vehicle sector accounted for nearly half of the petroleum displaced in 2023 and is projected to account for more than two-thirds of the petroleum displaced over 10 years.
- Over a 10-year period, the currently operational sites will displace more than 13 million gallons of petroleum.

Greenhouse Gas and Criteria Pollutant Impacts

The Evaluation Team calculated reduced emissions from displaced fossil fuel use from ICE vehicles that were not in service because of the Charge Ready Transport program. First, we developed ICE counterfactual equivalents for each market sector, and then we calculated the emissions associated with these vehicles under conditions that otherwise matched the EVs, which provided a baseline. Although EVs have no tailpipe emissions, the mix of generation sources from the electric grid used includes renewable as well as fossil fuel power to supply electricity to the charging stations, with the latter primarily responsible for emitting GHGs and criteria pollutants into the atmosphere.

Table 39 shows GHG impacts estimates from the Charge Ready Transport program for three time periods: (1) estimated reductions that reflect what program sites saved in 2023, (2) PTD reductions from all sites, and (3) a 10-year projection based on annualized data from all sites.

Table 39. SCE Charge Ready Transport Program GHG Reductions Summary

Market Sector	Usage (n=54)				GHG Reduction (MT)		
	2023 Actual[a] kWh	PTD Actual[b] kWh	2023 Actual Use	PTD Actual Use	2023 Actual	PTD Actual	10-Year Projection
Forklift					3	3	43
Heavy-Duty Vehicle					3,698	3,981	73,074
Medium-Duty Vehicle					1,489	2,323	9,141
School Bus		2,771,146		2,148,099 miles	1,189	1,985	12,127
Transit Bus					1,211	2,359	10,138
TRU					464	846	2,552
Total	**12,904,543**	**17,742,352**	**6,925,554 miles 67,812 hours**	**9,632,226 miles 123,175 hours**	**8,052**	**11,497**	**107,075**

[a] "2023 Actual" represents the data for EY2023 from all sites activated in the program to date.

[B] "PTD Actual" represents the data from all activated sites from program inception for all program years.

Table 40 shows estimated local tailpipe emissions from ICE vehicles that the Charge Ready Transport program displaced. The transit bus sector showed the highest reduction in CO emissions due to the assumption that the displaced buses ran on CNG. In addition, our analysis confirmed that TRU and heavy-duty vehicle sites can achieve significant savings due to the poor emissions profile of diesel-powered TRU and yard tractors.

Table 40. SCE Charge Ready Transport Program Local Emissions Reductions, PTD Actual

Market Sector	PTD Actual[a] (n=54)				
	HC (kg)	PM_{10} (kg)	$PM_{2.5}$ (kg)	ROG (kg)	CO (kg)
Forklift	0.3	0.4	0.4	0.4	18.1
Heavy-Duty Vehicle		45.9	43.9	133.6	1,696.3
Medium-Duty Vehicle		5.1	4.7	33.5	8,982.1
School Bus	–	4.8	4.6	21.4	615.7
Transit Bus	–	0.6	0.6	82.0	65,966.2
TRU	229.4	26.9	24.8	2,029.2	254.8
Total	**229.7**	**83.8**	**79.0**	**2,300.1**	**77,533.2**

[a] "PTD Actual" represents the data from all activated sites from program inception for all program years.

Table 41 shows the same information as Table 40 for 2023 actual. These are the localized emissions reductions that occurred based on actual Charge Ready Transport program operations this year.

Table 41. SCE Charge Ready Transport Program Local Emissions Reductions, 2023 Actual

Market Sector	2023 Actual[a] (n=54)				
	HC (kg)	PM_{10} (kg)	$PM_{2.5}$ (kg)	ROG (kg)	CO (kg)
Forklift	0.3	0.4	0.4	0.4	18.1
Heavy-Duty Vehicle	–	42.7	40.9	125.0	1,588.7
Medium-Duty Vehicle	–	3.3	3.0	21.2	5,613.2
School Bus	–	2.9	2.8	13.0	371.5
Transit Bus	–	0.3	0.3	41.8	33,609.7
TRU	158.8	15.8	14.6	1,366.4	176.4
Total	**159.2**	**65.5**	**62.0**	**1,567.7**	**41,377.6**

[a] "2023 Actual" represents the data for EY2023 from all sites activated in the program to date.

Table 42 provides estimates of savings over the 10-year period. These are the annualized emissions reductions from all program to date sites extended over a decade.

Table 42. SCE Charge Ready Transport Program Local Emissions Reductions, 10-Year Projection for PTD Sites

Market Sector	PTD Sites 10-Year Projected Impact (n=54)				
	HC (kg)	PM_{10} (kg)	$PM_{2.5}$ (kg)	ROG (kg)	CO (kg)
Forklift	8.1	6.6	6.1	9.9	295.5
Heavy-Duty Vehicle	–	1,179.2	1,128.1	2,878.9	36,830.8
Medium-Duty Vehicle	–	21.3	19.9	119.0	26,705.2
School Bus	–	32.9	31.5	143.0	3,922.7
Transit Bus	–	2.9	2.8	342.4	275,718.7
TRU	2,119.8	129.9	119.5	20,719.1	2,355.4

Market Sector	PTD Sites 10-Year Projected Impact (n=54)				
	HC (kg)	PM_{10} (kg)	$PM_{2.5}$ (kg)	ROG (kg)	CO (kg)
Total	**2,128.0**	**1,372.8**	**1,307.9**	**24,212.2**	**345,828.3**

Table 43 shows counterfactual vehicle GHG emissions, emissions from the electricity used to charge the EVs, GHG emissions reductions, and percentage differences. Table 44 shows the net reductions of NO_x emissions from using EVs based on the counterfactual and Utility emissions. The Evaluation Team estimated a total annualized GHG reduction of 74% and a NO_X reduction of 78% from the use of EVs compared to counterfactual vehicles for EY2023 Sites. Reviewing the program to date reveals an estimated 77% actual reduction in GHG emissions and 75% reduction in NO_x emissions.

Table 43. SCE Charge Ready Transport Program Counterfactual GHG Reductions

Market Sector	EY2023 Sites Annualized GHG (MT) (n=15)				PTD Sites GHG (MT) (n=54)			
	Counter factual	Utility	Reduction	% GHG Reduction	Counter factual	Utility	Reduction	% GHG Reduction
Forklift	5.5	1.0	4.5	82%	3.3	0.6	2.7	81%
Heavy-Duty Vehicle	8,747.8	2,281.9	6,465.8	74%	5,515.9	1,535.0	3,980.9	72%
Medium-Duty Vehicle	164.7	29.7	134.9	82%	2,858.3	535.4	2,322.9	81%
School Bus	709.4	161.7	547.6	77%	2,492.5	507.3	1,985.2	80%
Transit Bus	81.3	17.6	63.7	78%	2,973.7	614.3	2,359.4	79%
TRU	35.4	5.7	29.6	84%	1,018.5	172.7	845.8	83%
Total	**9,744.0**	**2,497.7**	**7,246.3**	**74%**	**14,862.3**	**3,365.4**	**11,496.9**	**77%**

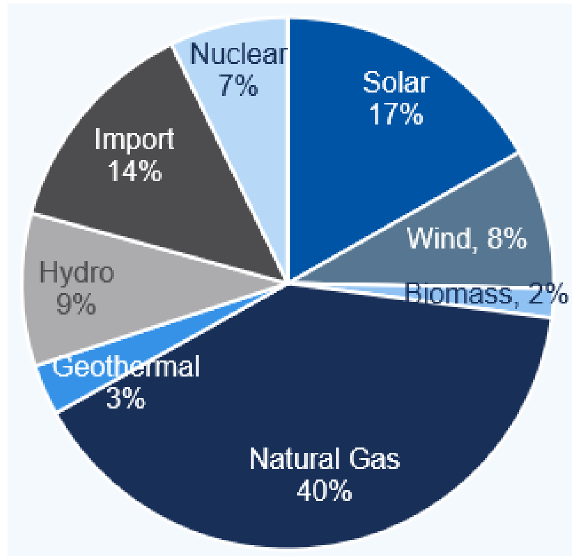
Table 44. SCE Charge Ready Transport Program Counterfactual NO_x Reductions

Market Sector	EY2023 Sites Annualized NO_x (kg) (n=15)				PTD Sites NO_x (kg) (n=54)			
	Counter factual	Utility	Reduction	% NO_x Reduction	Counter factual	Utility	Reduction	% NO_x Reduction
Forklift	7.1	1.0	6.1	86%	4.3	0.6	3.7	86%
Heavy-Duty Vehicle	9,762.3	2,133.8	7,628.5	78%	5,798.3	1,421.8	4,376.5	75%
Medium-Duty Vehicle	141.4	28.2	113.1	80%	341.0	513.5	(172.5)	None
School Bus	615.3	149.8	465.5	76%	2,218.3	476.2	1,742.0	79%
Transit Bus	3.9	16.5	(12.6)	None	149.7	570.9	(421.2)	None
TRU	140.4	5.5	134.9	96%	3,995.0	161.9	3,833.2	96%
Total	**10,670.3**	**2,334.7**	**8,335.6**	**78%**	**12,506.5**	**3,144.8**	**9,361.8**	**75%**

Figure 80 shows the annual program net electricity generation mix matching the hours when the EVs were charging. The California Independent System Operator (CAISO) grid mix continually changes depending on factors such as the level of total demand for power on the grid and the availability of fossil generation and variable renewable resources such as solar.

At this stage of the program, it appears that the vehicles were not predominantly charging during the peak hours of solar output when grid emissions were the lowest. Approximately 14% of the grid mix comprises electricity imports, which do not vary by time of day for analysis purposes but match the resource mix purchased for the California grid.[59]

Figure 80. SCE Charge Ready Transport Program Net Electricity Mix, Program to Date

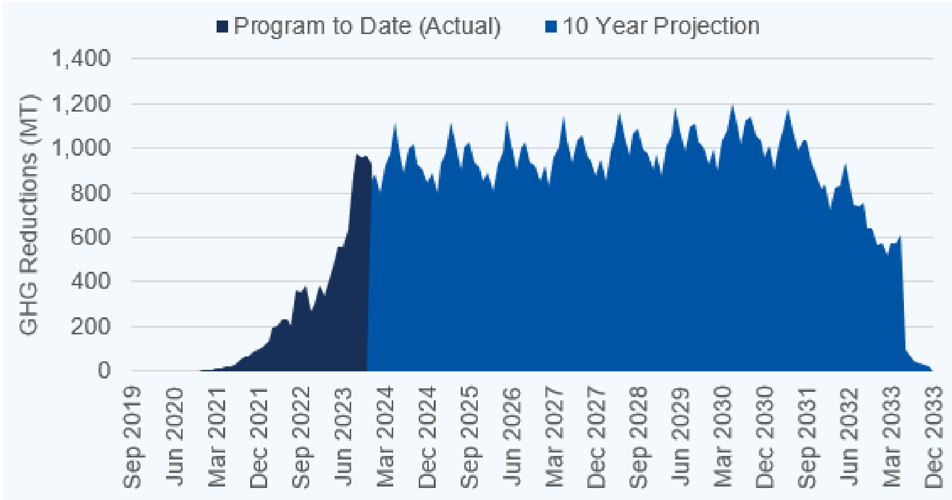


Based on the real-time grid conditions when charging occurred, the overall energy mix comprised 46% zero-emissions or renewable sources of electricity (including solar, wind, hydro, geothermal, biomass, and nuclear) and 40% natural gas. The Evaluation Team expects that emissions reductions from these sites over 10 years will increase as the grid becomes cleaner. Additionally, the increased use of managed charging, where possible, will reduce emissions as EVs charge at off-peak times and when the grid is supplied with greater amounts of renewable generation. Emissions will further decrease with the addition of more charging sites and EVs in future evaluation years.

Figure 81 shows how program GHG reductions have increased to date and are likely to grow over time for all active sites. The analysis period ranges from activation date of the first site in the program through the end of 2023. The analysis incorporates the net reduction (counterfactual emissions minus utility emissions) for each fleet within the SCE Charge Ready Transport program. PTD emissions reductions appear in dark navy while anticipated benefits based on annualization appear in royal blue. As each site has its own starting date of operation, the 10-year sunset for each appears as a gradual tapering off of program benefits between 2030 and 2033. While each year's operations appear similar, there are several key factors driving the variations such as seasonality of utility generation sources (high utility emissions will appear as a dip on the curves), holidays occurring on weekends versus weekdays, and sites that became operational late in 2023 having predicted operations year-round in future years.

[59] The power associated with imports comes from a mixture of renewables, hydro, nuclear, and natural gas power plants located outside of California (https://www.energy.ca.gov/data-reports/energy-almanac/california-electricity-data/2021-total-system-electric-generation).

Figure 81. SCE Charge Ready Transport Program Historical and Forecasted GHG Reductions for PTD Sites



Highlights

- PTD results show a 77% reduction in GHGs and a 75% reduction in NOx emissions.
- The greatest reduction in local emissions was CO with more than 41,000 kg in 2023 and a projected 10-year reduction of more than 345,000 kg.
- Based on the real-time grid conditions when the EV charging occurred, the overall energy mix contained about 46% zero-emissions or renewable sources of electricity (including solar, wind, hydro, geothermal, biomass, and nuclear) and 40% natural gas.

Health Impacts

The Evaluation Team calculated public health impacts (as benefits and costs) of reductions in criteria pollutants from vehicle electrification. The pollutants we included in the analysis are primary $PM_{2.5}$ and precursors of secondary $PM_{2.5}$, including NO_x, sulfur dioxide (SO_2), ammonia (NH_3), and VOCs. The analysis considers only tailpipe emissions reductions rather than full lifecycle emissions (such as power plant emissions). The Evaluation Team used the EPA CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA) to evaluate the health benefits associated with the emissions reductions. COBRA estimates the county-level benefits for the county in which emissions are reduced. It also estimates the effect of the transport of emissions on all counties in the United States; however, this analysis includes only the effects of the emissions reductions in California. The Evaluation Team disaggregated the county-level effects to estimate the potential health benefits of sites for DACs and non-DACs.

Economic value depends on the health effects associated with the emissions, that is, whether they are associated with illnesses or death. The monetary value of the morbidity reductions associated with emissions reductions include avoided lost wages, avoided medical costs, and the amount of money people are willing to pay to avoid an illness or condition like respiratory disease. The value of the reduced mortality associated with emissions reduction is measured by the value of a statistical life, which uses value-of-life studies to determine a monetary value of preventing premature mortality. COBRA reports both a low and high impact, representing the uncertainties in the estimates.

The total value of the health benefits associated with emissions reductions is between $408,218 and $916,171. Table 45 shows the cumulative health benefits in California associated with the emissions reductions realized by the electrification of SCE Charge Ready Transport sites in EY2023.

Table 45. SCE Charge Ready Transport Program California Health Benefits for EY2023 Sites

Health Endpoint	Change in Incidence (Annual Cases)		Monetary Value (Annual, 2023 Dollars)	
	Low	High	Low	High
Mortality	0.030	0.067	$400,330	$906,174
Avoided Medical Care				
Nonfatal Heart Attacks	0.001	0.013	$254	$2,363
Infant Mortality	< 0.000	< 0.000	$2,297	$2,297
Hospital Admits, All Respiratory	0.006	0.006	$334	$334
Hospital Admits, Cardiovascular	0.006	0.006	$380	$380
Acute Bronchitis	0.053	0.053	$40	$40
Upper Respiratory Symptoms	0.954	0.954	$50	$50
Lower Respiratory Symptoms	0.670	0.670	$22	$22
Emergency Room Visits, Asthma	0.011	0.011	$8	$8
Asthma Exacerbation	0.991	0.991	$90	$90
Lost Productivity				
Minor Restricted Activity Days	29.474	29.474	$3,178	$3,178
Work Loss Days	5.011	5.011	$1,234	$1,234
Total Health Effects	–	–	**$408,218**	**$916,171**

At the site level, the heavy-duty vehicle market sector has the highest health benefits overall, accounting for 93% of the monetary value from benefits. The school bus market sector accounted for 6% of health benefits, followed by the medium-duty vehicle (1%), transit bus (< 1%), and TRU (< 1%) market sectors.

As part of this analysis, the Evaluation Team also examined health benefits within DACs, which may be disproportionately burdened by sources of pollution (including air pollution from ICE vehicles). Because COBRA estimates effects at only the county level, the Evaluation Team disaggregated the health benefits by census tract using the relative population of each tract from the most recent American Community Survey. For example, we allocated 10% of the value of the health benefits to a census tract with 10% of the county's population. The Evaluation Team then estimated the total benefits allocated to DACs and non-DACs.[60] This approach assumes that the benefits of emissions reductions are distributed evenly throughout the county. If the sites are located in DACs, and the emissions reductions are greater in the

[60] DAC census tracts are defined as those included in in the SB 535 Disadvantaged Communities List (2022), which includes DAC categories for CalEnviroScreen 4.0 Top 25%, CalEnviroScreen 4.0 High Pollution Burden Score and Low Population Count, and 2017 Disadvantaged Community (CalEnviroScreen 3.0 only).

tracts near the sites, this approach understates the potential benefit to DACs. Additional information about emissions dispersion within counties would provide more-precise estimates of health benefits to DACs and non-DACs.

In our analysis, Los Angeles County had 77% of the total benefits, followed by Orange County (7%), San Diego County (5%), Riverside County (4%), and San Bernardino County (2%). Overall, 36% of the total benefits were in DACs.

Highlights

- Cumulative health benefit results in California realized by EY2023 Charge Ready Transport sites in terms of monetary benefits range from $408,218 for the low estimate to $916,171 for the high estimate.
- Sites in the heavy-duty market sector had the highest health benefits overall.
- Los Angeles County had the highest proportion of overall impacts at 77%, followed by Orange County (7%), San Diego County (5%), Riverside County (4%), and San Bernardino County (2%).
- The proportion of overall benefits attributed to DACs is 36%.

Net Impacts

As part of the net impacts analysis, the Evaluation Team estimated program effects on participants to exclude impacts from actions that participants would have taken without the program (freeridership) and to include any program attributable indirect impacts on participants (participant spillover) and nonparticipants (market effects). The Team conducted three separate analyses to assess net impacts from the MDHD programs.

Enhanced Self-Report

The Evaluation Team based our approach for the MDHD programs' enhanced self-report NTG analysis on information we obtained as part of in-depth surveys with participating fleet managers. The Evaluation Team conducted the survey via an online survey platform, Qualtrics, and delivered a link to the survey using email contact information provided by SCE. The Evaluation Team based the MDHD fleet manager NTG methodology approach on the CPUC nonresidential customer self-report NTG framework.[61] *Appendix A* provides more detail about the MDHD fleet manager self-report NTG methodology.

The Evaluation Team estimated the core component of the CPUC NTG methodology through three separate program attribution index (PAI) site scores. The Evaluation Team used three separate sets of questions to assess three components of the core NTG ratio, with each PAI score on a scale of 0.0 to 1.0

[61] California Public Utilities Commission, Energy Division. February 20, 2015. *Methodological Framework for Using the Self-Report Approach to Estimating Net-to-Gross Ratios for Nonresidential Customers.*

representing a different way of characterizing Charge Ready Transport program influence. The analysis included fleet manager responses from 4 of the 14 participating sites that were sent the survey.[62]

The Evaluation Team calculated the resulting self-report NTG for each site, prior to accounting for participant spillover, as the average of the PAI-1A, PAI-2, and PAI-3 score values. One minus the final core NTG ratio of 0.38 equals the 0.62 freeridership ratio for the MDHD program.

The participant spillover analysis revealed that none of the surveyed sites reported electrifying more of their fleet since participating in the Charge Ready Transport program, without the benefit of funding from the SCE program or where their SCE Charge Ready Transport program participation was important in this additional purchasing decision. The resulting participant spillover ratio is 0.00. The final program-level NTG ratio of 0.38 equals one minus the freeridership ratio plus the participant spillover ratio. These NTG values are presented in Table 46, along with the average final core NTG for the surveyed SCE Charge Ready Transport program sites.

Table 46. SCE Charge Ready Transport Program NTG Fleet Manager Analysis Results in EY2023

Fleet Manager Survey Completes (n)	Average of PAI-1A Score NTG	Average of PAI-2 Score NTG	Average of PAI-3 Score NTG	Average of Final Core NTG	Freeridership Ratio	Participant Spillover Ratio	Final NTG Ratio
5	0.51	0.40	0.22	0.38	0.62	0.00	0.38

Highlight

- EY2023 program-level freeridership ratio is 0.62 with a 0.00 participant spillover ratio, which resulted in a program-level NTG ratio of 0.38.

4.1.3. Lessons Learned

The Evaluation Team identified a number of lessons learned. These lessons, presented below with key supporting findings and recommendations, may be applied to future program years and to other similar efforts. Note that these lessons were derived from a limited number of program participants across most but not all market sectors. Additional insights will be gained as more sites are completed in the coming years.

Although site costs and delays continue to challenge implementation, Charge Ready Transport program staff are committed to continued program adaptation to reflect the current market conditions.

Similar to previous evaluation years, site costs continue to be a challenge; vehicle procurement and construction costs which have been compounded by labor constraints, material costs, and supply chain delays. In 2023 staff secured approval to adjust the site target from 870 to 500 sites through Resolution E-5257. In addition, staff identified that small fleets, which represent a large percentage of the SCE

[62] Three school bus sites, one distribution site and one heavy-duty vehicle site completed the survey.

customer base, often do not meet the Charge Ready Transport program requirements of owning or leasing their sites and lack the capital to meet vehicle requirements per site.

As a result, staff are carefully considering sites for acceptance into the extended program, particularly examining the trade-offs between meeting vehicle goals with larger sites that have lower per-vehicle cost and meeting site goals with a larger number of smaller sites that have higher per-vehicle costs but add more strain to implementation costs. Furthermore, program staff continue to implement other changes to improve the program such as including an environmental questionnaire as part of the initial high-level review of the site; assigning staff to preempt material shortages causing bottlenecks in program implementation, such as switchgear delays in previous years; focusing on up-front education and decision-making to increase the number of quality applicants; and developing strategic partnerships with additional market sectors in electrification to expand and diversify the program's participating customer base.

Site activation timelines have gotten longer in EY2023 relative to earlier evaluation years due to a multitude of reasons.

The timeline for application to activation was 592 days on average in EY2023 compared to 530 days in EY2022 and 462 days in EY2021. The Design and Permitting phase has been the longest in duration across all evaluation years. However, this phase increased to 288 days in EY2023, rising from 208 days in EY2022, or a 38% increase and represents 49% of the total average activation timeline. Other program phases remained consistent between EY2022 and EY2023.

The extension of site activation timelines has been attributed to a number of factors, most prominently supply chain delays with switchgear presenting the greatest difficulty for procurement. SCE has also noted the long lead time required for permit approvals and changes to customer site designs causing significant delays. Many sites activated in EY2023 were large and complex, making them inherently more time-consuming to complete.

Policy uncertainty continues to impact utility planning, program participation, and customer choices in the EV market.

While program staff anticipated an influx in applications once new regulations go into effect, there is currently uncertainty surrounding when new regulations (such as ACF) will be applied. Therefore, program staff cannot properly plan for an increase in interest, inquiries, and potential applications. Staff also confirmed with the CPUC in 2023 that the program is held to ISO-15118, which outlines standards for communication between EVs and charging stations. In addition to retroactively determine what noncompliance means for sites that were completed during the compliance period and what, if any, corrective action needs to be taken, staff anticipate potential ongoing consequences of compliance, such as limited customer choice of equipment options available, which may reduce participation and impact program goals.

The Charge Ready Transport program is progressing well towards its EV-supported goal but lags behind its number of sites goal.

In EY2023, 16 sites with 430 charging ports were activated supporting 459 vehicles, based on VAPs of activated sites. Six market sectors are now supported by the program, with school bus fleets representing the highest participation (50% of sites) and forklifts representing the lowest (2% of sites). The 55 total activated sites (1,019 charging ports) in the program to date meets 11% of the program's *per se reasonableness* goal of 500 sites and support 1,206 vehicles which meet 14% of the program's *per se reasonableness* goal of 8,490 additional vehicles electrified.

The Charge Ready Transport program will make additional progress towards these goals as more sites reach activation. For example, the 156 contracts signed in the Charge Ready Transport program to date support 3,337 MDHD vehicles, which would meet 31% of the program's site goal and 39% of the program's vehicle goal. The total 226 customer applications received in the program to date could satisfy approximately 45% of the program's site goal and 62% of the vehicle goal. However, staff are concerned about achieving programmatic site goals. The prescriptive program design may restrict some customers and impact the total number of sites. Charge Ready Transport program staff noted that some of the program requirements can be challenging for small fleets. Specifically, staff reported that the requirements are challenging because some small fleet customers do not own their sites and are not able to meet the vehicle requirements per site, which may limit the number of sites that can enroll in the program.

Although cost remains a barrier, fleet managers are satisfied with their program experience and may be positively influenced to take further actions.

Surveyed fleet managers were motivated to transition to EVs primarily by rebates/incentives (six of six fleet managers), environmental benefits (five of six fleet managers), and expected fuel cost savings for their vehicles (four of six fleet managers). In addition, the primary barriers both before and after participation (seven fleet managers) were the cost of installing charging infrastructure (three before; two after) and the cost of EVs (two before; one after). Despite these remaining cost concerns four of six fleet managers rated themselves as very satisfied with Charge Ready Transport overall and five said they had already recommended the program to others. In addition, four of seven fleet managers rated the EV charging equipment as very reliable, and six of six fleet managers rated the charging equipment as very easy to use. Finally, three of seven fleet managers reported that they plan to accelerate procurement of EVs because of their experience with the program.

Overall program spending continues to be very slow; however, program spending on DAC sites exceeds targets.

SCE spent $12.8 million of the Charge Ready Transport program budget in EY2023, bringing total spending to $34.8 million out of $342.6 million of the approved program budget, or 10.2% of available funding. Forty-four percent of SCE Charge Ready Transport program spending on infrastructure for financially closed out sites to date has been on DAC sites, exceeding the 40% program target. Additionally, both in EY2023 and PTD, greater than seventy percent of sites, charging ports, and vehicles are in DACs.

Recommendation: The Evaluation Team found that the vehicle counts observed during site visits tend to be significantly lower than customers' VAPs (even when compared with the expected annual procurement). Taking a proactive approach to tracking progress toward the VAP (by contacting customers annually about vehicle procurement, for example), would allow Utilities to ensure that customers are following their VAP, which could contribute to improved program performance with respect to energy consumption, petroleum displacement, emissions reductions, and health impacts.

Recommendation: Utilities are significantly lagging in their progress toward site goals and are spending their allocated budgets more slowly than expected. Ongoing lessons learned by Utility staff and from evaluation findings should be incorporated into programs to promote improvements. To ensure changes can be implemented in a timely manner, Utilities should continue to communicate recommendations for updates to program design and metrics to regulators and other stakeholders. For many changes, regulatory support will be needed to implement these recommendations. An example of a potential barrier is the cost threshold metric the Utilities use to determine whether to accept or reject a site into the programs. These metrics are in terms of dollars per charging port and dollars per vehicle—based on CPUC decisions—and vary by Utility. Ultimately, the thresholds reduce the number and diversity of participants which is an unnecessary constraint in the current early market stage of electric MDHD vehicles. Utilities need greater flexibility in program design to meet the overarching goals of the SRP related to advancing TE.

The Charge Ready Transport program sites are helping to displace petroleum, reduce GHG and local emissions, and achieve health impacts overall and within DACs.

The Charge Ready Transport program sites accounted for a PTD impact of more than 1.5 million gallons of petroleum with the heavy-duty vehicle sector accounting for nearly half of the petroleum displaced in EY2023. In addition, the Program resulted in a reduction of nearly 12,000 MT of GHGs to date. These sites all positively contributed to lowering local emissions, with CO reduction being the most prominent, achieving a reduction of 77,533 kg to date. Overall, 36% of the health benefits are in DACs with the monetary health benefits in EY2023 from sites ranging from $408,218 to $916,171.

Though overall demand increased significantly, peak demand represents a small portion of installed charging capacity, and the majority of fleet operators are not implementing load management.

Across EY2023 operational sites, more than 24 MW of new charging capacity was installed, bringing total capacity for the PTD sites to nearly 37 MW. Overall demand increased by over 250% from EY2022. However, peak demand never exceeded 4.7 MW in EY2023, or 12.6% of installed capacity in the program to date. Many fleet operators said they had not yet received some or all of their vehicles, contributing to a lower overall demand across sites.

Only nine of 54 operational sites (17%) in the program-to-date exhibited the use of load management, up from 10% in EY2022. Three heavy-duty vehicle sites with large charging capacity and a significant number of electric trucks on site were activated in 2023 and are planning to use some form of load management but have yet exhibited its consistent used in 2023. On a monthly basis, 39% of non-school bus charging and 57% of school bus charging took place during the peak rate time period of 4 p.m. and 9 p.m., resulting in higher operational costs and grid congestion. However, 40% of school bus charging sessions and 10% of non-school bus fleet charging sessions have enough flexibility to avoid charging during that peak rate time-period.

Not all EVSPs offer load management capability, and utility bills may not be available to fleet operators so they can understand TOU cost impacts. During site visits most operators had a disconnect between what they expected the electricity to cost versus their actual costs. However, most fleet operators were aware of TOU pricing, regardless of knowing usage trends and costs.

Some Utilities provide supplemental information to customers to promote load management. For example, in 2022 SCE created the educational video, Charge Ready Time of Use, which serves as a reminder that electric rates are based on TOU periods.

> **Recommendation**: Utilities should continue to contact customers on an annual basis (at minimum) following site activation to ensure that sites are proactively identifying load management opportunities. The Evaluation Team recommends focusing on school bus sites—which typically do not manage load—and large sites such as those with greater than 1 MW installed capacity—which have the greatest opportunity to manage load. By identifying and documenting reasons why customers are not actively managing load, program staff and the Evaluation Team can build more-targeted recommendations for addressing load management barriers.

TTM and BTM infrastructure costs continue to vary widely between sites. Program participants continue needing Utility infrastructure incentives.

Across 29 financially closed out sites, Utility spending resulted in an average infrastructure cost of $304,057 per site, $41,395 per vehicle, and $1,356 per kilowatt of installed charging capacity, when including TTM and BTM infrastructure but excluding EVSE cost. These values include both L2 and DCFC sites and aggregate multiple market sectors across EY2021, EY2022, and EY2023. This is an increase (>20%) over EY2022 costs of $195,420 per site, $23,990 per vehicle, and $1,269 per kilowatt. The higher average cost in EY2023 is primarily attributed to site size, which rose to an average of 411 kW per site this year. Estimated all-in costs paid by the customer and SCE vary widely between sites, with an average of $504,275 per site.

4.2. Schools and Parks Pilots

4.2.1. Overview

This overview provides a detailed description of the SCE Schools and Parks Pilots; summaries of the Pilot implementation process, performance metrics, program materials, and budget; and a timeline of major milestones. Following the overview are detailed findings, highlights, and lessons learned.

Pilot Description

Schools Pilot: Per Decision 19-11-017, SCE's Schools Pilot offers direct installation of and incentives for installing approximately 250 L2 charging stations at 40 K–12 schools. SCE staff designed the Pilot to enable K–12 schools to offer public charging to support not only school staff, but also the local community.

Schools Pilot Targets

- 250 L2 charging stations
- 40 K–12 schools
- 40% in DAC locations

Participating schools can opt for SCE-owned EVSE or choose to own the EVSE themselves. In cases in which SCE owns the EVSE, SCE also operates and maintains the EVSE. However, the site host is still required to meet the needs for make-ready deployment (such as easement) and to pay all electricity charges. If the site host opts to own the EVSE, SCE offers a rebate based on the market costs for each type of charging station. At the time of the Decision this rebate was up to $2,000 per charge port for L1 and L2 charging stations. However, before the Pilot was launched, staff adjusted the incentive approach to ensure that sites choosing the ownership option receive the same benefits as those choosing to have SCE own the EVSE. This adjustment maintains a static cost for the EVSE, but also considers the required agreement to operate and maintain the equipment, warranty, and network fees for eight years. As a result of this change, the Pilot rebate is focused on L1 and L2 chargers. As per the Decision, SCE staff offers customers an option to manage and pay for qualified state-licensed labor to install customer-side infrastructure, for which SCE provides a rebate of up to 100% of the installation cost. Participating schools also commit to providing charging equipment usage data for a minimum of eight years.

Schools Pilot Design Goal

Empower K–12 schools to offer public charging to staff, students, parents, and the greater community.

The Energy Coalition (TEC) staff developed a K–12 Campus EV Awareness Campaign in 2022, that officially launched in March of 2023.

Parks Pilot: Per Decision 19-11-017, SCE planned to offer direct installation of approximately 120 L2, 10 DCFC, and an optional 15 mobile chargers across 27 state parks and beaches. After a master agreement was signed in 2022 and site viability was explored further, the Parks Pilot's goals were adjusted per AL 4626-E (approved in 2023).[63] SCE staff designed the Parks Pilot to encourage state parks and beaches to charge their own EV fleets and to offer charging services to staff and patrons of LDVs.

Parks Pilot Targets

- 120 L2, 10 DCFC, and 15 optional mobile charging stations
- 27 state parks and beaches
- 25% in DAC locations

2023 Updated Parks Pilot Targets

- 21 state parks and beaches
- 25% in DAC or DAC-adjacent

[63] Although up to 21 sites were viable at the time of the Advice Letter, ultimately, SCE and the DPR moved forward with 9 sites.

SCE owns, builds, and operates the EVSE and contracts with a third-party vendor to serve as the customer of record for the charger. The third-party vendor is responsible for all electricity costs, must participate in a demand response program, and must report on prices it passes on to the EV drivers.

Parks Pilot Design Goal

Encourage state parks and beaches to charge their own EV fleets and to offer charging to staff and patrons with LDVs.

SCE staff planned to deploy a customer marketing campaign in 2023 to publicize the availability of EV charging stations, with the goal of reducing range anxiety, facilitating EV adoption, and encouraging park patrons to drive EVs to parks or beaches with EVSE. As no sites were completed in 2023, this campaign has been delayed until sites are ready for promotion, likely in 2024 or 2025.

Implementation

Figure 82 shows the implementation process for the Schools Pilot from site identification to close-out. Note that the Schools Pilot is fully subscribed and no longer taking applications, and the Contract Issuance step is slightly different for the Parks Pilot, since the California DPR approved a MPA in 2022 that applies to all state parks in SCE service territory participating in the Parks Pilot. Each individual site will have site addendums to the master agreement based on specific site needs and designs.

Figure 82. SCE Schools Pilot Implementation Process

SITE IDENTIFICATION

1. SCE identifies a potential site
2. SCE conducts a desktop review
3. SCE reaches out to the customer to engage with the Pilot

SITE ASSESSMENT

1. SCE conducts a site visit
2. SCE drafts a conceptual design

CONTRACT ISSUANCE

1. SCE issues the program agreement to the site host
2. Site host reviews and signs the agreement
3. SCE executes the program agreement

DESIGN AND PERMITTING

1. SCE details the site design
2. Site host reviews and approves the design
3. SCE and site host complete the easement process
4. SCE requests and secures permits

SUPPORTING INFRASTRUCURE IS CONSTRUCTED

CHARGING EQUIPMENT IS INSTALLED AND ACTIVATED

CLOSE-OUT

1. SCE issues the rebate (if applicable)
2. Customer is on-boarded with EVSP
3. Customer commits to port-level data sharing for eight years
4. Customer commits to maintaining and operating charging equipment for eight years

Program Performance Metrics

The Evaluation Team reviewed sites participating in SCE's Schools Pilot and analyzed them by Pilot status. Table 47 provides the count of SCE Schools Pilot sites by completion status in EY2023 and for the Pilot to date.

Table 47. SCE Schools Pilot Complete Site Count by Status

Site Status	EY2023	Pilot to Date
Utility Construction Complete	8	21
Activated	8	21
Operational	8	17
Closed Out	0	1

In EY2023, all eight sites activated in the SCE Schools Pilot were operational. Seven of the 8 activated sites are located inside DACs, with the final EY2023 activated site being outside of a DAC, as shown in Figure 83. Note that multiple sites in a single location will appear as a single point in Figure 83. Six additional signed contracts with 6 additional sites, bringing the cumulative number of signed contracts to date to 30.

Figure 83. SCE Schools Pilot EY2023 Activated Charging Stations

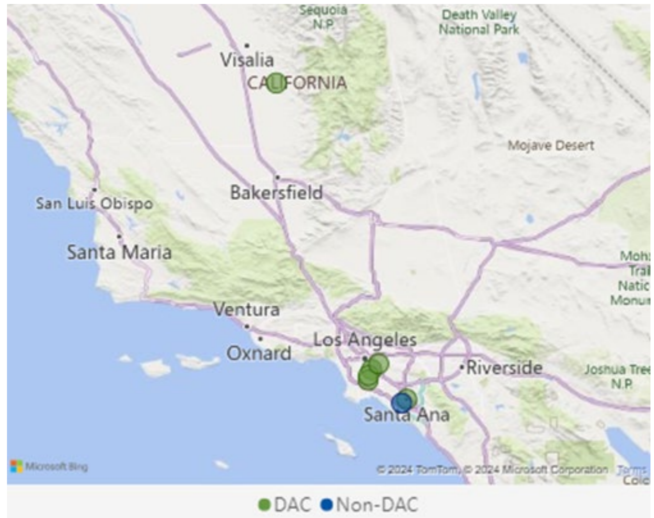


Table 48 presents site-level data for the SCE Schools Pilot, showing DAC status and number of L2 ports for the activated sites in EY2023 and for the program to date. In EY2023, 88% of activated sites were in a DAC, bringing the cumulative percentage of DAC sites to 52%, which exceeds the Pilot's *per se reasonableness* DAC goal of 40% of sites. The number of ports ranges from 6 to 12 per site, with a total of 166 L2 charging ports installed in the Pilot to date.

Table 48. SCE Schools Pilot Activated Site Data in EY2023 and Pilot to Date

EY2023			Pilot to Date		
Number of Activated Sites inside DAC	Number of Activated Sites outside DAC	Number of L2 Charging Ports	Number of Activated Sites inside DAC	Number of Activated Sites outside DAC	Number of L2 Charging Ports
7	1	66	11	10	166

As shown in Table 49, the 21 activated sites to date in SCE's Schools Pilot meets 70% of the Pilot's *per se reasonableness* goal of 30 sites. There are 166 L2 ports at the activated sites, meeting 66% of the Pilot's *per se reasonableness* goal of 250 L2 charging ports. The 30 customer contracts signed in the Pilot to date could satisfy 100% of the Pilot's site goal and would provide 250 L2 ports, which could meet 100% of the Pilot's L2 charging port goal.

Table 49. SCE Schools Pilot Site and Port *Per se Reasonableness* Goal Progress

Pilot Metric	*Per se Reasonableness* Goal	Program to Date
Activated Sites	30	21
L2 Ports	250	166

The CPUC established six phases in the program timeline per the SB 350 reporting template. Table 50 shows the median durations by program phase for EY2023 and pilot-to-date activated sites. The median number of calendar days per program phase for EY2023 sites in the Schools Pilot ranged from 32 days for Contract Issuance to 506 days for Design and Permitting. For sites activated in EY2023, median durations across the Application Review, Site Assessment, Contract Issuance, and Activation phases were similar to those for the Schools Pilot to date. However, Design and Permitting and Construction took noticeably longer compared to pilot-to-date median durations.

Table 50. SCE Schools Pilot, Median Calendar Days per Phase

CPUC Program Phase	Median Calendar Days	
	EY2023 Sites	Pilot to-Date-Sites
Application Review	63	63
Site Assessment	34	38
Contract Issuance	32	21
Design and Permitting	506	399
Construction Complete	159	97
Activation	0	0

Program Materials Summary

Schools Pilot and Parks Pilot: In 2023 SCE staff focused on the construction of sites and working with site hosts. The primary marketing activity for 2023 was the launch of the school curriculum developed by TEC, there was no marketing specifically for the Parks Pilot.

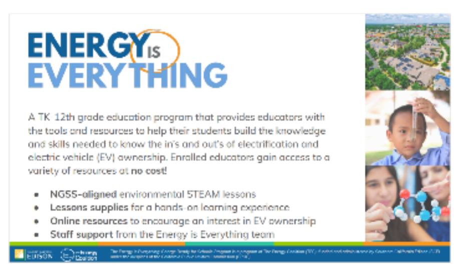
Figure 84. SCE Schools Pilot Launch Kit

Schools Pilot: In 2023, SCE staff finalized and launched the Schools Pilot ("Charge Ready Schools," Figure 84) curriculum in partnership with TEC. SCE provided grade-level-specific materials to provide educators with the tools and resources to educate students on electrification topics and EV ownership. As outlined in the Energy is Everything program overview (example slide Figure 85), the program provides educators with tools and resources to effectively teach their students the nuances of electrification and EV ownership.

In addition to the full K–12 grade curriculum, TEC/SCE provided a welcome letter and recruitment presentation to participating teachers and schools:

- **Welcome Letter:** Introduces schools and educators with an overview of the curriculum and its purposes. It also outlines the goals of Charge Ready for Schools, contains links and information about Energy is Everything, social media, TEC, and provides contact information for TEC staff.
- **Recruitment Presentation:** Provides the program overview, education standards, as well as lesson explorations, suggested timeline and actions, and ways to connect with TEC staff.

Figure 85. SCE Schools Pilot Curriculum Recruitment Presentation



Through the end of 2023, the implementer had engaged with 27 high schools, 87 administrators, and 176 educators.

The curriculum is structured as a set of lesson plans broken out by clustered grade levels. Table 51 shows the lesson objectives of each lesson for each grade level. The curriculum includes lesson descriptions, objectives, topics, materials, vocabulary as well as other educational materials for teachers to use.

Table 51. SCE Schools and Parks Pilots Curriculum Learning Objectives

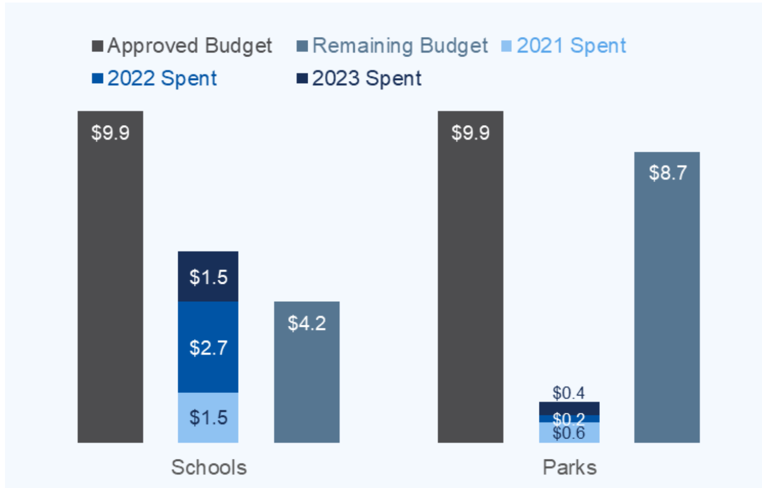
Grades	Lesson Title	Lesson Objective
K–2	Pollution Solution	Students will understand how emissions from gas-powered vehicles can cause air pollution and harm our health. They will understand the main differences between a gas-powered vehicle and an EV. Then, students will design an EV.
	Power to the People	Students will demonstrate understanding by communicating the differences between renewable and nonrenewable resources and how humans harvest them.
	Circuit Conductors	Students will use a model to examine the cause-effect relationships of energy transfer.
3–5	Electric Vacation	Students will follow a travel itinerary within their community to determine how far they can drive an EV before re-charging. They will also research EV charging station locations in their community to reflect on the benefits and challenges of EVs.
	Emissions Detectives	Students will analyze the impact of carbon emissions from transportation on air quality and climate change. They will also explain the benefits of electrification within the transportation industry.
	Electric Charge	Students will apply what they learn about EVs to design and build their own battery-operated EVs.
6–8	Spin the Turbine	Students will design and build their wind turbines. In this activity, students will act as engineers and compare different blade designs to assess which design produces the most energy.
	Electrify Powerville	Students will plan and design an EV charging station plan for the City of Powerville. They will discuss, analyze, and re-design an urban plan for electrification.
	Watts Up!	Students will understand campus-wide energy use and analyze energy conservation measures. They will also learn various ways to reduce energy use at school and home.
9–12	Drive into the Future Part.1	Students will prepare a comparative analysis of an EV and gas-powered vehicle. Students will compare costs, gas mileage, and trip distances, among other features, to make a well-informed decision on a vehicle to purchase based on a provided scenario.
	Drive into the Future Part.2	Students will research and gather data. Then, they will prepare an analysis of and share data about the economics and benefits of owning an EV.
	Drive into the Future Part.3	Students research and gather data. Then, students will prepare an analysis of and share data about the maintenance and repairs associated with owning an EV.

Parks Pilot: SCE did not conduct any Parks Pilot–specific marketing or outreach activities in 2023.

Budget Summary

As shown in Figure 86, through the end of 2023 SCE spent $5.7 million of $9.9 million on the Schools Pilot and $1.2 million (constant dollars) of $9.9 million on the Parks Pilot. SCE spent $1.5 million of the Schools Pilot budget in 2023. Through 2023, the Schools Pilot continued to outspend the Parks Pilot as the Schools Pilot was well into the process of constructing planned sites, while Parks Pilot sites were still being planned in 2023.

Figure 86. SCE Schools and Parks Pilots Budget (Millions USD) as of Dec. 31, 2023



Timeline

Since the beginning of the Pilots SCE has filed four Advice Letters: three pertaining to the Schools Pilot and two to both Schools and Parks Pilots. SCE filed AL 4926-E on December 22, 2022, requesting the reallocation of funds for charging in DACs to include potential sites within five miles of DACs (i.e., DAC adjacent). Approval for AL 4926-E was delayed because of a protest on January 11, 2023, from the Public Advocates Office (PAO) that requested more detail of the efforts made by SCE to prioritize DAC sites. SCE submitted a reply on January 19, 2023, detailing the pre-work that the Pilot team completed to assess viability of each potential Parks site. The detail provided was sufficient for the PAO, and AL 4926-E was officially approved on June 22, 2023.

Figure 87 shows all major milestones since the beginning of the Pilots.

Figure 87. SCE Schools and Parks Pilots Key Milestones

4.2.2. Findings

This section provides findings from analyses of the incremental EV adoptions, site visits and site costs, grid impacts, petroleum displacement, GHG and criteria pollutant reductions, and health impacts, as well as insight from Utility staff interviews.

Table 52 summarizes key impact parameters for EY2023 as well as for the program to date. Annual estimates of impacts are provided for metrics calculated as part of the impact evaluation. Additionally, the table provides estimates of impacts across all sites included in the program population through the end of 2023.

Table 52. SCE Schools Pilot Impacts Summary

Impact Parameter	EY2021 Sites[a]	EY2022 Sites[a]	EY2023 Sites[a]	EY2023 Sites Percentage in DAC	PTD Sites Actual	PTD Sites Actual Percentage in DAC
Population of Activated Sites	1	12	8	88%	21	52%
Sites included in analysis (#)	0	8	4	75%	17	42%
Charging Ports Installed (#)	12	88	66	90%	166	54%
Electric Energy Consumption (MWh)	N/A	50	33.8	69%	145	26%
Petroleum Displacement (gasoline gallons equivalent [GGE])	N/A	4,137	2,555	63%	11,954	26%
GHG Emission Reduction (MT GHG) [b]	N/A	32	20.32	63%	90.0	26%
PM_{10} Reduction (kg)	N/A	0.2	0.11	63%	0.47	25%
$PM_{2.5}$ Reduction (kg)	N/A	0.1	0.10	63%	0.43	25%
ROG Reduction (kg)	N/A	2.6	1.55	63%	7.63	25%
CO Reduction (kg)	N/A	86	54.5	63%	257	25%

[a] Energy consumption, petroleum displacement, and emissions reductions are based on annualized data. Pilot-to-date results in the table are based on actual data (see *Appendix A* for more details). The one site in EY2021 was not included in the EY2021 Evaluation Report due to insufficient data but is included in PTD impact results in this report.

[b] GHGs include CO_2, CH_4, and N_2O multiplied by their respective GWP as defined by IPCC AR5 (see *Appendix A* for more details).

Incremental EVs Adoption

The Evaluation Team estimated the effect of the public charging stations on household EV adoption for neighboring populations[64] with a two-stage analysis: (1) historical analysis of public EV charging impacts on vehicle ownership, and (2) analysis of EV ownership attributable to SCE Schools Pilot investments. See *Appendix A* for details about the Stage 1 analysis.

Using the impact estimates from the Stage 1 analysis,[65] the Evaluation Team estimated the impact of SCE investments in public charging on EV ownership. By the end of EY2023, 21 charging sites in SCE's

64 The availability of public charging networks may affect EV purchases via two main avenues. The first is a network effect, through which EV owners gain increased access to the public charging stations due to station placement at destinations such as workplaces, commercial establishments, schools, and parks. We expect the availability of EV charging equipment at convenient locations (for midday charging away from home) to increase the convenience of owning an EV (such as by reducing range anxiety) and to increase the probability of EV ownership. The second avenue is a neighborhood effect on the driving population living in areas neighboring the public EV charging stations. We expect the availability of nearby charging infrastructure to lower the cost of EV ownership by providing alternatives to home charging. We anticipate that public EV charging will have the biggest impact on residents of multifamily buildings, many of whom will have limited access to EV charging equipment, or on low-income households, who may be unable to afford home EV charging equipment. Public charging access may boost EV ownership through both channels and positive interactive effects may exist between the channels that boost the overall impact of public charging networks. The Evaluation Team focused on analyzing the second channel. We will analyze impacts for the first channel separately when data become available.

65 The Stage 1 analysis used vehicle registration data from 2015 to 2020, the most recent period with complete information at the CBG level. The EY2023 estimates assume the impact of Utility-specific stations remains unchanged over time, which may not reflect actual market and technological changes.

Schools Pilot were activated. We estimated the impact of these stations based on annual EV registrations as well as pilot-to-date cumulative EV registrations driven by the program.

Based on the composite measure of public charging access, the Evaluation Team calculated the change in access to public charging due to SCE's Schools Pilot investment for each census block group (CBG) where the investments affected access. Table 53 shows that the pilot-to-date average change in access across all affected CBGs was 7.6, and the average change in the number of chargers (ports) was 6.3 per affected CBG. For reference, the average change in access across all CBGs in California was 0.57 between 2015 and 2020. The average normalized EV annual registration per 1,000 households was 70.3 in the affected CBGs in 2020.

Table 53. SCE Schools Pilot Summary Statistics of Effects on CBGs

	CBG Mean (Standard Deviation)			
	Change in Composite Measure of Access[a]	Change in Number of Chargers[a]	Normalized Annual EV Registrations[b]	Number of Households[c]
SCE Schools Pilot	7.60	6.32	70.29	447.30
	(5.31)	(3.71)	(375.49)	(263.23)
CBGs (N)	44	44	44	44

These values are averages for the CBGs whose access to public charging was affected by SCE's investments.
[a] Change in composite measure of access and number of chargers is from 2020 to 2023.
[b] Normalized annual EV registrations are average annual values in the affected CBGs in 2020 per 1,000 households.
[c] Number of households is based on 2015–2019 American Community Survey (ACS).
Sample standard deviations are in parentheses.

The Evaluation Team calculated the impact of the Schools Pilot Utility charging investments on neighboring EV ownership. This involved combining the ordinary least squares (OLS) and instrumental variable two-stage least squares (IV-2SLS) regression estimates of the impact of public charging access on EV registrations from Stage 1 with the estimates of the CBG changes in public charging access and household counts.[66] The impacts of the SCE investments on EV registrations will depend on the extent to which the investments increased access in the affected CBGs and the number of neighboring households in the CBGs.

Table 54 shows estimates of the annual and pilot-to-date EV registrations attributable to the SCE Schools Pilot charging investments. Based on the OLS long differences model,[67] SCE School Pilot investments in charging facilities increased EY2023 annual EV registrations by 5.3 vehicles. The pilot-to-date impact is eight vehicles. Based on the IV-2SLS long differences model, the School Pilot investments increased annual EV registrations by 24.7 vehicles. The Evaluation Team prefers the IV-2SLS-based

66 In Stage 1, the Evaluation Team estimated the impact of public EV charging access on EV ownership. Stage 2 built on the Stage 1 analysis and was an attribution analysis for Utility-specific investments. A notable benefit of this approach is that it is applicable to evaluations of other programs increasing EV charging access as well, which ensures methodological consistency.

67 The long differences model estimates indicate the impact of public charging on EV registration over five years. TheTeam annualized these estimates by dividing the results by five.

estimates because they account for the potential endogenous siting decisions of public charging (i.e., siting public charging infrastructure in locations likely to have above- or below-average rates of EV adoption). These estimates reflect the 21 activated Schools Pilot facilities operating for a whole year.

Table 54. SCE Schools Pilot EV Registrations Attribution

EY2023 Annual Increase of EV Registrations Driven by the Utility Program		PTD Cumulative Increase of EV Registrations Driven by the Utility Program	
OLS	IV-2SLS	OLS	IV-2SLS
5.31	24.68	7.98	37.08
(0.56)	(2.76)	(0.71)	(3.55)

Note: The table shows the EV registrations attributable to the utility investments in public charging infrastructure. The left panel shows the impacts of utility investments since 2020 on registrations in EY2023. The right panel shows the cumulative impacts of Utility investments since 2020 on EV registrations in EY2021, EY2022, and EY2023. The Evaluation Team based these estimates on the OLS and IV-2SLS long differences models. The Team estimated the OLS long differences model using data for all CBGs in the analysis sample. We estimated the IV-2SLS long differences model for CBGs in the 20 largest California cities. The long differences are five-year estimates, which the Evaluation Team annualized by dividing the results by five. For each affected CBG, the Team calculated the increase in annual registrations as the product of the regression-based access coefficient divided by five, multiplied by the change in composite public charging access from utility investments (between baseline 2020 and EY2023), multiplied by the number of CBG households (in thousands). Robust standard errors clustered at the CBG level are in parentheses.

The SCE Schools Pilot investments in public charging had relatively small impacts on EV ownership in EY2023. Across all 44 affected CBGs, the total annual number of EV registrations is about 3,093 (44 * 70.29), so the preferred IV-2SLS regression method estimates that the SCE Schools Pilot had the pilot-to-date cumulative impact of lifting EV registrations by about 1.2% (37.08 / 3,093). While similar to that of the last program year (EY2022), the estimated impact remains small but tripled the impact of last program year. An average of 70 EV registrations per CBG puts these CBGs in the 94th percentile for EV registration among CBGs, implying a high level of baseline EV registration. This high baseline may explain why the percentage effects are small. The Evaluation Team primarily attributes the impact to the growth in charging stations and the increased number of influenced CBGs.

Highlights

- In EY2023, the Schools Pilot contributed to an increase in EV adoption of 25 EVs for households neighboring the infrastructure (37 in the Pilot to date).
- The estimated impact of the program's charging stations on EV adoption tripled from last year (EY2022), largely as a result of the expansion of charging stations and the increased number of affected CBGs.

Site Visits

The Evaluation Team visited seven of eight newly completed sites in 2023. During these site visits, the Team documented the number of ports installed in EY2023 (54 L2), installed charging capacity (356 kW), and parking spaces within reach of charging cords (221) including one or more ADA-compliant spaces per site. Figure 88 and Table 55 show ports and capacity based on site visits in 2023 and prior years.

Figure 88. SCE Schools and Parks Pilots L2 Ports and Capacity Observed in 2023 and Prior Years

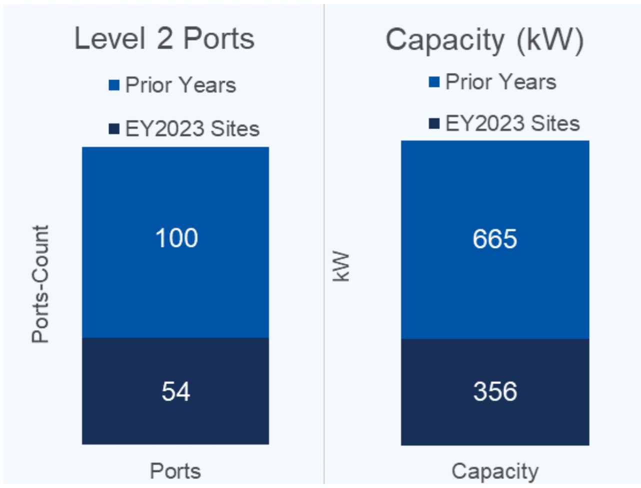


Table 55. SCE Schools Pilot Ports and Capacity Observed during Site Visits

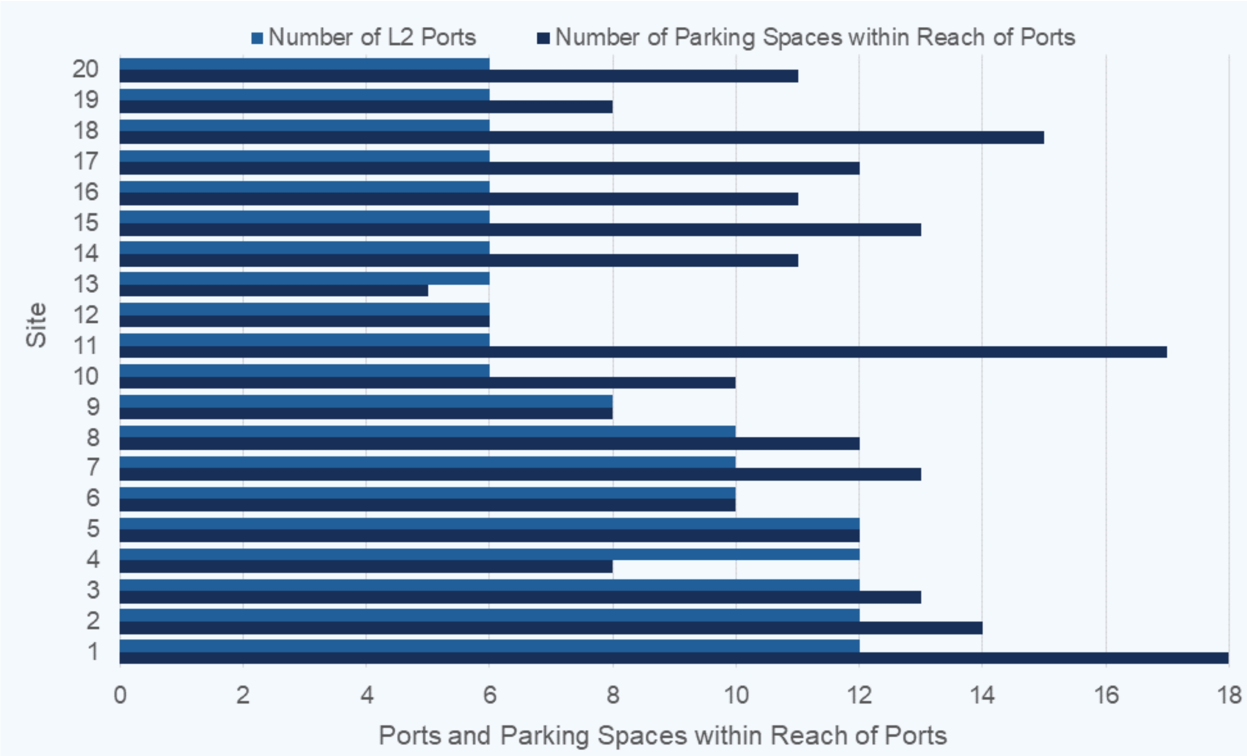
Site Visit	Ports	Installed Capacity	Number of Sites
2023 Site Visits	54	356	7
Prior Years	100	665	13

The Team assessed how these new sites fit within the workplace (and to some extent within the public-charging) ecosystem. This is partially a function of the number of parking spaces within reach of a charging cord regardless of whether they are designated as EV charging spaces. Typically, head-to-head parking offers high access if charging stations are not adjacent to one another. Figure 89 shows a typical arrangement for a high-access charging facility.

Figure 89. Example of High-Access Charging Layout

Nine sites average more than 1.5 parking spaces within reach of each charging cord, which allows them to maximize charging turnover rates and potentially minimize capital costs. This arrangement facilitates resilience (in the case of hardware issues), provides enhanced access for EV drivers, and allows for future growth to accommodate demand. To highlight the value of positioning multiple parking spaces within reach of cords, Figure 90 shows the number of ports and the number of spaces that can access these ports for the sites the Evaluation Team visited.

Figure 90. SCE Schools Pilot Visited Sites Charging Port Availability by Site for PTD Sites



The Evaluation Team reviewed the pricing structure available to EV drivers relative to turnover and VGI (where possible). SCE uses TOU EV-oriented billing rates that do not include demand-oriented costs. Seven of the 20 sites visited proved to be inconclusive based on both the site visit and subsequent research at Plugshare.com or other NSP websites. Of the remaining 13 sites, the following pricing trends were observed:

- Five sites provide TOU rates that may influence when drivers charge.
  - Costs for low- to high-cost time periods range from 125% to 330% of the lowest costs for charging.
  - Actual cost increases (from each site's lowest option) range from $0.05 (less influence) to $0.35 (more influence) per kilowatt-hour.
- Seven sites use idle fees to encourage turnover and therefore improve access to charging ports.
  - Idle fees range from $3 to $20 per hour.
  - Grace periods after charging ranged from 15 minutes to four hours.
  - Idle fees were in use at sites with and without TOU rates.
- Costs at eight sites using flat rates ranged from $0.30 to $0.53 per kilowatt-hour.

Highlights

- Nine sites average more than 1.5 parking spaces within reach of each charging cord.
- Five sites provide TOU rates that may help influence when drivers charge.
- Seven sites use idle fees to encourage turnover and therefore improve access to charging ports.
- Pricing may be a deterrent in some cases to EV drivers unless in an emergency to charge.

Site Costs

The EY2023 report does not include a site cost analysis for these programs because of insufficient data (a single site was fully closed out, which does not meet the 15-15 Rule threshold).

Grid Impacts

The Evaluation Team determined grid impacts for the SCE Schools Pilot based on the analysis of energy consumed by operational charging stations installed by the program through the end of 2023, combined with charging session data from the NSPs.

Data Sources

The primary data source used in this section is the energy usage data provided in regular 15-minute intervals from the AMI. Other data sources include customer bills, and data provided by NSPs. There are several important differences between AMI and NSP data. While the AMI data reflects only energy usage, NSP data includes energy usage, session start and stop time, the duration of a vehicle's connection to a charging port, the duration of a vehicle actively pulling power, and the specific port used for a session. An AMI meter does, however, track standing loads (such as those the EVSE uses for communications, cooling, active power converters, solenoids, and screens), which NSPs typically cannot do. When AMI data is missing from the dataset, the Evaluation Team uses NSP data to fill the gaps.

Summary of Grid Impacts

Table 56 presents the estimated Schools Pilot program grid impacts.

Table 56. SCE Schools Pilot Grid Impacts

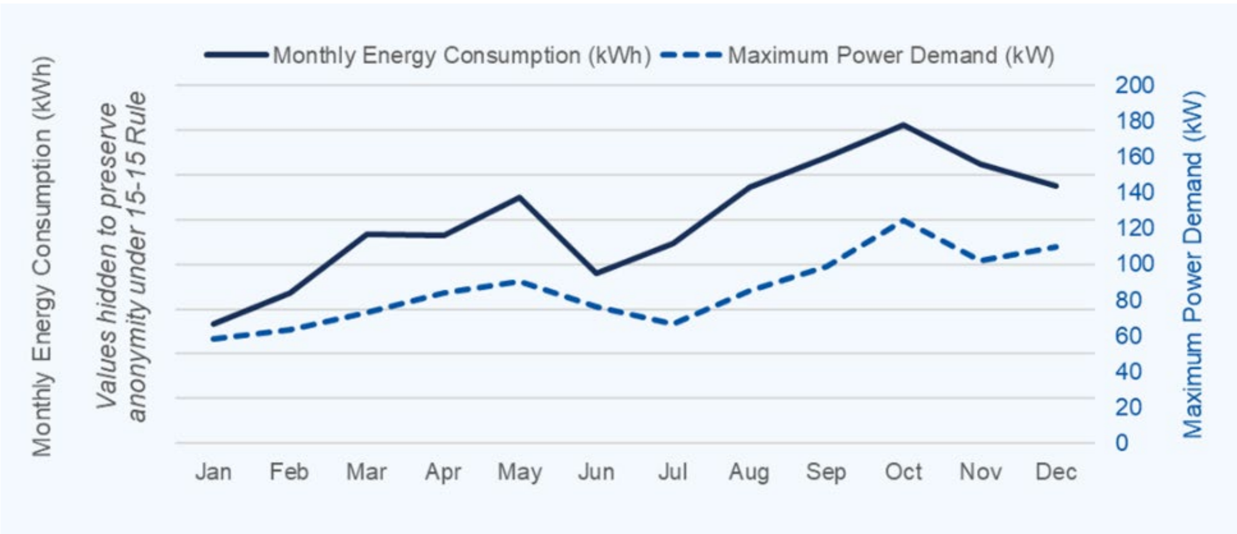
Impact Parameter	2023 Actual	PTD Actual	10-Year Projection
Operational Sites	17	17	17
Installed Charging Capacity, kW	863	863	863
Electric Energy Consumption, MWh	121	145	1,584
On-Peak (4 p.m. to 9 p.m.) MWh, (percentage of total)	22 (18.6%)	26 (17.7%)	267 (16.8%)
Maximum Demand, kW (date and time)	124 (10/31/23: 11:45 a.m.)	124 (10/31/23: 11:45 a.m.)	N/A
Maximum On-Peak Demand, kW (date and time)	54 (10/10/23: 4:15 p.m.)	54 (10/10/23: 4:15 p.m.)	N/A

The remainder of this section offers detailed findings on actual consumption, demand, and charging session–oriented trends of the combined sites for calendar year 2023.

Energy Trends

Sites in the Schools Pilot reached a total consumption of over 120 MWh in 2023, leading to a pilot-to-date total of over 140 MWh. Eight sites were activated in 2023, yielding 21 total activated sites through the end of December 2023. Demand peaked at 124 kW in aggregate across all sites at 11:45 a.m. on October 31, 2023, compared to 1,100 kW of installed capacity. The Evaluation Team attributes this gap between installed capacity and demand to the adoption rate of these charging stations by EV drivers, as discussed later in this section. Figure 91 plots daily energy consumption and maximum demand values for the Pilot.

Figure 91. SCE Schools Pilot Monthly Energy Consumption and Maximum Demand in 2023



Broadly, site consumption has increased steadily over time, with net daily consumption between 300-600 kWh per day. Maximum demand across all sites experiences significant fluctuation but is generally observed between 5 and 45 kW on a daily basis. Figure 92, below, highlights these patterns.

Figure 92. SCE Schools Pilot Daily Consumption and Maximum Demand – All Sites

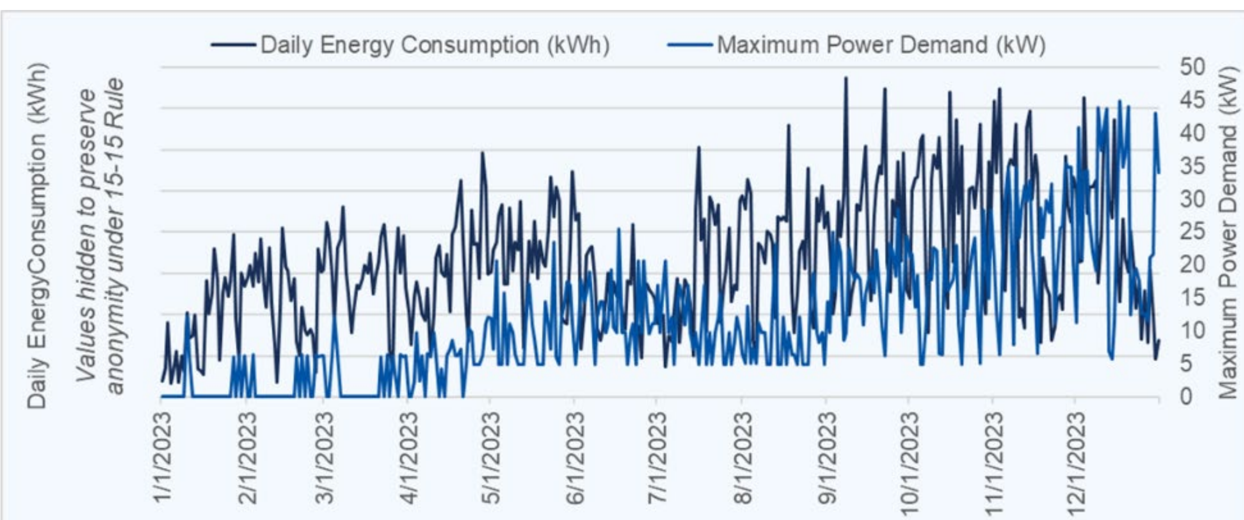


Figure 93 shows average load curves of weekdays and weekends in the fourth quarter of 2023 representative of typical workplace charging. This pattern consists of a load that ramps up between 6 a.m. and 9 a.m. as drivers arrive, peaks between 9 a.m. and 11 a.m. as all connected vehicles are charging, and tapers off over the rest of the day as individual vehicles complete their charge. On average, weekends are much flatter and show slightly higher average charging demand than weekdays late at night and in the early morning, which may represent charging during events outside of regular school hours. Figure 94 depicts load curves for the days of historical maximum demand (109 kW; 12/4/23) and historical maximum consumption (9/8/23; 775 kWh).

Figure 93. SCE Schools Pilot Average Weekday and Weekend Load Curves

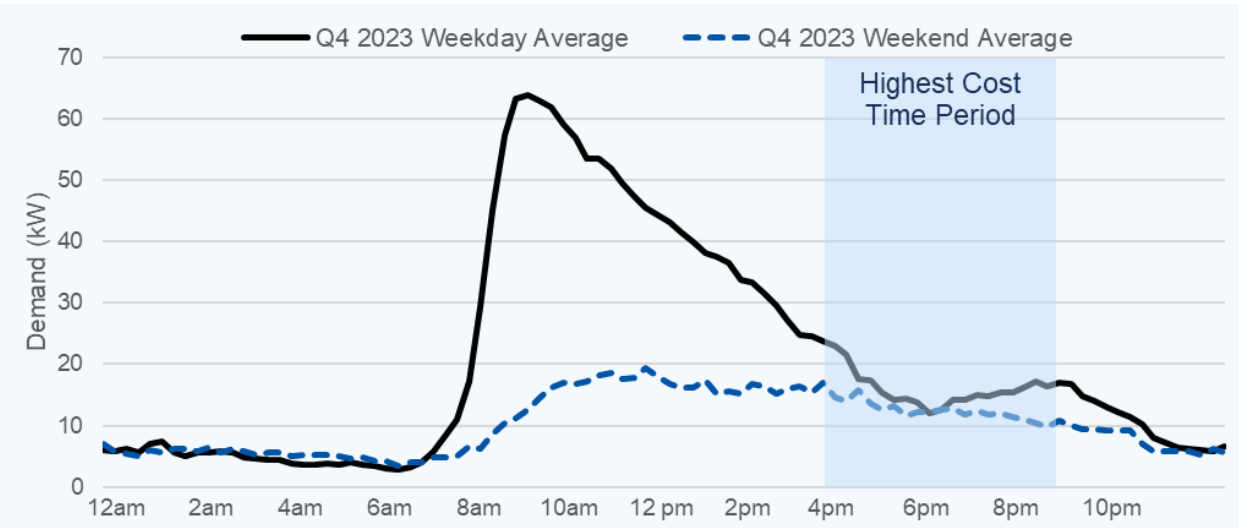
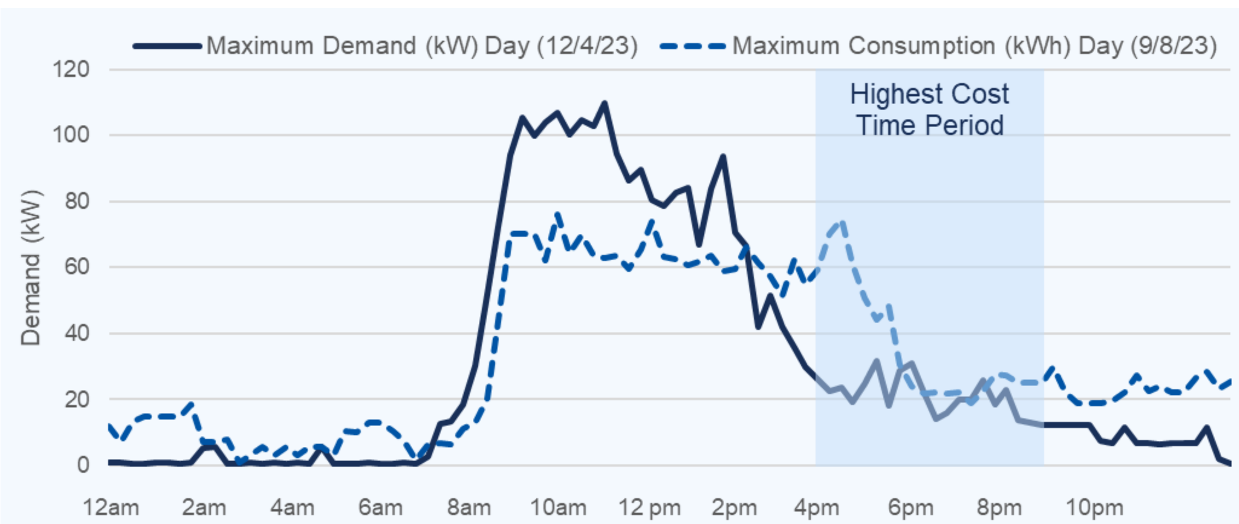


Figure 94. SCE Schools Pilot Load Curves on Days of Maximum Demand and Consumption



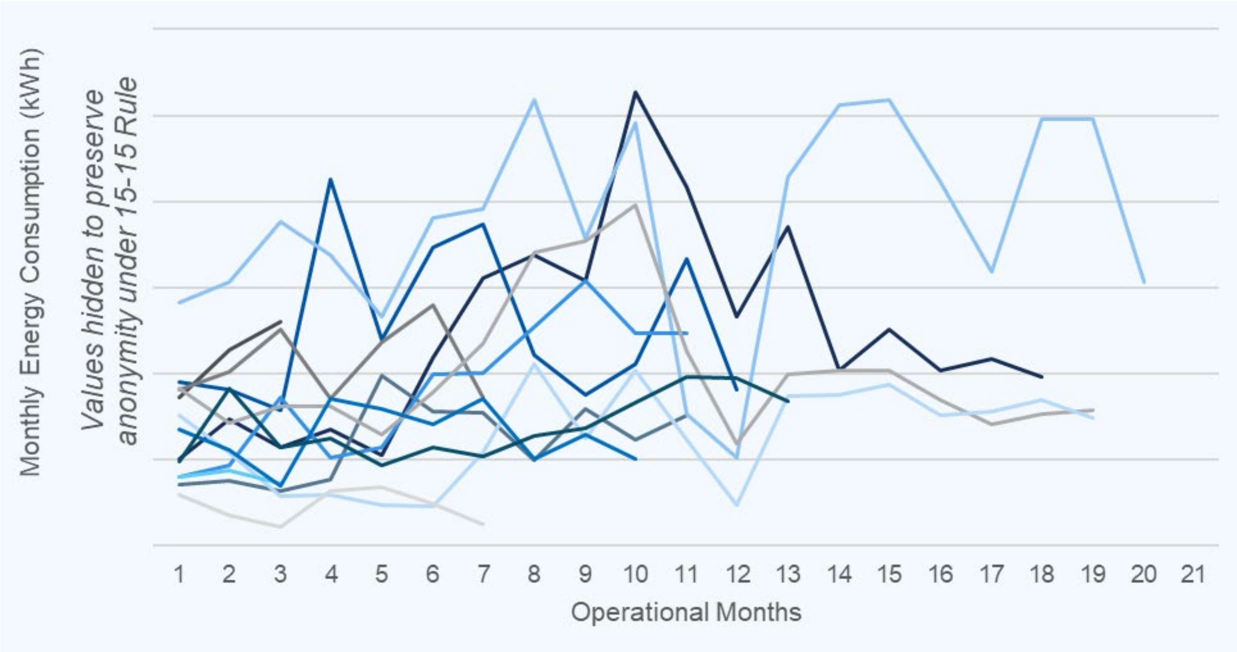
Some of these sites show charging activity outside of traditional 8 a.m. to 5 p.m. work hours and on weekends, which may indicate EV drivers who do not work on site utilizing the chargers while using on-site sports fields or other amenities. There is also sporadic usage at a few sites from late evening into early morning, which may represent nearby residents making use of the charging infrastructure in place of at-home charging. Most of these sites are considered private and, as such, are not shown on native NSP websites or Plugshare.com. Given the typical workplace trends and the generally private status of these charging facilities, this portfolio leaves many hours each day, each weekend, and throughout the year with little demand or opportunity to improve utilization. One feature of note in Figure 93 is that the average weekday and weekend day have nearly the same average demand from roughly 10 p.m. to 7 a.m., outside normal working hours.

The impact of pricing on grid impacts for these sites—such as how and to what extent EV drivers use energy—remains inconclusive. Surveying these drivers may reveal whether the price they pay for energy influences their patterns. For instance, we might anticipate an EV driver using less energy during peak periods (around 4 p.m. to 9 p.m.) if they receive TOU signals indicating higher energy costs at this time. During site visits, the Evaluation Team can typically determine what pricing EV drivers receive. However, many of these sites did not provide a reliable pricing plan in 2023, often due to sites deliberating extensively over energy pricing or stations being in extended free-vend or offline modes while awaiting commissioning from NSPs. SCE reports that all AB 1082 Schools Pilot sites use their EV-specific tariffs, which make use of TOU rates for the customer of record—i.e., school districts. However, the site hosts can select what pricing the NSP offers to EV drivers who use the charging facilities. Workplaces tend to have higher charging utilization when TOU rates are lowest throughout the day (late morning into early afternoon), which also typically aligns with a higher proportion of renewable energy on the grid, even if pricing available to EV drivers does not represent this.

Usage Trends

The Schools Pilot initiative and other public-facing projects across the state may provide insight into how long similar sites take to reach operational maturity. Considerations may include how people identify and gain charging access, and how workplace charging may influence a driver to trade their conventional vehicle for a PHEV. Figure 95 aggregates monthly energy consumption trends for the batch of sites activated in EY2023.

Figure 95. SCE Schools Pilot Monthly Energy Consumption Across Pilot Sites



Sites range from 7 to 20 months of operation (based on initial charging sessions rather than the beginning of AMI data, which frequently captures lengthy periods when chargers are connected but not commissioned by their NSPs). Performance varies greatly, with a few sites regularly consuming over 1 MWh monthly. The analysis omits the first few months with few or no charging sessions. Broadly, sites reach steady-state operations around 7 to 9 months after their first charging session. The dip around month 11 may reflect external factors impacting school facilities, such as summer breaks or holidays.

Figure 96 shows the aggregated monthly load factor of various program sites. Load factor compares a site's actual monthly energy consumption to the potential consumption if the maximum-demand 15-minute interval were consistent all month. A constant demand, for example, would result in a 100% load factor (which is highly unlikely in practice). Figure 97 shows that the load factor for most of these sites currently hovers between 6% and 12%. Such data may help site and/or project managers better understand the level of demand on a workplace charging site and how long it takes site to reach full operation and utility. This understanding can also facilitate planning of future sites in terms of charging-parking layout and capacity. Such load factor suggests that maximum demand is very inconsistent at most sites and may reflect what is currently low utilization. Charts are split based on whether projects have achieved over 10% by the end of 2023.

Figure 96. SCE Schools Pilot Monthly Load Factor across PTD Sites (up to 10%)

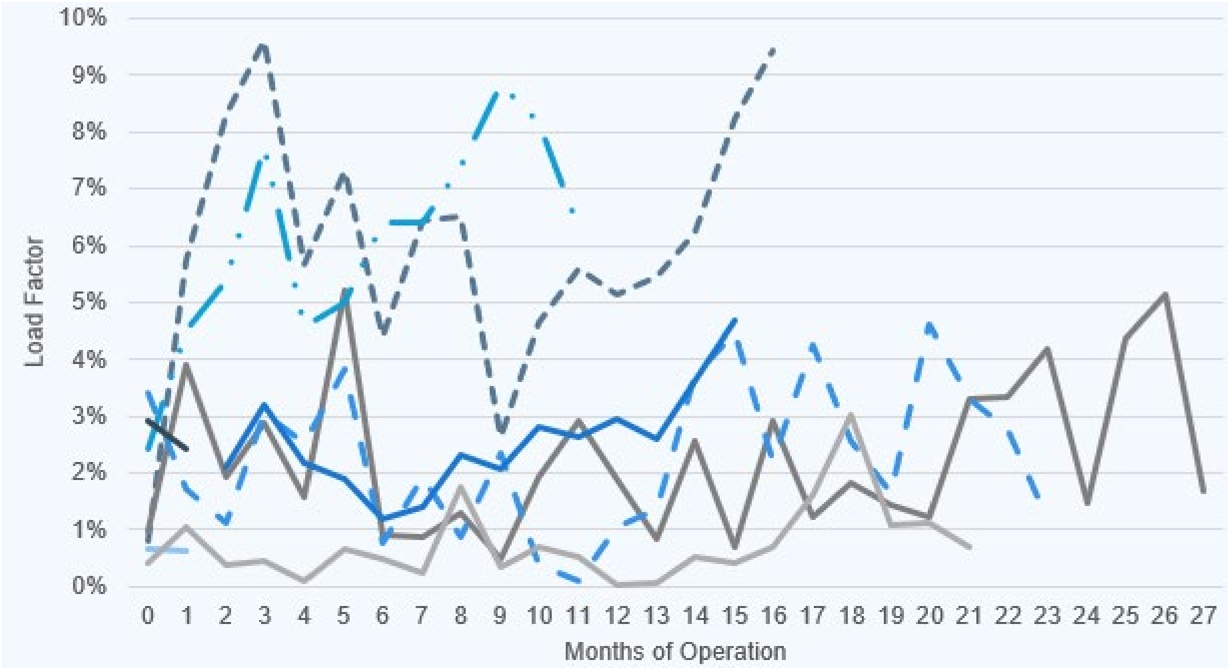


Figure 97. SCE Schools Pilot Monthly Load Factor of PTD Sites (Over 10%)

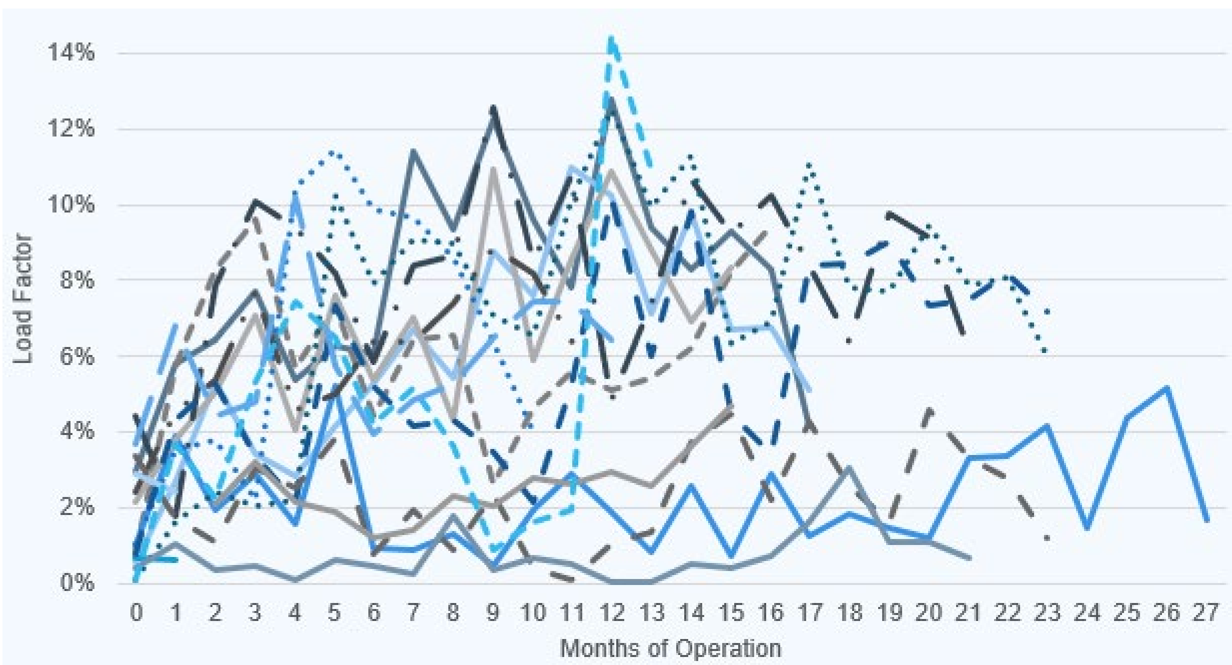
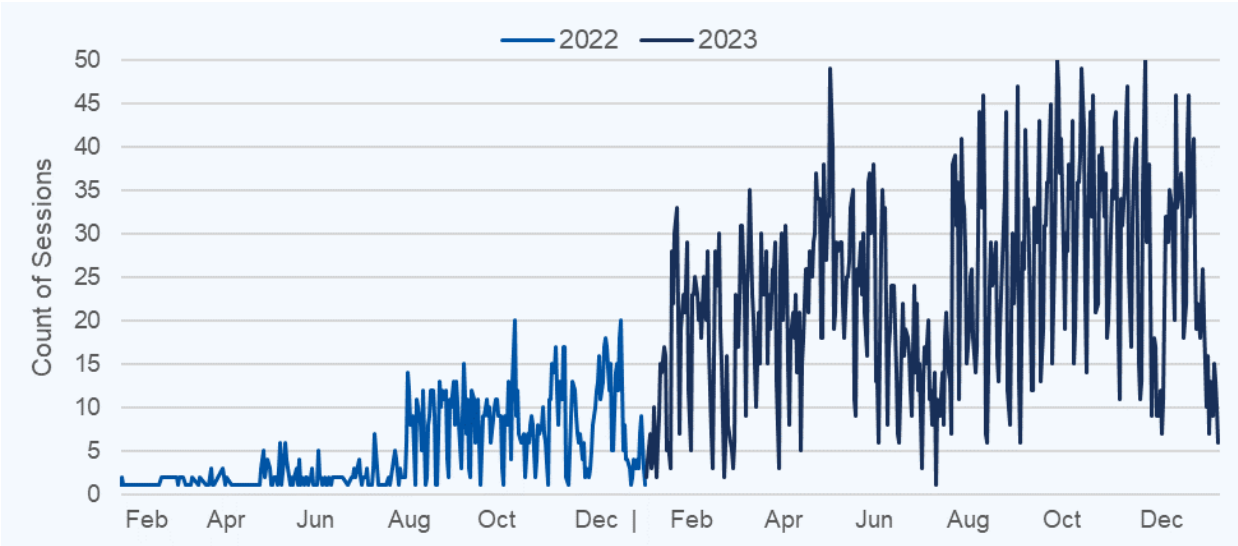


Figure 98 presents the total number of charging sessions in the Schools Pilot. Nearly 10,000 charging sessions have occurred in the program to date, with over 80% in 2023.

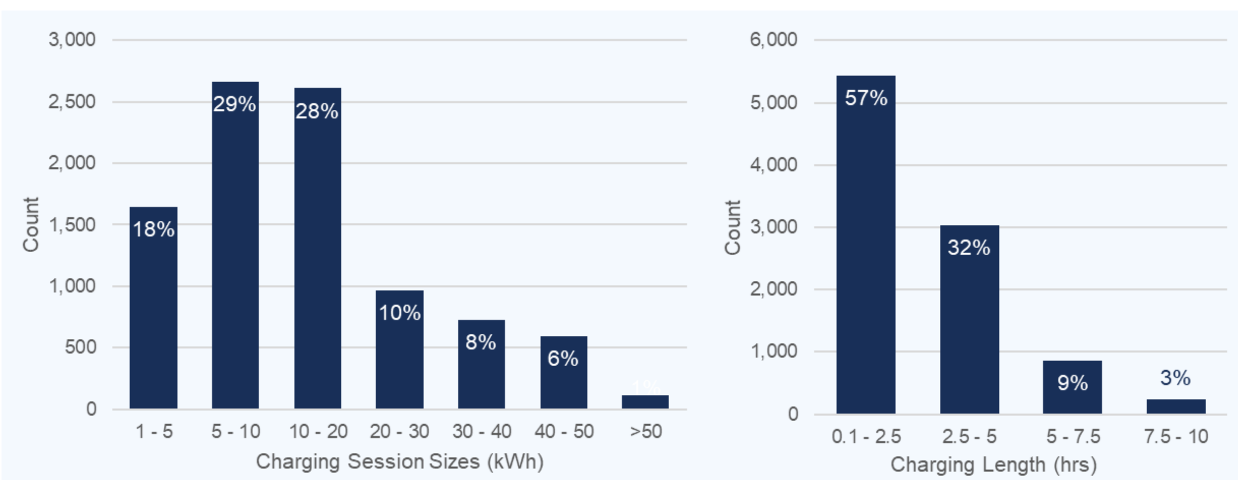
Figure 98. SCE Schools Pilot Daily Charging Sessions for PTD Sites



Given that these sites are within school districts, there is a noticeable valley throughout the summer of 2023 as well as the winter holidays, attributable to school being out-of-session at these times. Across the 21 sites, many of which started later in the year, several days in late 2023 saw up to 50 charging sessions per day. The usage appears to be growing overall.

Figure 99 presents the distribution of charging sessions by consumption (kilowatt-hours) and by the duration of those charging sessions (hours) for all sites in the Schools Pilot to date. Note that erratic charging sessions (below 1 kWh or less than 0.1 hours) were not included.

Figure 99. SCE Schools Pilot Charging Session Count by Consumption Size and Duration for PTD Sites



n = 9,934 sessions

Compared to EY2022, EY2023 charging sessions consume 33% to 38% more energy—between 10 kWh and 30 kWh per session. Several variables may influence this trend, including a higher number of larger battery vehicles, increased EV driver confidence (causing them to drive farther between charges), or increased use by EV drivers who do not have home charging. EY2023 data also reflects charging sessions are getting longer. The shortest sessions (0.1 to 2.5 hours) decreased from 71% to 57% of all sessions, while sessions 2.5 to 5 hours in duration doubled in frequency to 32%.

Highlights

- Consumption data indicates that most SCE Schools Pilot sites are still growing their user base.
- The impact of these sites may take many months or several years to influence people turning over their vehicle ownership or leases of conventional vehicles for EVs.
- Pricing may be a limiting factor of utilization at these sites for drivers if they can find significantly lower costs for charging at home or at other locations besides the school.
- 80% of pilot-to-date charging sessions occurred in 2023, showing much higher utilization.
- Charging sessions are growing in size both in energy consumed (kWh) and duration (hours).

Petroleum Displacement

The Evaluation Team estimated Pilot-induced petroleum displacement related to the 17 SCE Schools Pilot sites using three key pieces of information: electricity used for vehicle charging, EV annual miles traveled, and annual counterfactual vehicle fuel consumption. From this information, we estimated the reduction in equivalent gallons of petroleum as a result of the SCE Schools Pilot. Table 57 presents petroleum displacement impacts for the Schools Pilot sites through 2023, including estimated actual impacts for 2023, actual impacts for all sites PTD, and a 10-year forecast for pilot-to-date sites.

Table 57. SCE Schools Pilot Petroleum Displacement Summary, PTD Sites

DAC	Usage				Petroleum Displacement (GGE)		
	2023 Actual[a] (kWh)	PTD Actual[b] (kWh)	2023 Actual Use (miles)	PTD Actual Use (miles)	2023 Actual	PTD Actual	10-Year Projection
Inside DAC					2,514	3,022	36,157
Outside DAC					7,430	8,932	79,996
Total	**100,608**	**120,671**	**360,528**	**432,461**	**9,944**	**11,954**	**116,153**

[a] "2023 Actual" represents the data from all activated sites from program inception for the calendar year 2023.

[b] "PTD Actual" represents the data from all activated sites from program inception for all program years.

Highlights

- All operational sites in 2023 collectively achieved a pilot-to-date impact of nearly 12,000 gallons of petroleum, with 25% within DACs.
- Over a 10-year period, the sites will displace more than 116,000 gallons of petroleum.

Greenhouse Gas and Criteria Pollutant Impacts

The Evaluation Team calculated reduced emissions from displaced fossil fuel use from ICE vehicles that were not in service as a result of the SCE Schools Pilot. The Team first developed one ICE counterfactual, then calculated the emissions associated with this vehicle under conditions that otherwise matched the EVs to provide a baseline. Although EVs have no tailpipe emissions, the fossil-fuel power plants that supply electricity to the vehicle chargers still release some GHGs and criteria pollutants.

Table 58 presents the GHG reduction resulting from the Schools Pilot in 2023, along with the pilot-to-date and 10-year totals, by impact location. Overall, the Schools Pilot has achieved a 79% reduction of GHG emissions (90 MT total) relative to the counterfactual to date (114 MT, not shown in table), with just over 25% of the impact within DACs.

Table 58. SCE Schools Pilot GHG Reductions Summary, PTD Sites

DAC	Usage				GHG Reduction (MT)		
	2023 Actual[a] (kWh)	PTD Actual[b] (kWh)	2023 Actual Use (miles)	PTD Actual Use (miles)	2023 Actual	PTD Actual	10-Year Projection
Inside DAC					19	23	294
Outside DAC					56	67	638
Total	**100,608**	**120,671**	**360,528**	**432,461**	**75**	**90**	**932**

[a] "2023 Actual" represents the data from all activated sites from program inception for the calendar year 2023.

[B] "PTD Actual" represents the data from all activated sites from program inception for all program years.

Overall, of the local emissions, the Pilot had the highest impact in reducing CO, resulting in an estimated annualized reduction of 54 kg (Table 59).

Table 59. SCE Schools Pilot Local Emissions Net Reductions

Emissions	EY2023 Sites (n=4)			PTD Sites (n=17)	
	Inside DAC	Outside DAC	Total [a]	Actual	10-Year Projection
PM_{10} (kg)	0.07	0.04	**0.11**	0.47	4.63
$PM_{2.5}$ (kg)	0.06	0.04	**0.10**	0.43	4.26
ROG (kg)	0.98	0.57	**1.55**	7.63	96.35
CO (kg)	34	20	**54**	257	3,179

[a] Columns may not sum to total due to rounding.

Figure 100 shows the current mix of electricity from the CAISO grid used to support the SCE Schools Pilot sites.[68] Based on the real-time grid conditions when the EVs charged, the overall energy mix contained about 57% zero-emissions or renewable sources of electricity (including solar, wind, hydro, geothermal, biomass, and nuclear) and 35% natural gas. With the CAISO grid adding more renewables to meet the Renewable Portfolio Standard, GHG and criteria pollutant emissions will continue to decrease.

Figure 100. SCE Schools Pilot Net Electricity Mix, Pilot to Date

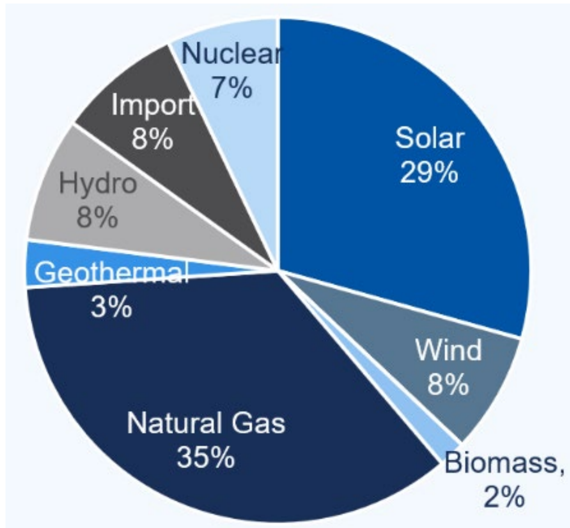
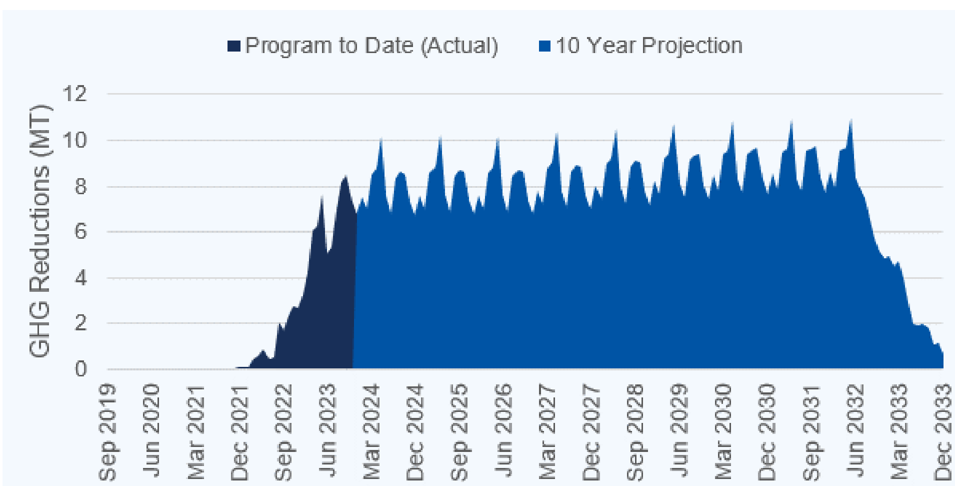


Figure 101 shows how Pilot GHG reductions have increased to date and are expected to grow over time for all activated sites. The analysis period ranges from the date of activation for the first site in the Pilot through the end of 2023. The analysis incorporates the net reduction (counterfactual emissions minus utility emissions) for each site within the SCE Charge Ready Schools Pilot. Emissions reductions from the Pilot to date are shown in dark navy, while anticipated benefits based on annualization appear in royal blue. Starting dates of site operation vary, so the 10-year sunset for each site appears as a gradual tapering off of Pilot benefits in 2032. Although operations appear similar from year to year, several key factors drive variations such as seasonality of Utility generation sources (high utility emissions will appear as a dip on the curves), holidays occurring on weekends versus weekdays, and sites that became operational late in 2023 having predicted operations year-round in future years.

Figure 101. SCE Schools Pilot Historical and Forecasted GHG Reductions, PTD Sites



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68 The power associated with imports comes from a mixture of hydro, nuclear, and natural gas plants located outside the CAISO grid.

Highlights

- The Schools Pilot has achieved a 79% reduction of GHG to date with 25% of its impact occurring within DACs.
- The greatest reduction in local emissions was for CO with a reduction of more than 257 kg in 2023 and a projected 10-year period reduction of more than 3,000 kg.
- Based on the real-time grid conditions when EV charging occurred, the overall energy mix contained about 57% zero-emissions or renewable sources of electricity (including solar, wind, hydro, geothermal, biomass, and nuclear) and 35% natural gas.

Health Impacts

The Evaluation Team calculated public health impacts (as benefits and costs) of reductions in criteria pollutants from vehicle electrification. Pollutants included in the analysis are primary $PM_{2.5}$ and precursors of secondary $PM_{2.5}$, including NO_x, SO_2, NH_3, and VOCs. This analysis considered only tailpipe emissions reductions rather than full lifecycle emissions (such as power plant emissions). The Evaluation Team used the EPA's COBRA to evaluate the health benefits associated with emissions reductions. COBRA estimates the county-level benefits for the county in which emissions are reduced. It also estimates the effect of the transport of emissions on all counties in the United States; however, this analysis includes only the effects of the emissions reductions in California. The Evaluation Team disaggregated the county-level effects to estimate the potential health benefits of sites for DACs and non-DACs.

Economic value depends on the health effects associated with the emissions, that is, whether they are associated with illnesses or death. The monetary value of the morbidity reductions associated with emissions reductions include avoided lost wages, avoided medical costs, and the amount of money people are willing to pay to avoid an illness or condition like respiratory disease. The value of the reduced mortality associated with emissions reduction is measured by the value of a statistical life, which uses value-of-life studies to determine a monetary value of preventing premature mortality. COBRA reports both a low and high impact, representing the uncertainties in the estimates.

The total value of the health benefits associated with the emissions reductions is small, between $375 and $842. Table 60 shows the cumulative health benefits in California associated with the emissions reductions realized by the electrification of EY2023SCE Schools Pilot sites.

Table 60. SCE Schools Pilot California Health Benefits for EY2023 Sites

Health Endpoint	Change in Incidence (Annual Cases)		Monetary Value (Annual, 2023 Dollars)	
	Low	High	Low	High
Mortality	< 0.0000	< 0.0001	$368	$833
Avoided Medical Care				
Nonfatal Heart Attacks	< 0.0000	< 0.0000	< $0	$3
Infant Mortality	< 0.0000	< 0.0000	$2	$2
Hospital Admits, All Respiratory	< 0.0000	< 0.0000	< $0	< $0

Health Endpoint	Change in Incidence (Annual Cases)		Monetary Value (Annual, 2023 Dollars)	
	Low	High	Low	High
Hospital Admits, Cardiovascular	< 0.0000	< 0.0000	< $0	< $0
Acute Bronchitis	< 0.0000	< 0.0000	< $0	< $0
Upper Respiratory Symptoms	0.0008	0.0008	< $0	< $0
Lower Respiratory Symptoms	0.0006	0.0006	< $0	< $0
Emergency Room Visits, Asthma	< 0.0000	< 0.0000	< $0	< $0
Lost Productivity				
Asthma Exacerbation	0.7857	0.7857	$0	< $0
Minor Restricted Activity Days	0.0263	0.0263	$3	$3
Work Loss Days	0.0045	0.0045	$1	$1
Total Health Effects	–	–	**$375**	**$842**

As part of this analysis, the Evaluation Team also examined health benefits within DACs, which may be disproportionately burdened by sources of pollution (including air pollution from ICE vehicles). Because COBRA estimates effects only at the county level, the Evaluation Team disaggregated the health benefits by census tract using the relative population of each tract from the most recent American Community Survey. For example, we allocated 10% of the value of the health benefits to a census tract with 10% of the county's population. The Evaluation Team then estimated the total benefits allocated to DACs and non-DACs. This approach assumes that the benefits of emissions reductions are distributed evenly throughout the county. If the sites are located in DACs, and the emissions reductions are greater in the tracts near the sites, this approach understates the potential benefit to DACs. Additional information about emissions dispersion within counties would provide more precise estimates of the health benefits to DACs and non-DACs.

Orange County had the highest proportion of overall benefits with 61% of the total, followed by Los Angeles County (27%), San Diego County (5%), Riverside County (2%), and San Bernardino County (2%). Overall, 24% of the benefits were in DACs.

Highlights

- The annual monetary health benefits from EY2023 SCE Schools Pilot sites range from a low estimate of $375 to a high estimate of $842.
- Orange County had the highest proportion of overall benefits at 61%, followed by Los Angeles County (27%), San Diego County (5%), Riverside County (2%), and San Bernardino County (2%).
- Overall, 24% of the benefits are in DACs.

Utility Staff Insights

In addition to monthly check-in calls with key SCE staff to discuss the status of the Schools and Parks Pilots, the Evaluation Team also conducted a close-out interview with staff in February 2024 to review overall Pilot challenges and successes in EY2023. The following sections group these challenges and successes by those that apply to both Pilots followed by those that are applicable to only one Pilot.

Schools Pilot and Parks Pilot

Starting 2021 and through 2023, SCE staff reported that site construction costs were higher than anticipated. These costs were compounded by labor constraints, material costs, and supply chain delays. Several years into implementation and dealing with the reality of increasing costs, SCE staff have learned to account for increased costs when planning.

- **Construction Labor Costs and Supply.** Staff noted that construction labor costs have increased as inflation has risen. In addition, like in 2021 and 2022, it has been difficult to secure a sufficient labor force since COVID-19.
- **Material Costs.** Staff reported that most site materials have been generally more expensive than originally anticipated in 2018 (when the Schools and Parks Pilots' funding caps were decided).
- **Supply Chain Delays.** Staff confirmed that supply chain delays, which started as a result of COVID-19, continue to be a challenge.

Schools Pilot

Since the Schools Pilot was considered fully subscribed in 2022, challenges for the 2023 Schools Pilot surrounded construction and operational barriers:

- **Permitting.** Like in 2022, staff noted in 2023 that jurisdictions and organizations that had authority to provide permits (such as the Division of State Architect) continue to have long lead times before site permits are approved, causing delays in beginning construction for many school sites.
- **Vandalism.** In 2023, two constructed sites were vandalized. All six cords at the site were cut and required replacement.
- **Charging Infrastructure Repair Times.** As part of the Pilot, SCE staff facilitate needed site repairs with EVSPs on behalf of participating schools who opted for SCE ownership. Unfortunately, during 2023 there were significant wait times before some EVSPs were able to send out staff to make needed repairs to sites. SCE staff noted that these long wait times were likely due to staff turnover at the EVSPs. Though some issues were addressed as replacement staff came on board at the end of 2023, additional staff turnover remains a concern.

Although staff identified clear challenges at this stage in the Schools Pilot, they also noted successes for 2023. In particular, SCE received positive feedback from participating schools and was able to successfully roll out its custom curriculum to schools in its territory:

- **Positive Engagement and Feedback from School Sites.** SCE staff noted that once construction was completed and chargers were utilized, some school staff and stakeholders become enthusiastic about having the chargers there. This has led to positive word-of-mouth promotion of the chargers, the Pilot, and sometimes to districts contacting SCE to explore possibilities of more chargers at existing sites and/or new sites at different schools.
- **School Curriculum.** In March 2023, SCE, in partnership with TEC, made the EV-focused Schools Pilot Curriculum (primarily designed in 2022 and described in detail in the *Program Materials Summary* section) available to any school in SCE's territory, regardless of participation status.

Parks Pilot

Since SCE staff was able to receive the signed MPA from the State Parks Department in 2022, work in 2023 focused on seeking approval for AL 4926-E and developing site-specific addendums to the MPA. Though these discussions generally went well, the level of coordination needed with multiple parties at the DPR is a challenge for the Pilot:

- **Cross-Jurisdiction Coordination.** With the MPA signed by state-level authorities at the DPR, SCE staff have moved on to primarily coordinating with separate contacts that can represent the sites that have been selected for participation. Though navigable, juggling the needs of the different sites and coordinating with different staff (both site-specific staff and state-level staff, paired with DPR staff turnover) can lead to small delays throughout the site planning and implementation process.

Despite these challenges, SCE staff reported that overall, it was a productive year for the Parks Pilot due to two major successes:

- **Approval to Expand DAC Definition.** During the site selection process with the DPR, a total of 19 sites were identified as viable for the Parks Pilot. However, only two of these sites were in DACs as defined in Decision 19-11-017 (which set the original parameters for the AB Pilots). The Decision also set the goal of 25% of sites in DACs for AB 1083, meaning SCE would have had to cap the Parks Pilot to eight total sites. Therefore, in 2022 SCE submitted AL 4926-E, seeking to reallocate funds that had previously been reserved for sites located in DACs to sites within five miles of DACs. With the approval of AL 4926-E in June 2023, SCE can now explore the viability of up to 11 additional Parks Pilot sites more deeply.
- **Secured Initial Addendum Signatures.** Though coordinating with staff across multiple jurisdictions can be challenging, ultimately SCE succeeded in securing the first eight (out of nine currently planned as of April 2024) site-specific addendum agreements in 2023.

Highlights

- **Schools & Parks:** Similar to previous evaluation years, site costs continue to be a challenge. In particular, securing construction labor as well as the rising labor and materials costs, which continue to be compounded by supply chain delays.
- **Schools:** In addition to costs, long lead times for permitting and repair times were a challenge in 2023, as well as some infrastructure vandalism.
- **Schools**: Despite these continued challenges, once construction is completed and chargers utilized, school staff and stakeholders become enthusiastic which can lead to subsequent peer influence at other schools.
- **Parks:** Though cross-jurisdiction coordination remains a challenge, ultimately, SCE was able to secure the first eight site-specific addendum agreements in 2023.

4.2.3. Lessons Learned

The Team identified a number of lessons learned. These lessons, presented below with key supporting findings and recommendations, may be applied to future Pilot years and to other similar efforts.

Schools and Parks Pilots

Although higher-than-expected site costs and delays continue to challenge implementation, Pilot staff are adapting Pilot targets to reflect market conditions.

SCE began the Schools and Parks Pilots during the COVID-19 pandemic, which had unprecedented economic impacts across nearly every market. These changes were so significant that the estimates SCE had created for Decision 19-11-017 (which mandated the Schools and Parks Pilots at their determined funding levels) did not reflect the actual costs for implementation. Similar to previous evaluation years, in 2023 school site costs continued to be a challenge. Securing construction labor and absorbing rising labor and materials costs were compounded by supply chain delays. Other challenges in 2023 include long lead times for school site permitting and repairs and some infrastructure vandalism. In 2023, SCE staff focused on seeking approval for AL 4926-E, which adjusted the Schools and Parks Pilots targets from 27 to 21 sites and from 25% DAC to 25% DAC or DAC-adjacent and allowed SCE to develop site-specific addendums to the MPA.

Schools Pilot

The Schools Pilot sites are helping to displace petroleum, reduce GHG and local emissions, and achieve nominal health impacts overall and within DACs.

The School Pilot sites accounted for a pilot-to-date impact of more than 12,000 gallons of petroleum, with 25% within DACs. In addition, the Pilot resulted in a 79% reduction in GHGs, of which 25% occurred within DACs to date. These sites all contributed to lowering local emissions, with CO reduction being the most prominent, achieving a reduction of 3,000 kg over a ten-year period. Overall, 24% of the health benefits are in DACs with the monetary health benefits in EY2023 from the SCE Schools Pilot sites ranging from $375 to $842.

SCE's School Pilot has a nominal, but growing, influence on neighborhood EV adoption.

In 2023, the Schools Pilot increased the number of operational sites by 8, bringing the Pilot-to-date total to 21. This uptick in sites contributed to increased EV adoption of 25 EVs for households neighboring the infrastructure (37 in the Pilot to date) as determined through a two-stage spatial regression described in *Appendix A*. While the SCE Schools Pilot has had a relatively small impact on EV adoption, its influence significantly increased in EY2023 compared to EY2022. This growth in impact can be attributed to the expansion of and better access to charging stations within the community.

Parks Pilot

Although cross-jurisdiction coordination remains a challenge, the SCE staff's commitment to the Parks Pilot development is starting to show progress.

The original plan for the Parks Pilot in 2021 was for all Utilities to enter into a collective participation agreement with the DPR, but in 2022 the Utilities separated their efforts and began pursuing independent agreements. In 2023, although discussions generally went well, SCE staff noted that coordinating with site-specific and state-level staff paired with DPR staff turnover led to minor delays throughout the site planning and implementation process. However, SCE was able to secure the first eight site-specific addendum agreements in 2023 for the Parks Pilot.

5. Pacific Gas & Electric Transportation Electrification Programs

5.1. EV Fleet Program

5.1.1. Overview

This overview provides a detailed description of the PG&E EV Fleet program, summaries of the program implementation process, performance metrics, materials, and budget; and a timeline of major milestones. Following the overview are detailed findings, highlights, and lessons learned.

Program Description

Per Decision 18-05-040, PG&E designed the EV Fleet program to provide infrastructure for fleet electrification at low or no cost to participants. The program launched in June 2019 and encompasses incentives and rebates, site design and permitting, construction and activation, and maintenance and upgrades. The program goal is to help fleets install EV charging easily and cost-effectively, saving money, eliminating tailpipe emissions, and simplifying maintenance.[69] PG&E's EV Fleet program has an approved budget of $236.3 million and a program-specific goal to support fleet electrification for 700 sites supporting 6,500 medium-duty and heavy-duty (MDHD) EVs that are procured or converted.[70]

EV Fleet Program Target

Achieve a minimum of 700 sites supporting 6,500 MDHD EVs.

Through the EV Fleet program, PG&E constructs all TTM infrastructure and, depending on the cost-effectiveness of each site, will cover the costs for behind-the-meter (BTM) infrastructure. Otherwise fleet operators design, build, own, operate, and maintain BTM infrastructure. PG&E provides rebates for BTM infrastructure based on the number of vehicles supported by the infrastructure or 80% of the cost of the BTM infrastructure, whichever is lower. Additional charger rebates of up to 50% of the cost are available for transit agencies, school districts, and fleets located in DACs that are not operated by Fortune 1000 companies.

EV Fleet Program Design Goal

Accelerate adoption by providing fleet assistance to install EV charging easily and cost-effectively, saving money, eliminating tailpipe emissions, and simplifying maintenance.

The EV Fleet program requires participating customers to lease, purchase, or convert at least two MDHD EVs. Applicants are not restricted by industry: PG&E will support any nonresidential site aiming to procure two or more MDHD EVs. Additionally, fleets must own or lease the property where the chargers are installed, operate and maintain the infrastructure for 10 years, provide data related to EV usage for five years, and use EVSE that meets CPUC safety checklist requirements among other participation requirements. PG&E offers EV-specific TOU rates (BEV-1 and BEV-2). The SB 350 Decision determines the ranges of spending for the EV Fleet

69 Pacific Gas & Electric Company. Accessed April 28, 2022. "EV Fleet Program."

70 This amount does not include the evaluation budget.

program. The infrastructure budget must allocate a minimum of 15% for transit agencies, a maximum of 10% for forklifts, and a minimum of 25% on installations in DACs in PG&E's territory.

Implementation

Figure 102 shows the key steps in the EV Fleet program implementation process. In December of 2023, PG&E staff revised the process to ensure that customers had already secured a vendor for site/infrastructure construction before signing a contract.

Figure 102. PG&E EV Fleet Program Implementation Process

PRELIMINARY DESIGN PHASE

1. Customer applies through the online application portal
2. PG&E develops an initial design and cost estimate for the site based on the scope and site characteristics
3. PG&E determines if the site is eligible for TTM only, TTM plus incentives, or TTM plus BTM
4. Customer secures a vendor for site/infrastructure construction
5. Customer and PG&E sign contract

FINAL DESIGN AND EXECUTION PHASE

1. Customer designs BTM infrastructure and begins permitting process (may be done by PG&E if applicable)
2. PG&E finalizes TTM design
3. Customer constructs BTM infrastructure
4. PG&E constructs TTM infrastructure
5. PG&E turns on service
6. Customer commissions the EVSE
7. PG&E issues rebates

Program Performance Metrics

The Evaluation Team reviewed the sites participating in PG&E's EV Fleet program and organized them by program status. Table 61 provides the count of sites in the PG&E EV Fleet program by completion status as of December 31, 2023.

Table 61. PG&E EV Fleet Program Complete Site Count by Status

Site Status	EY2023	Program to Date
Utility Construction Complete	26	72
Activated	20[71]	62
Operational	19	60
Closed Out	20	52

71 For 2023, Evaluation Team and PG&E in their SB 350 Data report list 20 new sites, 2 of which have 2022 activation dates that were not available at the time of the 2022 evaluation report and PG&E's SB 350 Data report. For purposes of evaluation reporting, these two sites are counted as newly activated sites in 2023, which is when they were first reported as activated.

In EY2023, PG&E's EV Fleet program received an additional 107 applications, signed contracts with 90 sites, and activated 20 sites to support 368 MDHD EVs across four market sectors. This increased the total number of applications[72] received to date by PG&E's EV Fleet program to 455 and the total number of contracts executed to date to 239. As Table 62 displays, 55% (11 of 20) of sites in the EV Fleet program activated in EY2023 and 44% (27 of 62) of sites activated to date are located within a DAC.

Table 62. PG&E EV Fleet Program Activated Sites by Market Sector in EY2023 and Program to Date

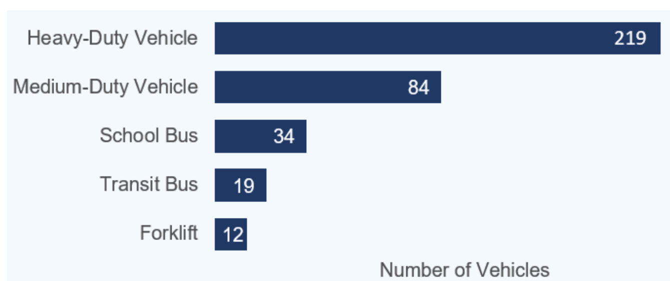
Market Sector	EY2023		Program to Date	
	Number of Sites in DAC	Number of Sites in Non-DAC	Number of Sites in DAC	Number of Sites in Non-DAC
Forklift	1	–	3	1
Heavy-Duty Vehicle	4	2	7	3
Medium-Duty Vehicle	2	2	4	5
School Bus	3	4	9	21
Transit Bus	1	1	4	4
TRU	–	–	–	1
Total	**11**	**9**	**27**	**35**

In EY2023, the highest participation rate in PG&E's EV Fleet program came from school bus fleets, which represented over a third (35%) of activated sites. Heavy-duty vehicle fleets represented 30%, followed by medium-duty vehicle fleets with 20% of EY2023 activated sites. Of EY2023 activated sites, 10% were transit bus fleets while only 5% were forklift sites.

Participation in PG&E's EV Fleet program continues to be dominated by school bus fleets, which represent nearly 50% of all activated sites in the program to date. Heavy-duty vehicle fleets are the second most common market sector overall, with 16% of all activated sites. Medium duty vehicle fleets account for 15% and transit bus fleets for 13% of activated sites, while the forklift and TRU market sectors combined have the fewest sites, with less than 10% of activated sites as of December 31, 2023.

Through the EV Fleet program, PG&E installed charging infrastructure to support 368 MDHD vehicles across four market sectors in EY2023 based on 5-year VAPs submitted by customers at the time of application. This brings the total number of supported MDHD EVs in PG&E's EV Fleet program to 874 per VAPs. In EY2023, heavy-duty vehicle market sector accounted for most vehicles, followed by medium-duty vehicle, school bus, transit bus, and forklift market sectors, as shown in Figure 103.

Figure 103. PG&E EV Fleet Program Vehicles Supported by Market Sector, EY2023 Sites



[72] Total applications include any applications that were cancelled or put on hold.

As shown in Table 63 the PG&E EV Fleet program had 62 activated sites by the end of 2023 supporting the electrification of 874 MDHD vehicles per customers' VAPs. The 239 contracts signed in the EV Fleet program meet 34% of the program's *per se reasonableness* goal of 700 sites and could support 4,942 MDHD vehicles, meeting 76% of the program's *per se reasonableness* goal of 6,500 additional vehicles electrified. The total 455 customer applications could satisfy 65% of the program's site goal and would satisfy the program's electrified vehicles goal.

Table 63. PG&E EV Fleet Program *Per se Reasonableness* Site and Vehicle Goal Progress

Program Metric	*Per se Reasonableness* Goal	Program to Date
Activated Sites	700	62
MDHD EVs	6,500	874

The CPUC established six phases in program timelines per the SB 350 reporting template. As displayed in Table 64, at the end of 2023 over half of customer applications (52%) were in the Design and Permitting phase, which is a potential bottleneck because it involves external review and requires communication with applicants to finalize site plans. Overall, the majority (79%) of sites were in the final three phases of the program, with the remaining 21% of sites in the earliest three phases.

Table 64. PG&E EV Fleet Program Sites and Vehicles by Program Phase, as of December 31, 2023[73]

CPUC Program Phase	Number of Sites [a]	Total Number of EVs Supported
Application Review	26	785
Site Assessment	21	467
Contract Issuance	29	619
Design and Permitting	166	3,722
Construction Complete	12	354
Activation	62	874

Table 65 displays the median durations per program phase (measured in calendar days) for EY2023 and program to date activated sites. The column labeled EY2023 refers to sites activated in 2023. The Program to Date column refers to all sites activated from the initiation of the program to December 31, 2023.

Values in Table 65 provide insight into program phase length trends over time. Sites in each column did not necessarily pass through each phase in the same calendar year. For example, some sites in the EY2023 column may have passed through Design and Permitting in 2023 while others passed through in 2022. For sites activated in 2023, the Design and Permitting program phase had the longest median duration, while the remaining five program phases had roughly equivalent median durations.

[73] This table includes sites that were not cancelled as of December 31, 2023.

Table 65. PG&E EV Fleet Program Median Calendar Days per Phase for EY2023 and PTD Sites

CPUC Program Phase	Median Calendar Days	
	EY2023	Program to Date
Application Review	45	20
Site Assessment	41	48
Contract Issuance	43	46
Design and Permitting	446	317
Construction Complete	49	39
Activation	39	19

Durations also vary by individual market sectors. For instance, heavy-duty vehicle applications took a median of 130 days to complete the Construction Complete phase, while medium-duty vehicle applications took a median of 28 days.

Figure 104 expands the analysis of program phase durations by displaying the average number of calendar days (denoted by X), the median calendar days (middle line in box), first quartile (bottom of box), third quartile (top of box), minimum (bottom tail), maximum (top tail), and outliers (dots). Program applications experienced far greater variation in completion time within the Design and Permitting phase than in any other program phase. As previously mentioned, this could stem from this phase's external review and substantial back-and-forth with applicants to finalize site layout and design. This was followed by Construction Complete, which requires coordination among contractors and supply chain vendors. Customer applications in the Application Review, Site Assessment, Contract Issuance, and Activation phases experienced the lowest mean and variance in calendar days among all the program phases, despite a few outliers.

Figure 104. PG&E EV Fleet Program Calendar Days per Phase for EY2023 Sites

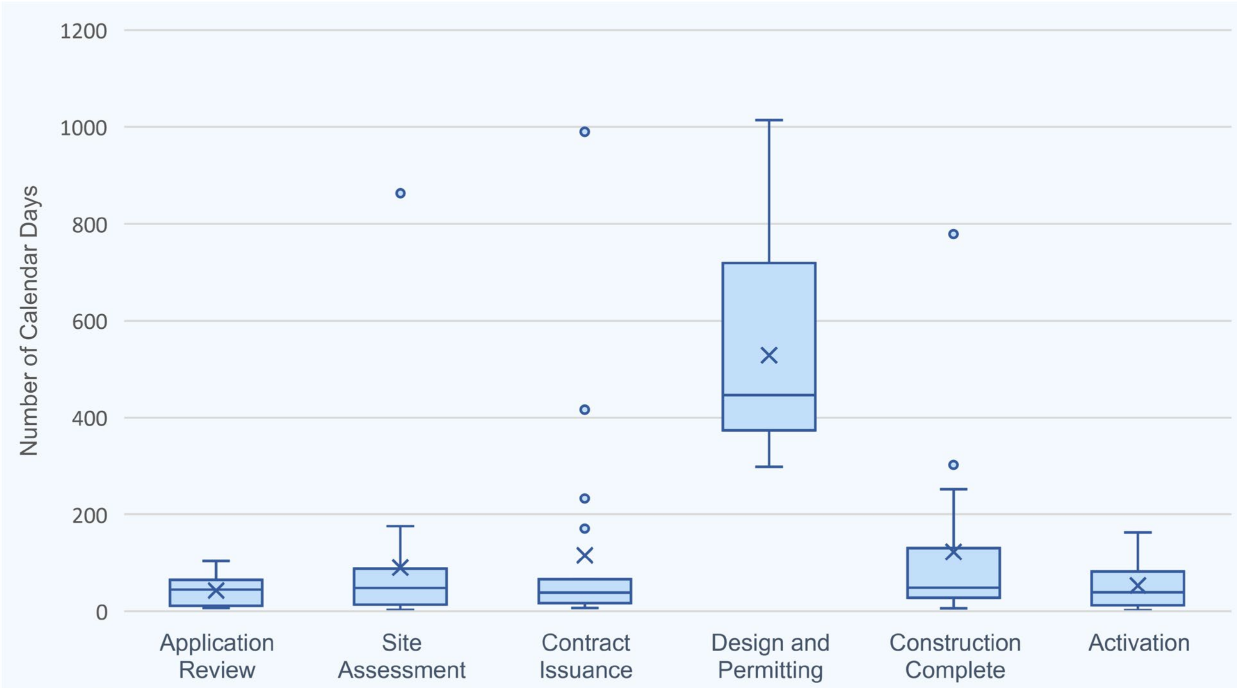


Table 66 displays the median number of calendar days that the EV Fleet program took from start to finish (application review to activation) for 20 activated sites across four market sectors in EY2023 and for 62 activated sites to date. The overall median start-to-finish timeline for site activation for EY2023 sites was 808 calendar days. The overall median start-to-finish timeline for site activation for these sites was the shortest for medium-duty vehicle sites with 556 days and longest for transit bus sites, which took more than twice as long (1,315 days) to complete the program. The overall median start-to-finish timeline for site activation for all PTD sites was 640 calendar days, ranging from 393 days for TRU applications to 915 days for transit applications. For PTD activated sites, Design and Permitting continues to be the longest phase, with a median of 317 days, or nearly 50% of the overall implementation timeline.

Table 66. PG&E EV Fleet Program Median Duration for Site Activation by Market Sector for EY2023 and PTD Sites

Market Sector	EY2023		Program to Date	
	Median Duration Start-to-Finish (Calendar Days)	Number of Activated Sites	Median Duration Start-to-Finish (Calendar Days)	Number of Activated Sites
Forklift	773	1	475	4
Heavy-Duty Vehicle	788	6	735	10
Medium-Duty Vehicle	556	4	595	9
School Bus	930	7	645	30
Transit Bus	1,315	2	915	8
TRU	–	0	393	1

All Market Sectors	**808**	**20**	**640**	**62**

Program Materials Summary

This section highlights findings from the review of program material and ME&O activities PG&E staff conducted in 2023. PG&E staff expanded customer education and outreach efforts to increase program participation through targeted engagement in events and leads generation:

- **Increasing Outreach Frequency.** PG&E staff reached out to customers via email, trade publication ads, and targeted events to educate audiences on the program. Program staff reported 124 webinar, 1,347 emails, and 341 event engagements with eligible fleets in 2023 on topics such as upcoming state EV legislation, funding opportunities, and a fleet electrification case study. As shown in Figure 105, PG&E often presents these topics together to demonstrate how the EV Fleet program can help support fleets during the transition.

Figure 105. PG&E EV Fleet Program Marketing Flier

- **Switch from Broad to Deep.** One of PG&E's primary outreach tactics in 2022 was contracting with a telemarketing firm to conduct cold calls with customer segments, which generated many leads from customers who expressed some interest but ultimately did not result in many applications or sites enrolled. Through this experience, PG&E staff learned that broad, light-touch outreach was not effective for identifying good candidates for the EV Fleet program. Therefore, in 2023, PG&E staff adjusted program recruitment and lead development tactics. Instead of using an outside firm to conduct cold calls to many customers, existing PG&E onboarding specialist staff now look for concrete indicators that a customer is looking to invest in EVs soon, such as discussions with a car dealership about purchasing an EV, actual EV purchases, or receipt of EV grants. After one of these efforts, staff reported 341 engagements with potential participants from a single targeted event with local car dealers. Despite challenges with customer readiness slowing down the application process, this approach has resulted in more successful applications and signed contracts than previous years' outreach efforts. In 2023, onboarding specialists were responsible for generating 95% of leads, a vast increase from the 5% estimated in the initial program design.

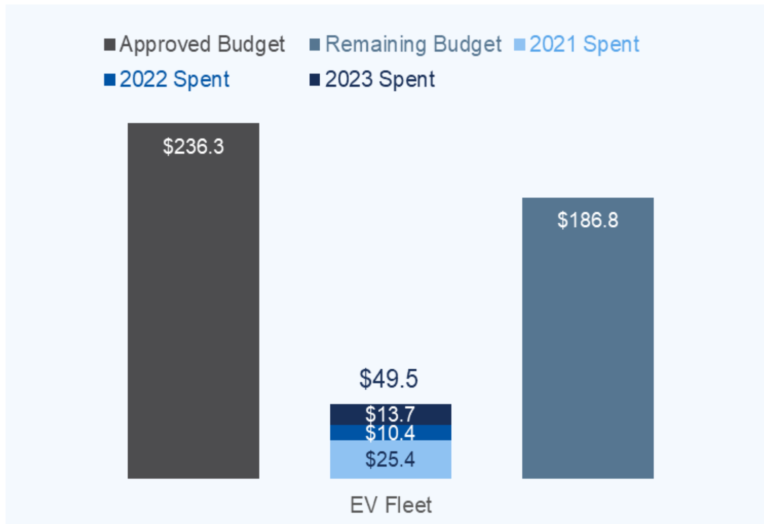
Budget Summary

As shown in Figure 106, from program inception through December 31, 2023, PG&E spent $49.5 million of the approved $236.3 million budget for the EV Fleet program. In 2023, program spending was $13.7M.

Timeline

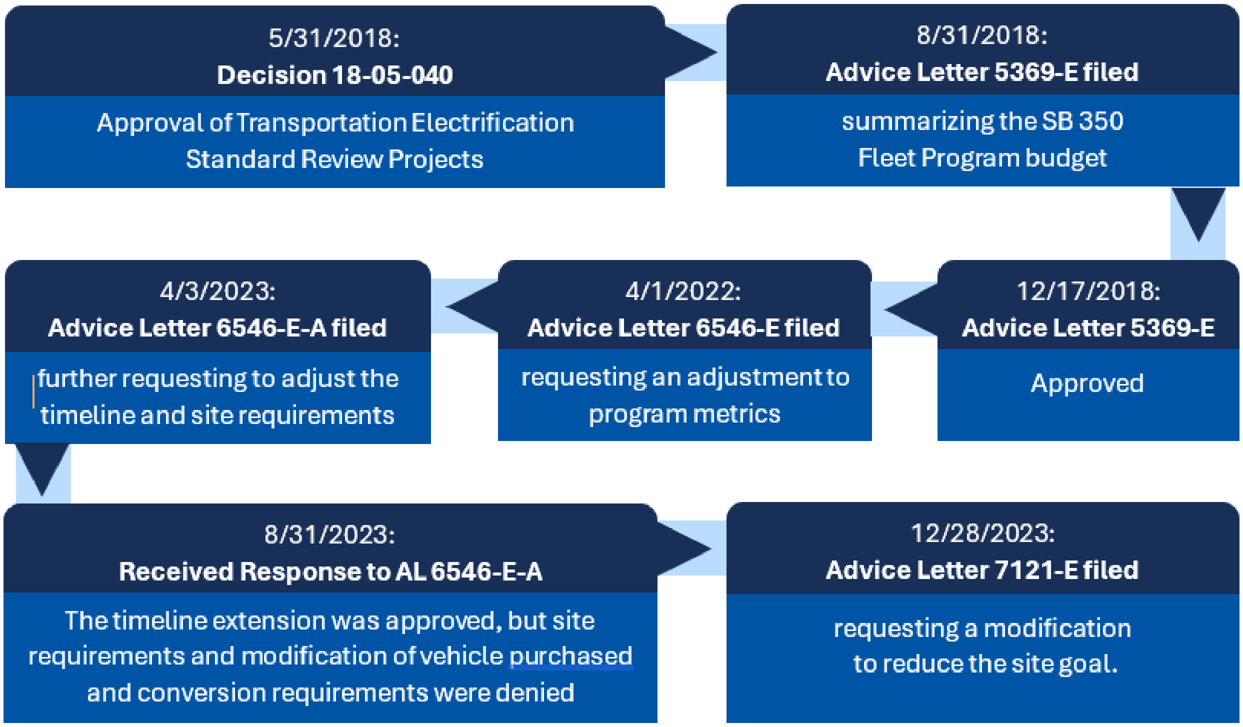
Since the beginning of the program PG&E has filed two Advice Letters. In 2022, PGE&E and SCE jointly filed AL 6546-E for program metrics and changes but received a protest from the CPUC. In response, PG&E filed AL 6524-E-A in April 2023 to address CPUC concerns from the initial Advice Letter. Although the CPUC granted the timeline extension in August 2023, it denied PG&E's proposal to eliminate the site requirements and to modify the vehicle purchase and conversion requirements. Therefore, PG&E filed AL 7121-E on December 28, 2023, as a response to the rejected modifications for site goals in AL 6546-E-A. Instead of eliminating the site requirement, AL 7121-E proposes a reduction of the site goal minimum.[74] Figure 107 shows all major milestones since the beginning of the program.

Figure 106. PG&E EV Fleet Program Spend Compared to Program Budget (Million USD) as of December 31, 2023



[74] As of June 2024, the Advice Letter was still under review by the CPUC.

Figure 107. PG&E EV Fleet Program Key Milestones



5.1.2. Findings

This section provides findings from the Utility staff interviews, surveys, and site visits and deep dives. The Evaluation Team also provides insights from the co-benefits and co-costs analysis, site costs, as well as grid impacts, petroleum displacement, GHG and criteria pollutant reductions, health, and net impacts.

Table 67 presents key impact parameters for EY2023 and the program to date. Annual estimates of impacts are provided for metrics calculated as part of the impact evaluation. Additionally, the table provides estimates of impacts across all sites included in the program population through the end of 2023.

Table 67. PG&E EV Fleet Program Impacts Summary

Impact Parameter	EY2021 Sites [a]	EY2022 Sites [a]	EY2023 Sites [a]	EY2023 Sites Percentage in DAC	PTD Sites Actual	PTD Sites Actual Percentage in DAC
Population of Activated Sites (#)	28	14	20	55%	62	44%
Sites Included in Analysis (#)	24	13	18	61%	60	45%
Ports Installed in Analyzed Sites (#)	197	132	250	47%	630	49%
EVs Supported (#) [b]	265	184	383	64%	874	55%
Electric Energy Consumption (MWh)	2,806	2,021	3,997	39%	13,019	57%
Petroleum Displacement (DGE)	306,260	207,454	342,618	41%	1,363,157	61%
GHG Emissions Reductions (MT GHG) [c]	2,655	1,660	2,314.8	36%	6,060	31%
NO_x Reduction (kg)	1,625	587	621.1	11%	3,831.74	31%
PM_{10} Reduction (kg)	32.9	2.5	11.79	26%	37.3	63%
$PM_{2.5}$ Reduction (kg)	29.5	2.4	11.22	26%	32.1	61%
ROG Reduction (kg)	236	33.5	63.9	52%	525.8	72%
CO Reduction (kg)	12,946	20,884	17,935	81%	85,360	64%

[a] Energy consumption, petroleum displacement, and emissions reductions are based on annualized data. PTD results in the table are based on actual data (see *Appendix A* for more details).

[b] The Evaluation Team derived the EVs supported value from applicants' VAPs. This value represents the maximum number of vehicles expected to be supported by the charging infrastructure.

[c] GHGs include CO_2, CH_4, and N_2O multiplied by their respective GWP as defined by IPCC AR5 (see *Appendix A* for more details).

Utility Staff Insights

In addition to monthly check-in calls with key PG&E staff to discuss the status of the EV Fleet program, the Evaluation Team conducted a close-out interview with staff in February 2024 to review overall Program challenges and successes in EY2023. Staff identified several program challenges:

- **Site Costs.** As noted in previous years, per-site costs continue to be higher than expected in 2023, both for TTM and BTM. For example, equipment costs continue to increase, making electrification harder for customers (as the program does not sufficiently cover all customer BTM costs) and decreasing the number of sites that would be cost-effective for the program. To be effective stewards of program funds while facing these challenges, PG&E staff carefully consider which sites are best suited for the program as the program matures. In 2023, with the program currently on track to meet vehicle goals, PG&E staff started to focus on smaller sites that would cost the program less as PG&E strives to reach as many fleets as possible.
- **Site Execution.** Once a contract is signed, PG&E has encountered multiple challenges to completing a site:
    - *Equipment Delays*. Equipment procurement (in particular, switchgear) remains a challenge for sites. Sites in 2022 had supply chain delays for switchgears of around 70 weeks (about 1.5 years), which decreased slightly to between 35 and 40 weeks in 2023.
    - *Customer Changes*. Customers have asked for equipment and design changes to their sites at later stages, even after a contract has been signed. This increases the cost of the site as

PG&E staff must review the request, work the changes into the contract, and potentially engage contractors to redo design work.

- **Customer Readiness.** Though some fleets in PG&E's territory may be close to electrification, prior to program participation, they are difficult to identify; PG&E staff compared finding these near-term electrification customers to finding a needle in a haystack. Most customers are new to electrification and need help understanding and estimating BTM costs (even if the program is not going to support those costs) to make crucial decisions about their equipment. PG&E staff often must provide electrification readiness support to prospective program participants, even though the EV Fleet program was not designed or budgeted to provide robust customer education. PG&E staff took two key actions 2023 to help address this concern:
    - *Vendor Requirements Prior to Program Contract.* In early 2023, PG&E staff noted that some customers who initially signed a contract would withdraw from the program before construction began because they were not actually ready for electrification and would back out when having to select a vendor for TE. These dropouts strain the program budget as PG&E spends time up front ensuring that the site is feasible for the program and even more time in design once a contract has been signed. To mitigate this challenge moving forward, the program added a new requirement in December 2023 for customers to secure a vendor for construction before signing a contract for the program. This requirement ensures that the program is working with customers only when they are ready to follow through on electrification.
    - *Non-EV Fleet Program TE Education.* To provide more-robust support to its customers, in 2023, PG&E began to seek approval for other initiatives around TE that are focused on raising customer awareness and helping customers assess their readiness, like California's TEAS program. This would allow PG&E staff to direct customers to deep dive consultations without additionally burdening the EV Fleet program budget.
- **Grid Capacity.** Though most projects to date are not impacted by grid constraints, in 2023, PG&E staff noticed that customers interested in the program are increasingly concerned with grid capacity. Even though customers may need significant education to understand if electrification is right for their program, they understand that large-scale electrification of MDHD fleets will strain the grid, and they want to understand how PG&E is mitigating those impacts. The EV Fleet program has some safeguards in place, such as ensuring that program participants are enrolled in TOU rates that favor usage for off-peak hours. And although load management continues to be a struggle for newly electrified fleets, PG&E program staff have been trying to help customers practice load management and will be exploring this further in 2024.

PG&E staff also report notable successes in 2023:

- **Public Awareness.** Because of the program's creativity in meeting customer needs even for niche industries, such as electrification of water vehicles (specifically, a ferry), PG&E has received national and international interest in the EV Fleet program. Through its implementation, the program naturally engages many kinds of stakeholders, including customers, prospects, designers, OEMs, dealerships, and EVSP/EVSE vendors. As more fleets are successfully electrified through the program and more stakeholders are engaged, PG&E staff have been invited to speak in a variety of engagements such as a panel for an ACT Expo, a conference for a trucking organization in the Midwest, and a Marine Expo in Long Beach. Through these wide-reaching activities, PG&E staff have shared their insights from the program with thousands of companies.

- **Improved Customer Outreach.** Because many pieces need to fall into place before fleets are ready for electrification, the program's successes have primarily been with customers who are already prepared to commit to electrification. Therefore, the Team adjusted customer engagement in 2023 to focus on finding these customers that are near-term on electrification. Because this can be challenging, the Team innovated around tactics to reach these customers, such as: outreach to EV grant awardees, working with OEM and EV dealers to find out what customers already have placed orders, having the customer relations team plug the EV Fleet program, and conducting smaller in-person events such as the Ride and Drives to connect with dealers and customers face-to-face.
- **Building Customer Trust.** Through the EV Fleet program, PG&E has become a provider of information and resources on TE to its customers. PG&E sees this role as an opportunity to build customer trust over the long term as it continues to publish new, unbiased materials that focus on education rather than promotion of specific equipment or companies.

Highlights

- Similar to previous evaluation years, site costs continue to be a challenge for both TTM and BTM.
- PG&E staff face challenges even after contracts are signed including with customer equipment and design changes and delays, which contribute to increased costs.
- To mitigate the number of customer withdrawals and secure interested customers, PG&E staff adjusted customer engagement to focus on finding customers that are near-term on electrification, started connecting with customers using other efforts focused on raising customer awareness, and began requiring customers to secure a vendor for construction before signing a contract for the program.
- Though most projects to date are not impacted by grid constraints, a growing number of customers are increasingly concerned with grid capacity.
- PG&E has received national and international interest in the EV Fleet program because of the Utility's creativity in meeting customer needs even for niche industries, such as electrification of water vehicles.
- The EV Fleet program has provided PG&E with the opportunity to build customer trust through its publicly available information and tools on TE.

Survey Results

The Evaluation Team surveyed fleet managers who participated in PG&E's EV Fleet program about their motivations for and barriers to electrification, satisfaction with and awareness of the program, experience with EVs and charging infrastructure, views about the impact of the program on fleet electrification, and perspective on the industry. Table 68 shows the sectors of each fleet manager that responded to the survey. In addition, the sections below provide insights from two fleet managers who withdrew from the program (known as withdrawn fleet managers).

Table 68. PG&E EV Fleet Program Manager Survey Sample for EY2023 Sites

Survey Type	Sector	Number of Surveys Sent	Number of Partial Surveys	Number of Completed Surveys
Participating Fleet Managers	Heavy-duty vehicle	5	–	2
	Medium-duty vehicle	2	–	–
	School bus	4	–	1
	Transit bus	3	–	1
	Forklift	1	–	–
Total Participants	–	**15**	**–**	**4**
Withdrawn Fleet Managers	–	30[a]	0	**2**

In some cases, the number of responses to a question is less than four (the number of completed surveys). This is due to cases in which not all respondents answered a question.

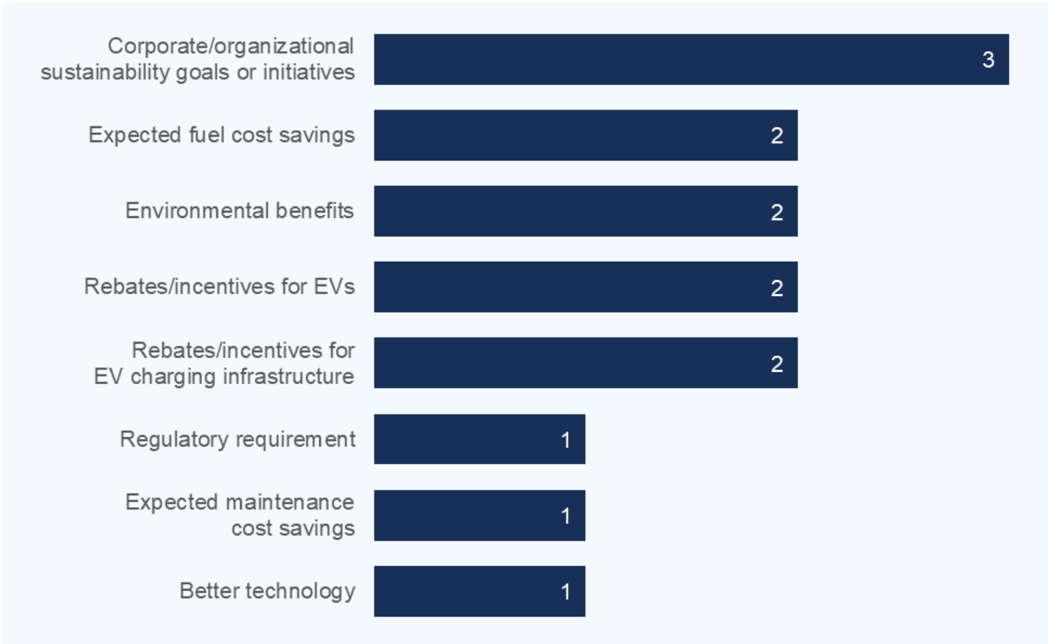
[a] Nine emails were returned as undeliverable from the original sample (39).

Despite the Evaluation Team's efforts to improve the response rate through multiple rounds of outreach and the available survey incentives, the fleet manager survey did not reach the target response number, which limits the insights available in a smaller sample size.

Electrification Motivators and Barriers

The Evaluation Team asked fleet managers about their motivations to transition to EVs. As shown in Figure 108, the top motivator, mentioned by three respondents, was corporate/organizational sustainability goals or initiatives (heavy-duty and one transit bus), followed by fuel cost savings (transit bus and heavy-duty), environmental benefits (transit and heavy-duty), rebates/incentives for EVs (transit and school bus), and rebates/incentives for EV charging infrastructure (transit and school bus), which were each selected by two of four respondents. For comparison, in EY2022, fleet managers had similar motivations with more emphasis on expected maintenance cost savings (three respondents) and less on expected fuel cost savings (one respondent). One transit bus fleet manager also specified that client preferences were a motivator.

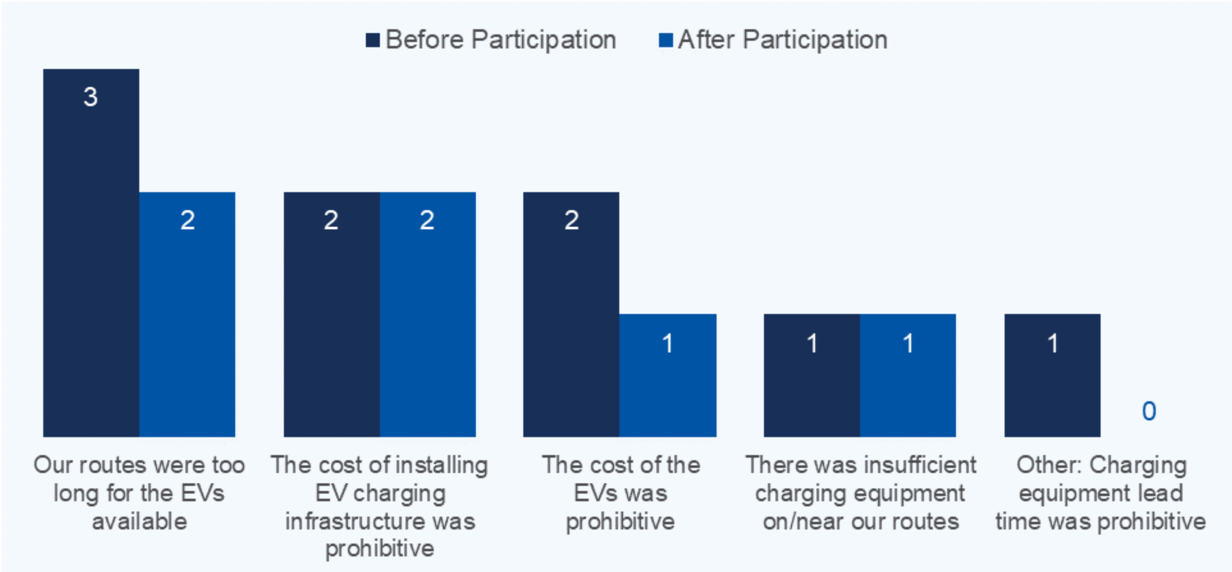
Figure 108. PG&E EV Fleet Program Participant Motivators for Transitioning to EVs in EY2023



Source: Fleet Manager Survey Question C1. "Why did your fleet decide to transition to EVs? Select all that apply." (n=4, multiple responses accepted).

The Evaluation Team asked fleet managers which barriers to electrification their fleets faced before participating in the PG&E EV Fleet program and which remained after participation. As shown in Figure 109, prior to participating in the EV Fleet program, fleet managers said the biggest barriers to electrification included routes too long for EVs available (one transit, one heavy-duty, and one school bus respondent), the cost of EVs (one school and one heavy-duty respondent), and the cost of installing EV charging infrastructure (two heavy-duty respondents). After participating in the program, long routes for available EVs remained a key barrier (one transit and one school bus respondents) and the cost of installing EV charging infrastructure was still seen as prohibitive (two heavy-duty respondents). One manager who had noted charging equipment lead time as a barrier prior to electrification did not report this as a barrier after participation.

Figure 109. PG&E EV Fleet Program Barriers to Electrification Before and After Program Participation in EY2023



Source: Fleet Manager Survey Questions F3 and F4. "Which of the following barriers to electrification did your fleet face before participating in the EV Fleet program?" (n=4; multiple responses allowed) and "You mentioned that the following were barriers to electrification before participating in the EV Fleet program. Do any of these barriers still exist after you participated in the program?" (n=4; multiple responses allowed)
Note: No respondents provided a rating of "It was challenging to find the right types of EVs for our needs," or "Finding qualified drivers or maintenance technicians for EVs."

Program Satisfaction

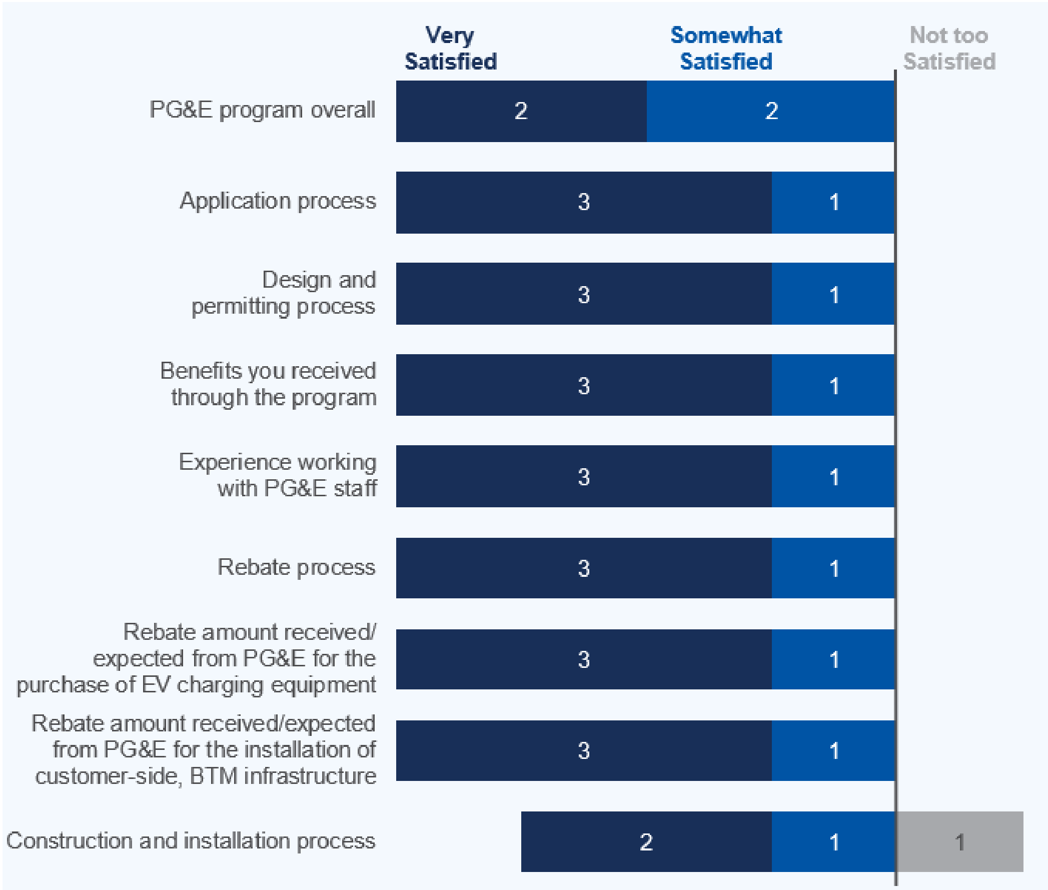
When asked how likely they were to recommend the EV Fleet program on a scale of 0 to 10, with 10 being already recommended, three of four fleet managers said they had already recommended the program. One respondent gave their likelihood of recommending the program a 6. Together, these ratings led to a NPS of +75.[75]

Figure 110 shows satisfaction with the EV Fleet program. The surveyed fleet managers were satisfied with their overall experience, with two managers rating themselves as *very satisfied* and two rating themselves as *somewhat satisfied*. Similarly, in EY2022 three managers rated themselves as *very satisfied* and two rated themselves as *somewhat satisfied.* Managers were particularly satisfied with the application, design and permitting, and rebate processes. In addition, managers reported being very satisfied with the benefits received, working with PG&E staff, and the rebate amounts received for the purchase of EV charging equipment and for the installation of customer-side, BTM infrastructure. One

[75] The NPS is calculated by subtracting program detractors (those who rated their likelihood to recommend the program to others as a 0 through 6) from the program promoters (those who rated their likelihood to recommend the program as a 9 or 10). The manager who gave a rating of 6 was labeled as passive and their rating did not negatively or positively impact the score.

respondent included in an additional comment about their positive experience with two PG&E staff members that they were “great to work with” and “very responsive” (Heavy-duty sector).

Figure 110. PG&E EV Fleet Program Satisfaction with Program Elements in EY2023



Source: Fleet Manager Survey Question B1. “Thinking about your experience with the EV Fleet program, how satisfied are you with the following?” (n=4)
No respondents provided a rating of *not at all satisfied* for any element.

One fleet manager was *not too satisfied* with the construction and installation process, stating that “behind-the-meter construction with a different construction firm (not PG&E) experienced several delays and design limitations.”

Program Awareness

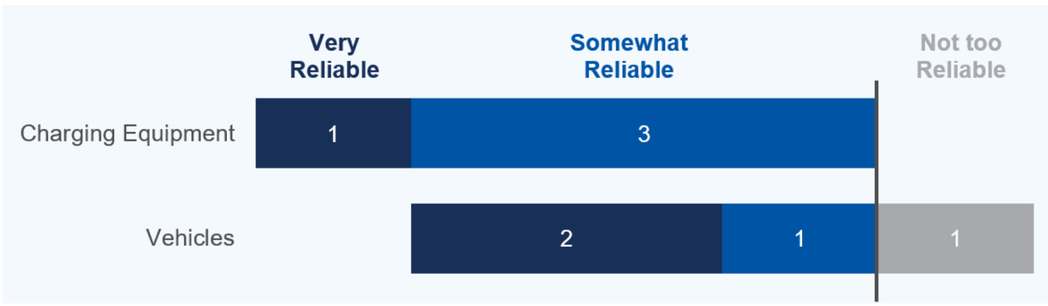
The Evaluation Team asked fleet managers how they learned about the EV Fleet program. Two of four fleet managers learned about the program directly from PG&E, while one learned about the program from another fleet (the respondent did not specify if it was a participant) and one heard about it from a contractor/engineer. When asked whether they knew prior to joining the program if the electrical infrastructure needed upgrades to charge EVs, three fleet managers said they were aware, and one said they were not.

The Evaluation Team asked fleet managers what they would have done differently if they could go through fleet electrification again. Two fleet managers provided answers. One said they would have "ensured greater flexibility with expansion and placement of future charging stations." Another said they would have "selected dual dispenser charging cabinets that had the capacity to charge simultaneously."

Experience with EVs and Charging Infrastructure

The Evaluation Team asked managers about the reliability and ease of using the EVs and charging equipment in their fleet; three of four respondents rated the EVs as either *somewhat reliable* or *very reliable* and four of four rated the charging equipment as either *somewhat reliable* or *very reliable*, as shown in Figure 111.

Figure 111. PG&E EV Fleet Program Reliability of Vehicles and Charging Equipment in EY2023



Source: Fleet Manager Survey Questions C3 and C4. "How would you rate the reliability of the electric vehicles that are part of your fleet?" (n=4) and "How would you rate the reliability of the electric vehicle charging equipment?" (n=4)
Note: No respondents provided a rating of not at all reliable.

Additionally, two fleet managers rated the charging equipment as *very easy* to operate and two rated it as *somewhat easy*.

Impact of Program on Fleet Electrification

Fleet managers were asked about their plans to accelerate their procurement of EVs and related equipment because of their program experience. Of the four fleet managers who answered this question, three had no plans to further accelerate procurement in the future, while one had plans to slow procurement but did not provide feedback on what impacted their decision.

While no fleet managers plan to accelerate procurement, fleet managers reported that they planned to acquire more EVs in the next 5 years and in the next 10 years (Table 69).

Table 69. PG&E EV Fleet Program EV Acquisition Projection by Vehicle Type in EY2023

Respondent and Sector	Current EV Fleet Size	EV Type							
		School Bus 5 yrs.	Transit Bus 5 yrs.	Medium-Duty 5 yrs.	Heavy-Duty 5 yrs.	School Bus 10 yrs.	Transit Bus 10 yrs.	Medium-Duty 10 yrs.	Heavy-Duty 10 yrs.
Heavy-Duty Vehicle	51	–	–	–	100	–	–	–	300

Respondent and Sector	Current EV Fleet Size	EV Type							
		School Bus 5 yrs.	Transit Bus 5 yrs.	Medium-Duty 5 yrs.	Heavy-Duty 5 yrs.	School Bus 10 yrs.	Transit Bus 10 yrs.	Medium-Duty 10 yrs.	Heavy-Duty 10 yrs.
School Bus	1	1	–	–	–	1	–	–	–
Transit Bus	9	–	14	–	–	–	25	–	–
Heavy-Duty	7	–	–	100	50	–	–	100	100
Total	–	**1**	**14**	**100**	**150**	**1**	**25**	**100**	**400**

Source: Fleet Manager Survey Question A3. "Please specify the number of electric vehicles/equipment that you plan to acquire in the next 5 years and in the next 10 years." (n=4)

When asked to provide further detail about how their participation in the program changed the number of EVs they acquired or planned to acquire, one fleet manager responded that they are "required to have a minimum of 14 EV buses by 2025" and one fleet manager responded that "participation in the program requires a minimum number of vehicles."

Industry Perspective

The Evaluation Team asked fleet managers for their thoughts on how well their industry or sector is positioned for electrification. Two transit fleet managers rated their industries as *extremely well-positioned*, while one heavy-duty vehicle manager rated their industry as *somewhat well-positioned,* and one school bus manager rated it as *neutral* Table 70).

Table 70. PG&E EV Fleet Program Industry Positioning for Electrification among Program Participants in EY2023

Market Sector	Extremely Well-Positioned[a]	Somewhat Well-Positioned	Neutral	Not Too Well-Positioned	Not at All Well-Positioned
Heavy-Duty Vehicle (n=2)	1	1	–	–	–
School Bus (n=1)	–	–	1	–	–
Transit Bus (n=1)	1	–	–	–	–

Source: Fleet Manager Survey Question F1. "How well-positioned do you think your industry/sector is for electrification?" (n=4)
Note: No fleet managers provided a rating of *extremely well-positioned* or *not at all well-positioned.*)

The heavy-duty vehicle manager who rated their industry as *somewhat well-positioned* for electrification reported this result because "power availability is improving and there are multiple local sites that are candidates for electrification." The heavy-duty fleet manager who rated their industry as *extremely well-positioned* said, "heavy-duty diesel vehicles are among the largest polluters on the roads."

When asked about the availability of EV options in their sector, one fleet manager reported being satisfied with the current EV options, and three reported not being satisfied. When asked about the limitations of current EV options, one respondent mentioned inadequate charging infrastructure/refueling availability, and another mentioned weather, distance, and mountain ranges.

The Evaluation Team asked fleet managers whether, given what they know or believe about requirements for fleets to purchase zero-emission MDHD trucks, electric or diesel trucks seem like a riskier purchase in the next three years and in the next 10 years. One of four managers said electric trucks seem like a riskier purchase in both three and 10 years, while three said diesel trucks seem like a riskier purchase for both.

Withdrawn Fleet Managers

In addition to the fleet managers who participated in the program, the Evaluation Team received a response from two fleet managers who withdrew from the program (known as withdrawn fleet managers). Both of these fleet managers said environmental benefits were their original motivation to participate. One fleet manager also cited other motivational factors, including a regulatory requirement, corporate goals, driver comfort, and customer expectations.

When asked why they withdrew from the program, one fleet manager said the BTM make-ready process costs were too high, the incentives were inadequate, and the organization had other priorities for funding. This fleet manager said that increased financial support for charging infrastructure, BTM make-ready processes, and fleet vehicles would have made them more likely to participate. The other withdrawn fleet manager said that the terms in the PG&E contract were “unacceptable.” This fleet manager explained that the terms in the contract “allowed PG&E to terminate [the customer’s involvement] at their own discretion,” and that “it’s impossible for a fleet to invest millions into a program [with unilateral termination conditions.]”

In terms of additional support they would have liked, both withdrawn fleet managers reported improved make-ready infrastructure support on both the utility and customer sides. When asked what items the program should rebate, both withdrawn fleet managers noted that construction costs should be eligible for rebates, and one reported that EVSE costs and dispensers should be eligible for rebates.

The Evaluation Team also asked the withdrawn fleet managers about their level of satisfaction with various program aspects. One fleet manager gave a rating of *not at all satisfied* for the program overall, driven by the level of the rebate. For all other program aspects, they said they were *very satisfied.* In contrast, the other withdrawn fleet manager provided a rating of *not too satisfied* for the program overall, the rebate levels, and working with PG&E staff and *somewhat satisfied* for other program aspects.

After withdrawing from the program, one respondent continued to build the site as intended, saying that the EV Fleet program was a somewhat important factor in the decision to build EV charging infrastructure. The other withdrawn fleet put the site on pause, pending contractual changes from PG&E.

Highlights

- Fleet managers were motivated to participate primarily because of corporate/organizational sustainability goals or initiatives (three of four fleet managers), expected fuel cost savings, environmental benefits, and rebates/incentives (two of four fleet managers).
- Top barriers to fleet electrification both before and after program participation were routes being too long for EVs, the cost of EV charging infrastructure, and the cost of EVs.
- Four of four responding fleet managers rated themselves as *very satisfied* or *somewhat satisfied* with their experience participating in the EV Fleet program.
- Two of four responding fleet managers learned about the EV Fleet program directly from PG&E.
- Three of four fleet manager respondents have already recommended the program to others.
- Three of four responding fleet managers said EVs are *somewhat,* or *very* reliable and four of four said charging equipment is *somewhat* or *very* reliable.
- Three of four responding fleet managers do not plan to accelerate procurement; however, all four of these fleet managers plan to acquire more EVs/equipment in the next 5 and 10 years.
- Two transit fleet managers consider their industry to be *extremely well-positioned* for electrification.
- The two fleet managers who withdrew from the EV Fleet program cited insufficient incentives.

Site Visit Findings

In EY2023, the Evaluation Team completed 14 site visits (n=14) in the PG&E territory across several market sectors: heavy-duty vehicle, medium-duty vehicle, school bus, transit bus, and forklift. During the site visits, the Team collected qualitative and quantitative information that provided the Team with an understanding of fleet composition and operations. We used site visits to verify aspects about sites such as the number of installed chargers, EVSPs the fleet uses, types of EVs in use or scheduled for delivery, and physical influences on construction designs.

Table 71 provides a summary of charging site characteristics by market sector, including number of site locations visited, number of L2 and DCFC ports, and total charging capacity. In total, the PG&E EV Fleet program added 56 L2 ports, and 184 DCFC ports with nearly 11 megawatts (MW) of EV charging capacity in EY2023. Two heavy duty sites, one medium duty and one transit site account for nearly 9 MW. Figure 112 presents charging port and charging capacity of the EV Fleet program site visit locations by market sector for EY2023 and for the program to date. Reported installed capacity only accounts for active charging ports installed on the Utility-provided TTM infrastructure while the Utility SB 350 report includes TTM installed capacity which for some sites includes future chargers that are not yet installed.

Table 71. PG&E EV Fleet Program Quantity of Ports by Type and Installed Capacity, by Market Sector

Market Sector	Number of Sites	L2 Ports	DCFC Ports	Total Installed Capacity (kW)
Heavy Duty Vehicle	5	0	131	6,380
Medium Duty Vehicle	3	37	5	713
School Bus	4	16	0	262
Transit Bus	1	0	46	3,450
Forklift	1	3	2	194
Total	**14**	**56**	**184**	**10,999**

Figure 112. PG&E EV Fleet Program EY2023 and PTD Ports and Capacity

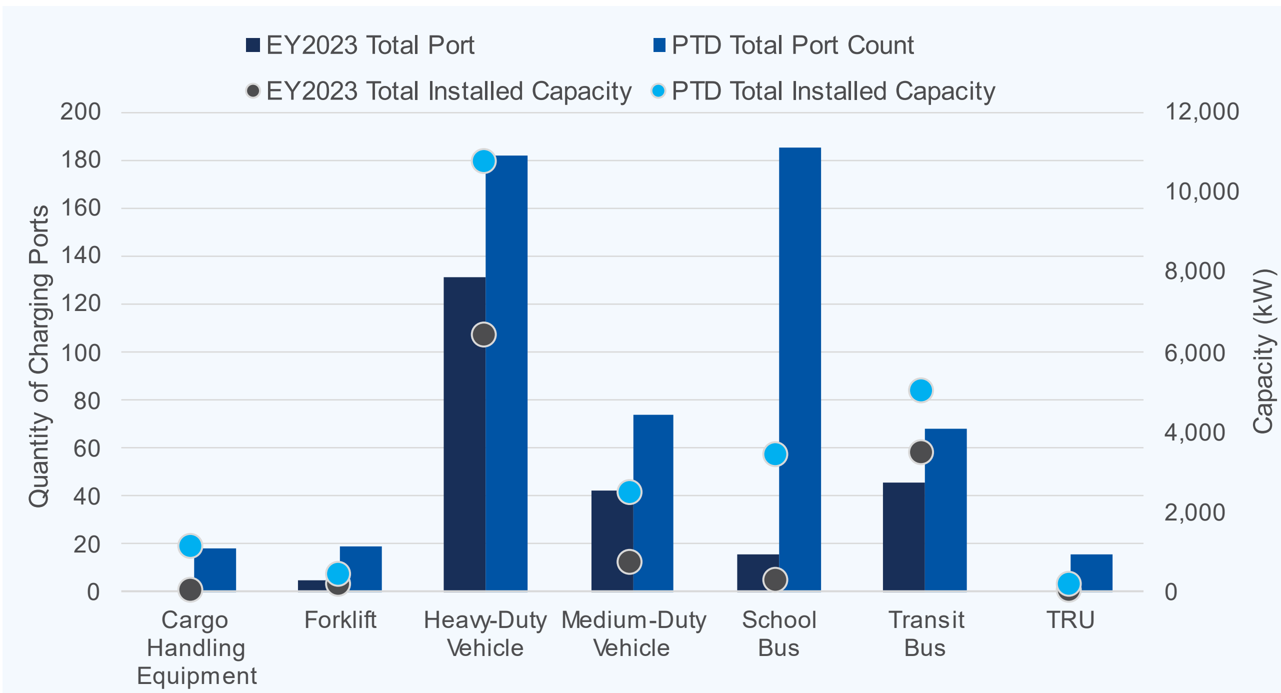
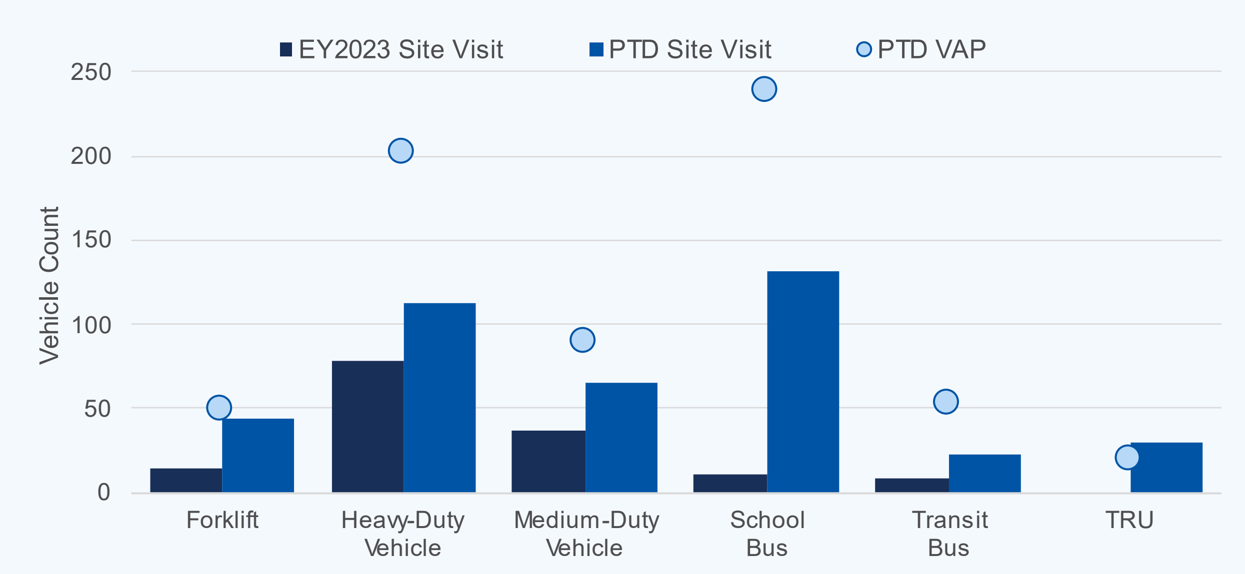


Figure 113 shows a count of vehicles verified through site visits for both PTD sites and the sites completed in 2023. The 5-year VAP for these sites is included as well. Although not shown in the figure, a comparison was also made to the VAP for vehicles anticipated through the end of 2023. Sites are not included that have not been completed even if their VAP lists prior years. The figure and analysis suggest that vehicle deliveries are not running on schedule and therefore the fleets have not yet acquired the vehicles per their agreement with PG&E. Market sectors closest to plan include TRU, forklift and medium-duty vehicles.

Figure 113. PG&E EV Fleet Program Comparison of Verified Vehicles to Long Term VAP



During site visits, the Evaluation Team reviewed charge management capabilities and electrical infrastructure, discussed future vehicle/equipment replacement plans (including future vehicle adoption) and public funding sources and investigated whether fleets had an interest in on-site solar and/or battery storage. Site visits allowed the Team to obtain direct feedback from the individuals involved with operations and to identify EVSP points of contact to obtain charging session data.

The following sections provide a summary of key observations and data collected during site visits, organized by market sector.

School Bus

As shown in Figure 113 most of the vehicles for this sector had not been delivered at the time of site visit. As observed in previous years, school districts rely heavily if not exclusively on public funding to build infrastructure and acquire EVs. The delay in meeting vehicle targets included both buses that have been ordered but not yet delivered by the OEM, as well as vehicles that had not been ordered due to funding availability.

One site has encountered substantial operational issues and delays with its buses, with two installed ports and plans for up to four vehicles but only a single delivered bus due to supply chain-related delays. Over approximately 18 months of operation, this first bus has encountered significant downtime due to issues with cooling systems and onboard 12V systems. Charge management did not work reliably during testing, so was disabled. A major complaint from the drivers is that the vehicle's limited range is insufficient for many of their routes and in the winter months requires that the heat not be used to maximize range and allow for route completion. These concerns about the EV's ability to complete the fleet duty cycles and a general loss of confidence in EV drivetrains' suitability for its routes has resulted in the site investing in continued operations for its existing diesel bus. Of the three remaining sites…

- one had not taken delivery of any buses as of April 2024;

- one had taken delivery of a single medium-duty vehicle and expects its two school buses to be delivered by the end of the school year; and
- one site had taken delivery of their project's switchgear less than two months prior to the site visit and had been relying on chargers acquired outside of the project to charge their vehicles but otherwise had very little experience to relay.

Transit Bus

In size and scale, these two deployments are among the largest sites in EY2023, with 46 DCFC ports, and the other operating 71 DCFC ports. Though the first site has installed a large number of ports, it has encountered substantial operational issues with both buses and electrical capacity[76], which have impeded operations and slowed the site's fleet electrification. PG&E had initially limited the site's capacity to 3 MW of a maximum possible 6 MW, requiring a new service agreement to access the additional power.

A second site installed 71 DCFC ports to electrify 48 parking spots to support a large fleet of 30-foot transit buses, which were procured before the site's enrollment in the EV Fleet program. The site used funding only to build out infrastructure and conduit on its new lot and procured chargers from another lot that the site was decommissioning—raising questions around whether this site could have been conducted without Utility assistance. Similarly, another site leveraging the EV Fleet program had electrified its buses several years prior to the program's implementation, similarly indicating potential free ridership.

Medium-Duty Vehicle

The team visited one medium duty site with delivery vehicles. One site has had a positive experience with its medium-duty cargo vans, which were manufactured by a major OEM. Given CARB's ACF regulation, more similar large sites can be expected in the future in this market sector. Figure 114 illustrates the scale of this installation with several dozen L2 charging ports. PG&E has several sites in the pipeline to support large national fleets as they expand electric truck deployments to meet the ACF regulation.

[76] https://ww2.arb.ca.gov/sites/default/files/2020-12/FAX_ICT_ROP_ADA122120.pdf

Figure 114. Large-Scale Deployment of Chargers at a Medium-Duty Site

Another site encountered significant EV deployment challenges, with a majority of their EV fleet experiencing debilitating problems with vehicle electronics, driveline systems, and the site's EVSE. The vehicles were manufactured by an EV start-up. This site received its vehicles a year in advance of the charging infrastructure and has since experienced issues with its trucks that require the site to submit work orders every one to two weeks. This site is unique in that charging equipment was installed on a pre-existing utility account. Data is expected to be collected using an NSP.

Heavy-Duty Vehicles and Forklifts

The team visited heavy-duty sites featuring large straight trucks as well as tractor-trailers. These sites required large power capacity and accompanying equipment, as shown in Figure 115. One of the sites has received overweight permits to operate the Class 8 electric trucks at more than 80,000 pounds gross vehicle weight. While only operating two vehicles currently, this site is built out for future expansion to 20 charging ports. Similar to other fleets the Team observed throughout the program, this site strategically partnered with private entities to leverage public funding, resulting in very low out-of-pocket costs for the fleet. This site went through a round of required rework on its infrastructure—specifically the transformer and switchgear pads and associated island. This stemmed from a miscommunication between the Utility and its subcontractor, delayed the site commissioning, and possibly resulted in additional costs.

Figure 115. Final Deployment of Transformer and Switchgear Pad and Island

Another site has opted to approach electrification in a more experimental manner, using modular hardware from a new manufacturer to supply power to multiple makes and models of heavy-duty vehicles. This approach has revealed the strengths and weaknesses of each vehicle and EVSE-vehicle interoperability issues for some vehicles.

Finally, a site operating heavy-duty vehicles and electrified forklifts (Figure 116) had a positive experience and is looking forward to electrifying additional vehicles in the future.

Figure 116. Outdoor Forklifts at a PG&E Site

Common Site Visit Findings

While a couple of fleets were not clear on the NSP need to meet data collection requirements, a couple of others expressed frustration with NSPs' managed charging capabilities. Several of the newest sites lack clarity on when or if they will subscribe to a NSP, and one site is using non-networked chargers. Additionally, one site communicated that it had experienced significant rework on multiple site components, which were duplicated between PG&E and the hired contractor. Rework has been cited as a costly and time-consuming challenge by sites in previous years. Future evaluations will attempt to quantify the cost and timeline impacts of such rework.

Across PG&E fleets, sites reported recurring issues with maintenance, service, and reliability among both nascent and established manufacturers of vehicles and charging equipment. Multiple fleets expressed significant dissatisfaction with their vehicles, citing poor vehicle reliability, recurring mechanical and electrical issues, and the inability to schedule load management in a sustainable and effective manner over the long term.

Vehicle-charger interoperability is not currently tested for charger/vehicle inclusion on the Qualified Products List offered by the Utility programs nor is validating a NSP's load management ability. Several fleets across Utilities suggested that highlighting EVSE/NSP/vehicle pairings that are known to work would minimize the risk of disruptions to basic service goals.

Highlights

- At the time of the site visits, most of the vehicles in the school bus sector had not been delivered.
- In EY2023, a large transit bus site was activated accounting for 43 DCFC ports. The site has experienced considerable operational challenges with its buses impeding the site's fleet electrification.
- Multiple sites were designed for future expansion of DCFC ports.
- Several fleets lacked NSP requirement clarity or plans, which continues from previous years. Two fleets expressed dissatisfaction with NSP load management capabilities. Vehicle-EVSE interoperability testing and validating NSPs' load management abilities could help minimize future disruptions.
- Duplicative construction work and rework was mentioned by two fleets.
- EV reliability issues and range limitations to meet operational requirements continued to be reported by more than two-thirds of the visited fleets.

Deep Dives

The Evaluation Team conducted deep dives in EY2023 for two sites in the EV Fleet program that were completed in 2022 and had significant demand, energy consumption, or installed charging capacity. The Evaluation Team was also interested in sites with a demonstrated ability to expand EV infrastructure, the presence of load management, unique vehicles or charging equipment, a large fleet size, and a fleet manager who was willing to participate.

The two PG&E EV Fleet program sites the Team examined were a medium-duty delivery site operating electric Class 6 delivery vans, and a transit agency operating 40-foot electric transit buses. The Evaluation Team conducted in-depth fleet manager interviews and analyzed data from advanced metering infrastructure (AMI) and EVSPs. During interviews, the Team requested permission to survey drivers; however, only one site's fleet manager was willing to administer the driver survey.

Findings presented in this section are based on interviews, data analysis, and driver survey feedback, as available. *Appendix A* presents more detailed case studies on each of these fleets.

Medium-Duty Delivery Site

The Evaluation Team selected a freight handling operator that operates two discrete locations and uses medium-duty delivery vans. We chose this site because of the vehicles' unique market sector and duty cycles (regional short-haul operation). The site charges its vans on 15 kW L2 chargers and operates five days a week in two blocks (Monday through Tuesday and Thursday through Saturday). On operating days, the vehicles follow single shift charging schedules, plugging in at the end of vehicles' shifts around 11 a.m. The vehicles do not draw enough power to fully charge during their off-shift times during operational days, so on off days (Wednesday and Sunday), they are plugged in to fully charge.

Charger reliability has been noted as an area for improvement. The operator expressed a desire for a charging management system with improved ability to manage power and adapt to changing schedules - during the holiday season, their delivery routes were lengthened, causing their vehicles to experience problems with range as the load management was designed to charge vehicles for their typical routes. The operator also expressed a desire for improved durability and onboard monitoring, as the stations have experienced issues with rapid connector wear, causing arcing and burning which is not captured by the EVSE's software.

The fleet noted that overall satisfaction with the EV manufacturer has generally been good, but that some software updates caused communication problems between the EVs and chargers. Due to lengthy EV dwell times, charging flexibility is available at both site locations, but the operator's attempts to capitalize on that flexibility stalled when the EVs began running into range limitations when routes changed with the implementation of a holiday-specific schedule.

Transit Site

The Evaluation Team selected a transit agency site operating 40-foot transit buses for a deep dive because of its early deployment of heavy-duty vehicles and its unique, long-duration shift schedule. The site charges its transit buses on 150 kW DCFCs. The EVs operate between 6 a.m. and 9 p.m. six days per week, with a shorter schedule on Sundays.

A major concern for this site is the dissolution of the site's bus manufacturer and the resulting uncertainty around the basics of maintaining and repairing site vehicles. Two of the four buses were experiencing issues with their onboard electrical systems (specifically, electrical inverters) at the time of the manufacturer's bankruptcy in Q3 2023, which put replacement parts on indefinite hold.

The transit site has not implemented automated load management but does rely on rotational charging to charge each of the buses overnight (i.e., even when all buses are plugged in, only one charges at any given time). The site's normal course of operations also brings the buses back to be charged starting at around 9:30 p.m. The buses' large batteries, full-day operations, and rotational charging allow them to charge only once after 9:30 p.m., which means that the site's power consumption between 4 p.m. and 9 p.m. is extremely low, reducing the site's expenses during high-rate periods.

The fleet manager expressed that a comprehensive maintenance package for the site's chargers would relieve the fleet of the need to conduct their own research, troubleshooting, and repair, and that they would like to see this offered in the future. They also noted that additional vetting and guidance about complementary vehicles, chargers, and networks, as well as with sizing and sequencing site components, would have been helpful in developing a roadmap to guide the installation at each stage.

Fleet Driver Surveys

As part of the deep dives, the Evaluation Team surveyed seven fleet drivers who participated in PG&E's EV Fleet program about their experience driving an EV and using the associated charging equipment. Five of the seven began operating EV equipment for their organization in 2024, and two began in 2023.

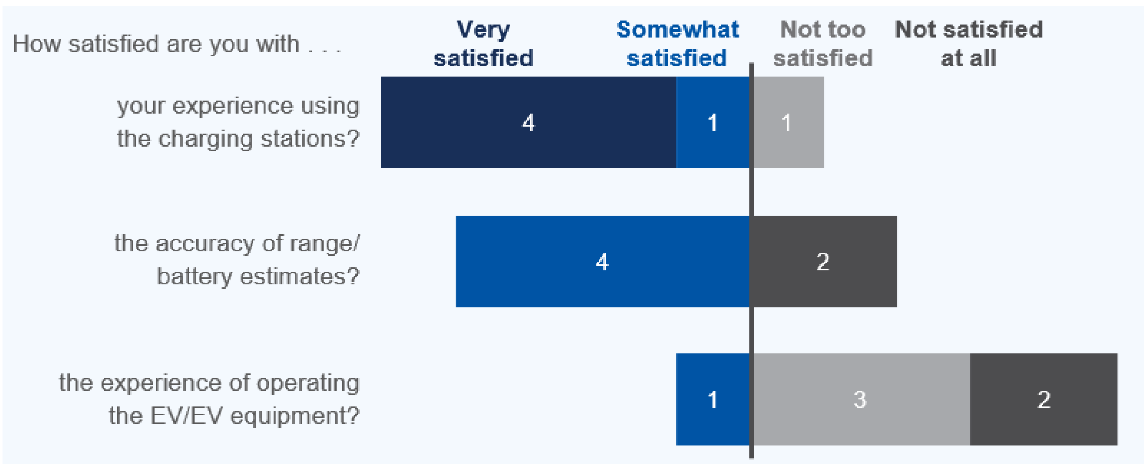
Training

All seven driver respondents received on-site training to operate the EVs, and four received on-site training on charging. Three drivers received a training manual for EV operation, and two received a manual on charging. One respondent also received classroom training. All six drivers received training from their company. Five drivers found the training to be very helpful, and one driver found the training to be somewhat helpful.

Operational Experience

Figure 117 shows driver respondents' satisfaction levels with their EVs and equipment. Overall, respondents were unsatisfied with the experience of operating the equipment, had mixed satisfaction with the accuracy of EV range and battery estimates, and were mostly satisfied with the experience of using the charging stations. Drivers frequently mentioned loud noise inside the vehicle, offering feedback such as: "Too noisy inside bus (a lot of rattling)" and "Not a smooth ride, very noisy inside." Drivers said the charging equipment was easy to use, providing feedback such as "It is easy and convenient" and "Charging station itself works great and is fully operational."

Figure 117. PG&E EV Fleet Program Fleet Driver EV/EV Equipment Experience



Source: Fleet driver survey question B1, "How satisfied are you with the experience of operating the EV/EV equipment?", B3. "How satisfied are you with the accuracy of your EV's/EV equipment's range/battery status estimates?", and B4. "How satisfied are you with your experience using the charging stations at your company's site?"(n=6)

Six fleet drivers provided reasons for their satisfaction rating regarding their experience operating the EVs (Table 72).

Table 72. PG&E EV Fleet Program Fleet Driver Operating Experience

Fleet Driver	Satisfaction Rating	Reason for Satisfaction Rating
Fleet driver #1	*Not satisfied at all*	"Vehicle is unnecessarily bulky. Doors (front and back) are slow to close creating too much dwell time at stops. They are very loud on certain roads. Battery doesn't have the life we need, very slow taking off from a stop."
Fleet driver #2		"Too noisy inside bus (a lot of rattling)."
Fleet driver #3	*Not too satisfied*	"Not a smooth ride, very noisy inside."
Fleet driver #4		"Very noisy inside of bus. Slow response of door."
Fleet driver #5		"Bus ride is not comfortable. Loud and some delays. Suspension is bad. I think the tires are too large, so when hitting small and big potholes the bus shakes terribly."

Fleet Driver	Satisfaction Rating	Reason for Satisfaction Rating
Fleet driver #6	*Somewhat satisfied*	"I felt like we needed more than one 10-minute trip driving the bus."

Source: Fleet driver survey question B1, "How satisfied are you with the experience of operating the EV/EV equipment and B2. "What made you give that specific satisfaction rating regarding your experience operating the EV/EV equipment?" (n=6)

Six fleet drivers provided reasons for their satisfaction rating regarding their experience using the charging stations. Four fleet drivers said they were *very satisfied*, one driver said they were *somewhat satisfied*, and one driver said they were *not too satisfied* (Table 73).

Table 73. PG&E EV Fleet Program Fleet Driver Charging Experience

Fleet Driver	Satisfaction Rating	Reason for Satisfaction Rating
Fleet driver #1	*Very satisfied*	"Straightforward"
Fleet driver #2		"Charging station itself works great and is fully operational"
Fleet driver #3		"It is easy and convenient"
Fleet driver #4		"I don't charge it"
Fleet driver #5	*Somewhat satisfied*	"Bus operator here at my company doesn't charge the bus. There is another position that maintains and charges bus."
Fleet driver #6	*Not too satisfied*	"Never been trained on starting a charge."

Source: Fleet driver survey question B4, "How satisfied are you with your experience using the charging stations at your company's site?" and B5. "What made you give that specific satisfaction rating regarding your experience using the charging stations?" (n=6)

All seven respondents answered questions about EV reliability. One fleet driver said EV operation is *very reliable/somewhat reliable*, two said it was *somewhat reliable/not too reliable*, three said it was *not too reliable* and one said it was *not at all reliable*. Regarding charger reliability, three fleet drivers noted that EV battery capacity and range concerns have increased, one said they trust the equipment, and one said odd codes appear on the screen (Table 74).

Table 74. PG&E EV Fleet Program Fleet Driver EV Reliability

Fleet Driver	Satisfaction Rating	Reason for Satisfaction Rating
Fleet driver #1	*Very reliable* and *Somewhat reliable*	"It works."
Fleet driver #2	*Somewhat reliable* and *not very reliable*	"Equipment for me has been reliable. I would have given a higher rating, but battery life isn't the best."
Fleet driver #3		"I haven't had too many major issues. Ramp is slow. Doors are slow—maybe something with w/ air pressure."
Fleet driver #4	*Not too reliable*	"2 or 4 buses don't charge"
Fleet driver #5		"Broken down buses"
Fleet driver #6		"The [buses are not good vehicles]."
Fleet driver #7	*Not at all reliable*	"We have experienced many issues since acquiring the new buses/EV's."

Source: Fleet driver survey question B6, "How reliable would you say the EV/EV equipment you operate is?" and B7. "What made you give that specific rating regarding the reliability of the EV/EV equipment you operate?" (n=7)

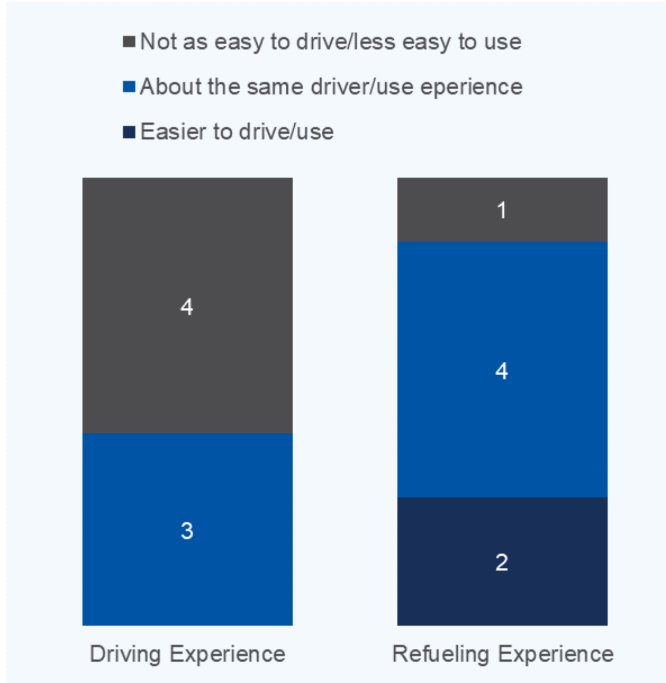
Fleet drivers had mixed opinions about operating an EV compared to an ICE vehicle. When asked to compare charging an EV with refueling an ICE vehicle, four said it was about the same user experience, two said the EV charger was easier to use, and one said the EV charger was less easy to use (Figure 118).

When asked how their job has changed now that they are driving EVs and operating charging equipment, less air pollution and more concern over range were both mentioned three times. Three respondents reported no changes to their jobs. One respondent noted there were more training requirements (Figure 119).

Desired Improvements

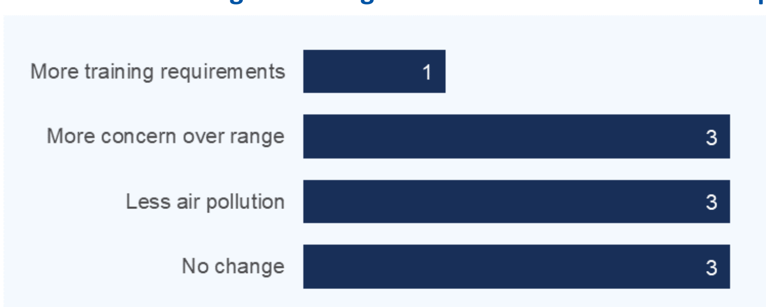
When asked to provide any additional thoughts on their experience with EVs, 5 of 7 drivers echoed dissatisfaction with the experience of operating the EVs due to a variety of issues, including the level of interior noise, unsettled ride quality, and unexpected delays in operating ancillary components (particularly the vehicles' door actuation). Four drivers also drew attention to the need for reliability improvements with their vehicles, citing issues with powertrain reliability, short range, and charging issues.

Figure 118. PG&E EV Fleet Program Fleet Driver Comparison of EVs to ICEs



Source: Fleet driver survey question B8, "Compared to operating a vehicle/equipment with an internal combustion engine, would you say operating the EV/EV equipment is overall?" and B9. "Compared to refueling a vehicle/equipment with an internal combustion engine, would you say using the charging stations for the EV/EV equipment is overall?" (n=7)

Figure 119. PG&E EV Fleet Program Changes to Fleet Drivers' Jobs Since Operative EVs



Source: Fleet driver survey question D3, "How, if at all, has your job changed now that you are driving/operating an EV/EV equipment?" (multiple responses allowed; n=7)

Highlights

- Both sites have experienced issues with their vehicles, though in different ways: one site had problems with EV and charging equipment communications, resulting in difficulties fulfilling their daily routes; the other site encountered several issues with their onboard inverters and associated electronics.
- The fleet manager at one site highlighted ongoing difficulties with their charging system, involving communication problems, charging connector failures, and issues adapting load management.
- Drivers generally found that while air pollution was noticeably lessened, the additional interior noise, reduced range, and reliability issues were significant detractors to the overall experience of operating EVs.

Co-Benefits and Co-Costs

Through fleet manager surveys, deep dive fleet manager interviews, deep dive fleet driver surveys, and site visits, the Evaluation Team identified several co-benefits and co-costs associated with the EV Fleet program's vehicle electrification sites.

Fleet Manager Surveys

The fleet manager surveys used both aided (asking fleet managers if they have noticed a specific co-benefit or co-cost) and unaided (open-ended) questions to assess co-benefits and co-costs.[77]

Table 75 shows that four of four fleet managers expected to realize benefits for their community or fleet as a result of electrifying, which is consistent with the result from EY2022, where four of five fleet managers expected to realize benefits. Three of the four fleet managers expected *significant benefits,* because electrification improves air quality and health and reduces noise pollution. Additionally, three of the four fleet managers expected *some benefits* from improved driver comfort/convenience and increased fleet flexibility.

Other benefits mentioned in responses to open-ended questions by two fleet managers were "Each of our EVs removes conventional passenger vehicles from the roads" and "We strive to be good stewards of our environment and reduce our carbon footprint."

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[77] The Evaluation Team received responses from four fleet managers, but the sample size (n) denoted in the following tables and charts may differ because fleet managers could skip questions and response options.

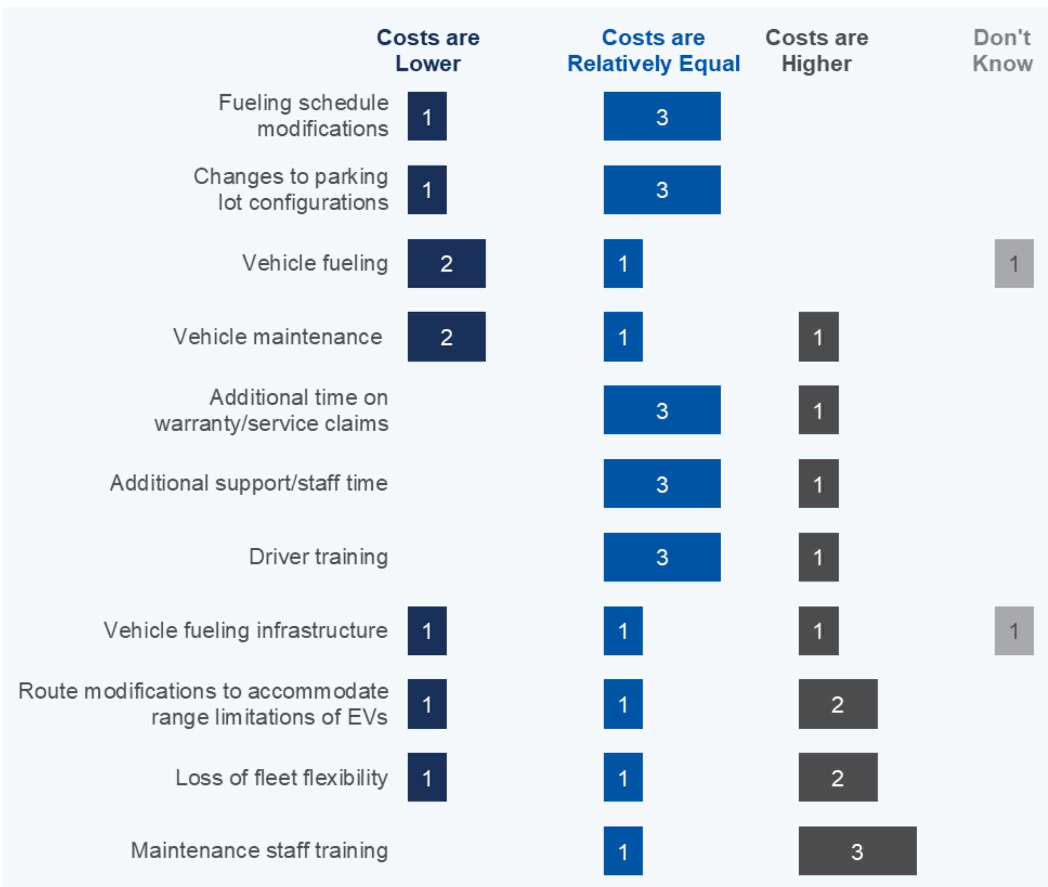
Table 75. PG&E EV Fleet Program Benefits Fleet Managers Reported from Electrification in EY2023

Benefits	*Significant Benefits*	*Some Benefits*	*No Benefits*	*Not Sure*
Encourages other individuals/fleets to convert to EVs	1	2	1	–
Improved air quality/health	3	–	1	–
Reduction in noise pollution	3	1	–	–
Improved driver comfort/convenience	–	3	1	–
Increased fleet flexibility	–	3	1	–

Source: Fleet Manager Survey Question D1. "What ancillary benefits do you think will be realized for your community/fleet as a result of electrifying?" (n=4)

Figure 120 summarizes responses to managers' observed costs associated with operating and maintaining EV fleets. Two of four fleet managers said vehicle maintenance costs and vehicle fueling were *lower* following fleet electrification. For several cost categories, three of four fleet managers said that costs are *relatively equal* since electrifying their fleets. Three of four fleet managers said costs are *higher* for maintenance staff training, and two of four cited *higher* costs from loss of fleet flexibility and route modification to accommodate range limitations of EVs.

Figure 120. PG&E EV Fleet Program Observed Cost Changes since Electrification in EY2023

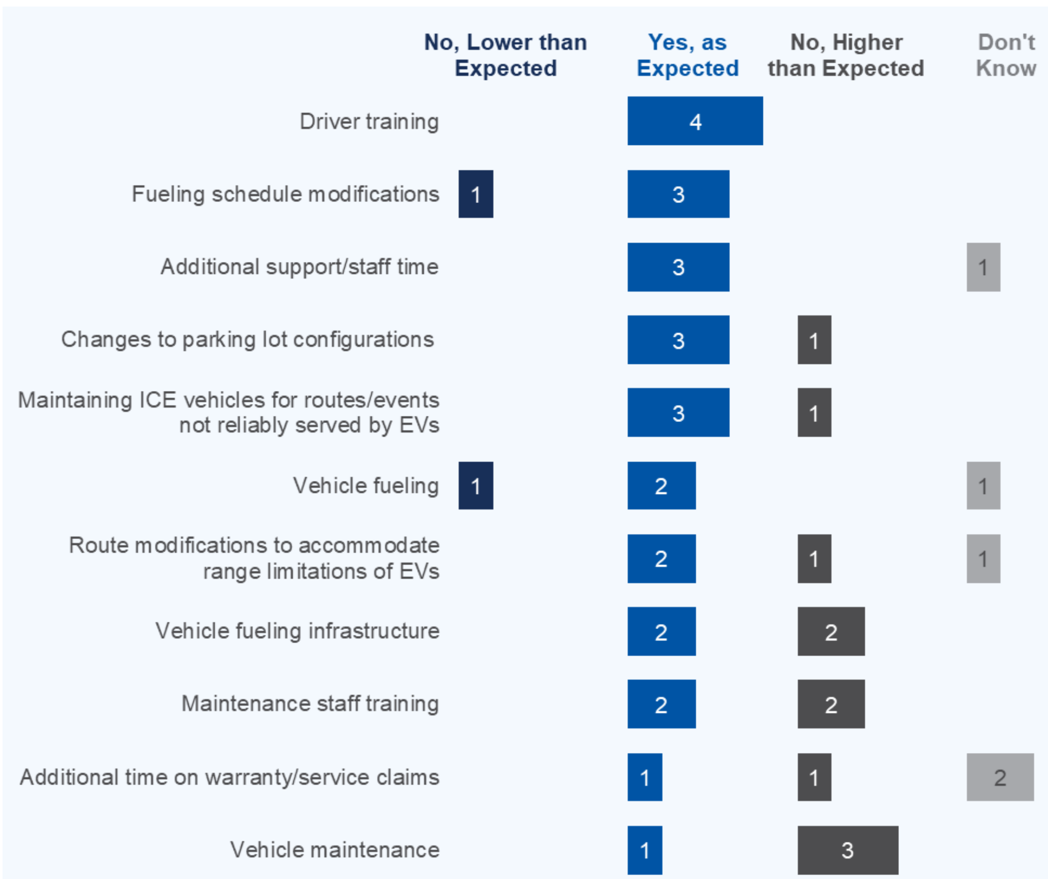


Source: Fleet Manager Survey Question E1. "Please think about all the costs associated with operating and maintaining your fleet. For each cost type shown below, please estimate how much the cost has changed since transitioning your fleet to EVs." (n=4)

The Evaluation Team also asked fleet managers to what extent they expected operational and maintenance cost changes. As shown in Figure 121, four of four managers who answered this question said that differences in costs were *as expected* across the various cost categories.

Fleet managers were split on costs for vehicle fueling infrastructure and maintenance staff training, with two reporting these costs were *as expected* and two reporting *higher than expected*. Costs were *as expected* for driver training according to four fleet managers and for fueling schedule modifications, additional support/staff time, changes to parking lot configurations, and maintaining ICE vehicles for routes/events not reliably served by EVs for three fleet managers. One fleet manager reported that costs were *lower than expected* for fueling schedule modifications and another gave this rating for vehicle fueling. Three of four fleet managers reported that vehicle maintenance costs were *higher than expected.*

Figure 121. PG&E EV Fleet Program Differences between Electrification Expectations and Costs in EY2023



Source: Fleet Manager Survey Question E2. "Have these operational and maintenance costs been what you expected?" (n=4)

Deep Dive Fleet Manager Interviews

The Evaluation Team conducted deep dive interviews with two PG&E fleet managers to assess the co-costs and co-benefits of TE for fleets and for fleet drivers. During the interviews, fleet managers noted several costs:

- **Site material procurement and installation.** Both fleets described significant disruptions as a result of the COVID-19 pandemic, leading to long lead times in the sourcing of crucial materials and system components, such as transformers, switchgear, and the vehicles themselves. One site described difficulties with aligning vehicle arrivals with the timeline for EVSE installation, as both timelines shifted unpredictably due to supply chain shortages and constrictions. One fleet described an experience at another of their sites, where charging equipment was delayed for between 24-30 months, and expressed that a focus for their California site was to align vehicle and infrastructure timelines as closely as possible.
- **Vehicle reliability.** One fleet described issues keeping their vehicles in service, with significant downtime resulting from electrical issues with third-party onboard inverters. Complicating their repairs, the fleet's vehicle manufacturer subsequently ceased business operations and sold off their electric mobility division. This closure raises questions around whether the scheduled repairs will be completed.
- **EV range and charging duration.** Both fleet managers said that generally their EVs have enough range to make it through most of their shifts. One manager noted that their vehicles and EVSE were carefully tailored to a standard duty cycle, and experienced issues when vehicles were asked to complete longer routes during holiday periods. The second fleet has been satisfied with their vehicles' ability to complete routes and has successfully maintained a rotational charging schedule on their DCFC units.
- **Charging equipment malfunctions.** One fleet manager has experienced ongoing challenges with their charging infrastructure, with issues arising with the EVSE's durability, load-management abilities, vehicle-EVSE communications, and self-healing abilities. The manager noted that the fleet had encountered dangerous fault conditions, including arcing and burning at the connector, which was not captured or reported by the charger.

Despite some of these initial challenges in electrification, all fleet managers conveyed an overall positive experience with their electrified fleets when vehicles were operating well. One fleet manager noted that their **EVs' fuel costs were definitively lower than with their ICE vehicles**, and the other highlighted that **driver comfort was significantly improved** with the EVs over their ICE vehicles, particularly with regards to the EVs' smoother ride and lower noise levels.

Fleet Driver Surveys

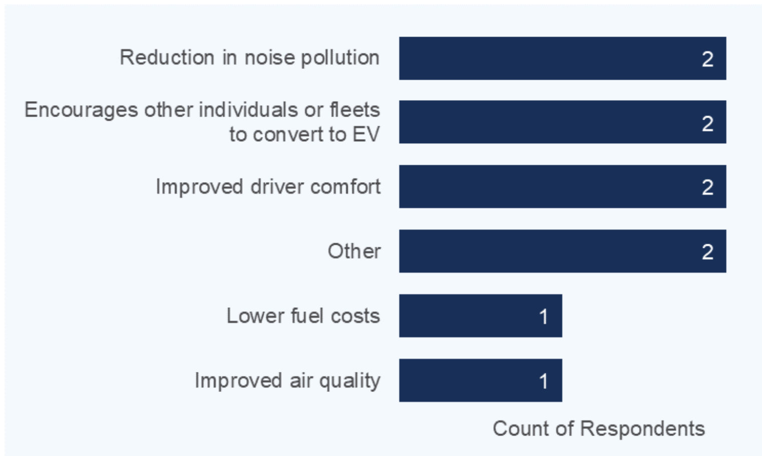
The Evaluation Team also fielded surveys with participating fleet drivers and received seven responses from one fleet. These drivers said that the primary benefit was **improved air quality** (n=3), and one driver also mentioned the openness of the driver's area. Drivers also noted difficulties with **insufficient vehicle range** (n=3) and increased training requirements (n=1).

Additional Insights from Site Visits

To inform co-costs and co-benefits findings, the Evaluation Team incorporated qualitative insights from the 16 PG&E EV Fleet program activated sites visited as part of EY2023 reporting. This cohort includes sites activated across EY2021, EY2022, and EY2023 that were not previously visited or reported on in prior evaluation reports. Note some fleet site contacts were unable to yet determine co-benefits and co-costs during site visits as their sites were only recently electrified and therefore lack operational experience with EVs and charging infrastructure.

As shown in Figure 122, the most frequently reported co-benefits included reductions in noise pollution, encouraging other individuals and fleets to convert to EVs, and improved driver comfort (two sites each). Two site contacts reported *other* co-benefits, with one mentioning that partial electrification of their fleet encouraged conversion of their entire fleet and the other not providing additional context. In addition, one fleet site contact reported lower fuel costs, while another cited improved driver comfort following fleet electrification.

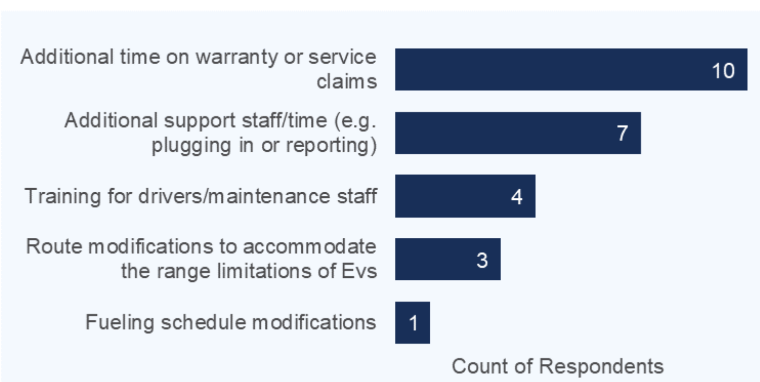
Figure 122. PG&E EV Fleet Program Co-Benefits Identified during Site Visits



Source: Site Visit Prompt. "What ancillary benefits have been realized for your fleet/community as a result of electrifying?" (n=7)

Figure 123 displays the frequency with which co-costs were reported during site visits. The most reported co-cost was additional time spent on warranty or service claims (ten sites). Five of these ten site contacts cited issues with their EVs, with another three contacts mentioning delays in switchgear delivery, which prevented EV charging. Seven fleet site contacts reported needing additional support staff and/or time due to their fleet's electrification. Four site contacts reported that their drivers and/or maintenance staff required additional training, and three contacts reported making route modifications to accommodate the range limitations of their EVs. Only a single site contact reported modifications to their fueling schedule as a result of fleet conversion.

Figure 123. PG&E EV Fleet Program Co-Costs Identified during Site Visits



Source: Site Visit Prompt. "What challenges, if any, has your fleet/community experienced as a result of electrifying?" (n=11)

Highlights

- All four responding managers anticipated benefits for their community or fleet because of electrification.
- Three of the four fleet managers expected significant benefits from electrification from improved air quality/health (also mentioned by three fleet drivers) and reduced noise pollution.
- Three of four fleet managers said costs are higher than with ICE vehicles for maintenance staff training, and two of four cited higher costs from loss of fleet flexibility and route modifications to accommodate range limitations of EVs.
- One fleet manager reported that costs were lower than expected for fueling schedule modifications and another gave this rating for vehicle fueling. Three of four fleet managers reported that vehicle maintenance costs were higher than expected.
- Two fleet managers noted difficulties with aligning their vehicle delivery and charging activation timelines, as shifting and unpredictable supply chains led to delays on site component delivery and installation.
- Site contacts reported reduction in noise, influence on others to convert to EVs, and improved comfort as key benefits (two each); however, the most commonly reported co-cost was the additional time on warranty or service claims (10), followed by additional required staff time (7).

Site Costs

The Evaluation Team conducted a cost analysis on 52 sites with fully closed out finances as of December 31, 2023, including EY2021, EY2022, and EY2023 sites. The set of fully closed out sites is smaller than the set of activated sites because of the time lag involved in collecting receipts, paying invoices, administrative approvals, etc.

Sites had a mix of L2 and DCFC ports, with an average of 421 kW installed capacity and 10 ports. The 52 sites included 27 school bus sites, 7 transit bus sites, 9 heavy-duty vehicle sites, 5 medium-duty vehicle sites, 3 forklift sites, and 1 TRU site. The Team aggregated findings across all market sectors to meet customer confidentiality requirements.

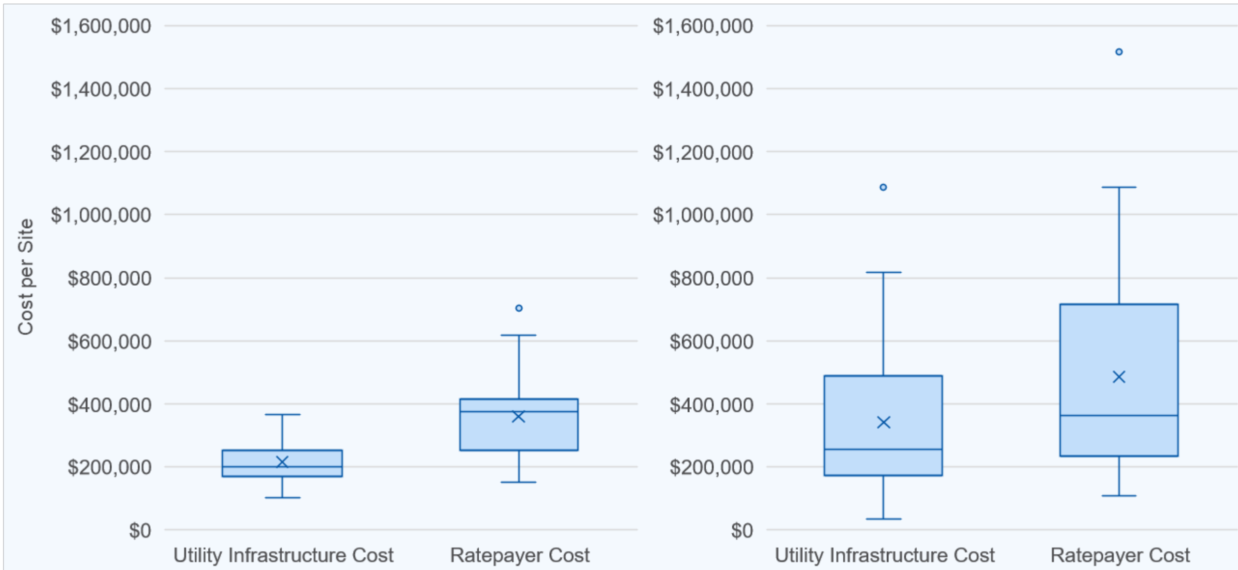
Figure 124 shows the distribution of site-level costs of the 52 sites. The horizontal lines of the boxes show the 25th, 50th, and 75th percentile of sites; the “x” represents the mean site cost; and the three panels in are defined as follows:

- **Utility Infrastructure Costs**. Site costs borne by PG&E for TTM and BTM rebates.[78]
- **Ratepayer-Funded Costs.** All site costs paid for by the Utility, including TTM, BTM (or BTM incentive if infrastructure is customer owned), and EVSE rebate.

[78] Values are the same as the Ratepayer-Funded Costs, except they do not include the EVSE rebates.

- **Estimated All-in Costs.** The total estimated cost of installing the site, including capital and labor costs for the Utility and the customer. The value is calculated by summing 100% of TTM,[79] BTM,[80] and EVSE costs.[81]

Figure 124. PG&E EV Fleet Program Per Site Costs Organized by Two Perspectives Across 52 Closed-out School Bus and Non-School Bus PTD Sites



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79 The Utility pays 100% of the TTM costs and therefore reports actual TTM costs to the Evaluation Team.

80 The Evaluation Team receives actual BTM costs for sites with Utility-owned BTM. Only 1 of 52 sites has Utility-owned BTM. For the customer-sponsored BTM sites, the BTM cost is estimated using the following equations, which are best-fit curves of utility-owned BTM datapoints from other programs:

For DCFC ports, the BTM cost per kilowatt is $\$11{,}6133 * Installed\ kW^{-0.541}$.

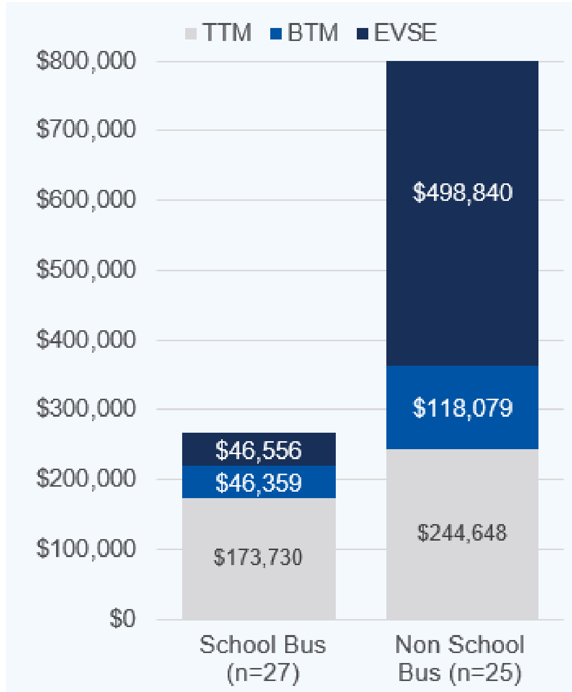
For L2 ports, the cost per kilowatt is $\$42{,}975 * Installed\ kW^{-0.705}$.

81 Since actual EVSE costs are not known by the Utility, The Evaluation Team estimates EVSE equipment costs using an assumption of $3,000 per port for L2 ports and $45,000 for DCFC ports.

Figure 125 shows average all-in costs for the 52 sites. EVSE is the largest estimated cost across the sites, followed by estimated BTM, then TTM. Together, the average all-in actual TTM, estimated BTM, and estimated EVSE cost is $551,757.[82]

Figure 126. shows the distribution of utility infrastructure costs presented per site, per vehicle, and per kilowatt. The average Utility infrastructure cost of TTM and BTM borne by PG&E across sites was $273,450 per site,[83] $23,881 per vehicle, [84] and $1,576 per kilowatt.[85] School bus sites are cheaper than non-school bus sites on a *per site* basis but more expensive on a *per kilowatt* basis, reflecting the higher reliance on L2 chargers (which are more expensive per kilowatt for BTM, TTM, and EVSE) at school bus sites. School bus sites are roughly equivalent to non-school bus sites on a *per vehicle* basis.

Figure 125. PG&E EV Fleet Program Average Estimated All-In Costs across 52 Closed-out School Bus and Non-School Bus PTD Sites



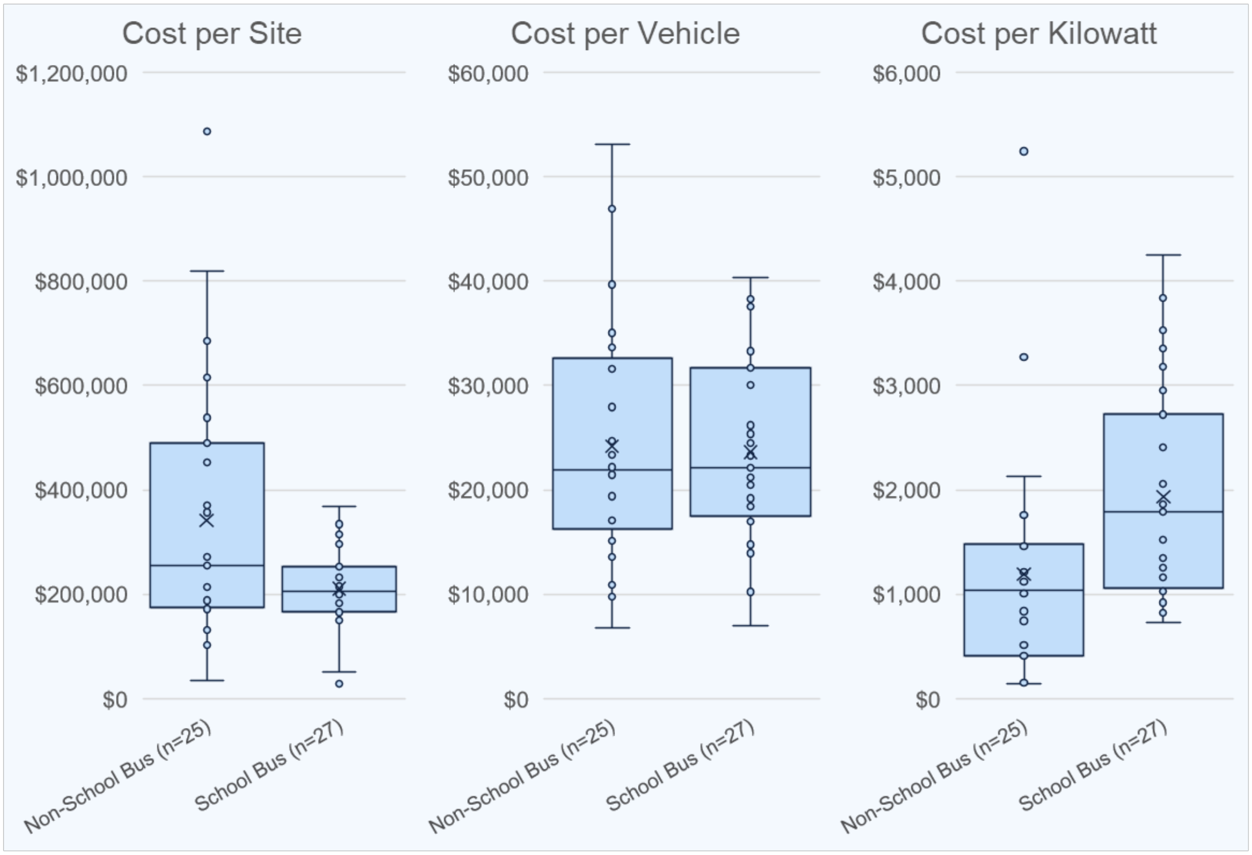
82 Calculated by summing all TTM, BTM, and EVSE costs borne by PG&E and the customer and dividing by 52 sites.

83 Calculated by summing all TTM and PG&E-sponsored BTM costs and dividing by the number of sites. Number reflects maximum infrastructure rebate offered for sites that have not yet applied for rebates, which may vary significantly from actual infrastructure rebate amount paid.

84 Calculated by summing all TTM and PG&E-sponsored BTM costs and dividing by the sum of all vehicles.

85 Calculated by summing all TTM and PG&E-sponsored BTM costs and dividing by the sum of installed capacity.

Figure 126. PG&E EV Fleet Program, Utility Infrastructure Cost per Site, per Vehicle, and per Kilowatt for School Bus and Non-School Bus PTD Sites



Highlights

- Estimated All-in costs (i.e., estimates of 100% of the Utility and customer costs) vary widely between sites with an average of $551,757 per site. The estimated EVSE cost accounted for over half of non-school bus all-in costs.
- While the EV Fleet program provides TTM infrastructure upgrades for all sites, only 1 of 52 closed out sites had Utility-constructed BTM infrastructure.
- The average cost of PG&E-sponsored TTM and BTM across sites was $273,450 per site, $23,881 per vehicle, and $1,576 per kilowatt. School bus sites are cheaper than non-school bus sites on a per-site basis but more expensive on a per-kilowatt basis, reflecting the higher reliance on L2 chargers (which are more expensive per kilowatt for BTM, TTM, and EVSE) at school bus sites.

Grid Impacts

This section describes grid impacts for the EV Fleet program based on an analysis of energy consumed and customer bills by operational charging stations installed through the program in EY2023.

Data Sources

The primary data source for the analyses detailed in this section is the energy usage–related data provided in regular 15-minute intervals from the Advanced Metering Infrastructure (AMI). Other data sources include customer bills, LCFS program information, and charging session–specific data provided by NSPs. There are several important differences between AMI and NSP data. While AMI data includes only energy usage, NSP data also includes session start and stop time, the duration of a vehicle's connection to a charging port, the duration of a vehicle actively pulling power, and the specific port used for a session. AMI meters track standing loads (such as those the EVSE uses for communications, cooling, active power converters, solenoids, and screens), which NSPs typically cannot do. For cases in which AMI data was missing from the dataset, the Evaluation Team used NSP data to fill in the gaps.

Summary of Grid Impacts

Table 76 presents the estimated EV Fleet program grid impacts.

Table 76. PG&E EV Fleet Program Grid Impacts

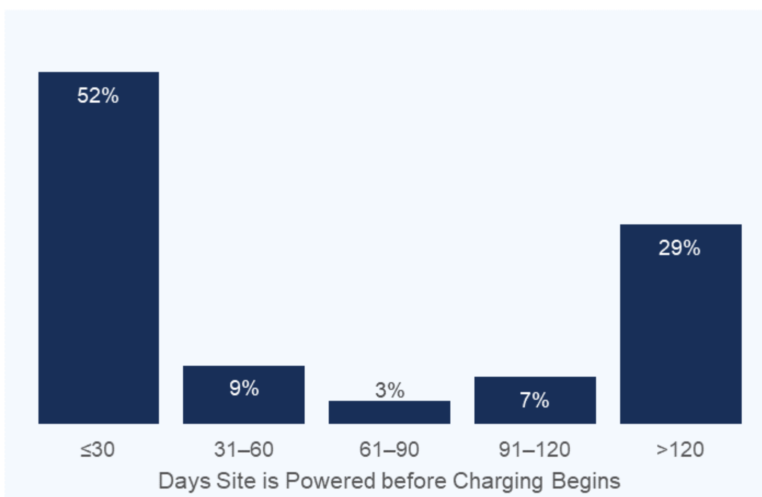
Impact Parameter	2023 Actual	PTD Actual	10-Year Projection
Operational Sites	62	62	62
Installed Charging Capacity, kW	11,000	23,000	23,000
Electric Energy Consumption, MWh	7,256	13,019	99,967
On-Peak (4 p.m. to 9 p.m.) MWh (percentage of total)	1,719 (23.1%)	3,328 (25.2%)	N/A
Maximum Demand, kW (date and time)	4,947 (12/14/23: 9:30 p.m.)	4,947 (12/14/23: 9:30 p.m.)	N/A
Maximum On-Peak Demand, kW (date and time)	2,603 (12/4/23: 8 p.m.)	2,603 (12/4/23: 8 p.m.)	N/A

Energy Trends

Site Startup

The Evaluation Team examined the duration between EV Fleet program site activation and operation to illustrate the timing relationship between readiness of charging infrastructure and actual vehicle charging. AMI data demonstrates that 61% of sites had significant operations within 60 days of activation, as illustrated in Figure 127. However, as seen in the final column of this figure, 29% of all sites were not in use for at least 4 months after activation. Based

Figure 127. PG&E EV Fleet Program Percentage of Sites, by Days between Activation and Operation for PTD Sites



on discussions during site visits, the primary cause of delays in operation was a delay in vehicle delivery. Additionally, transit operators often took several months to commission vehicles.

Consumption and Maximum Demand

Figure 128 depicts the growth of PG&E's monthly energy consumption and maximum demand for all operational sites in the EV Fleet program to date. In EY2023 both consumption and maximum demand increased as new sites became operational.

EV Fleet program sites collectively reached 4.9 MW of demand at the end of 2023, with an installed capacity of approximately 23 MW. As detailed in the *Site Visit Findings*, the low demand relative to the installed capacity is likely due in part to operators still gaining expertise and working out EV reliability and operations issues and/or waiting for delivery of all vehicles. However, those challenges are likely not the only reasons for the gap between installed capacity and maximum demand. Comparing the early 2023 demand of approximately 2 MW to the peak demand of nearly 5 MW in late 2023 shows that demand for EV Fleet program sites more than doubled in EY2023. EV Fleet program sites have increased their energy consumption at a similar rate in recent months. Figure 128 shows that each of the final two months of 2023 recorded energy consumption of nearly 800 MWh compared to the 400 MWh consumed monthly in the beginning of EY2023. PG&E's SB 350 report to the CPUC states a higher monthly value due to their inclusion and estimate of consumption for fleets for which infrastructure and consumption was added to pre-existing utility accounts.

Figure 128. PG&E EV Fleet Program Monthly Energy Consumption and Maximum Demand for PTD Sites

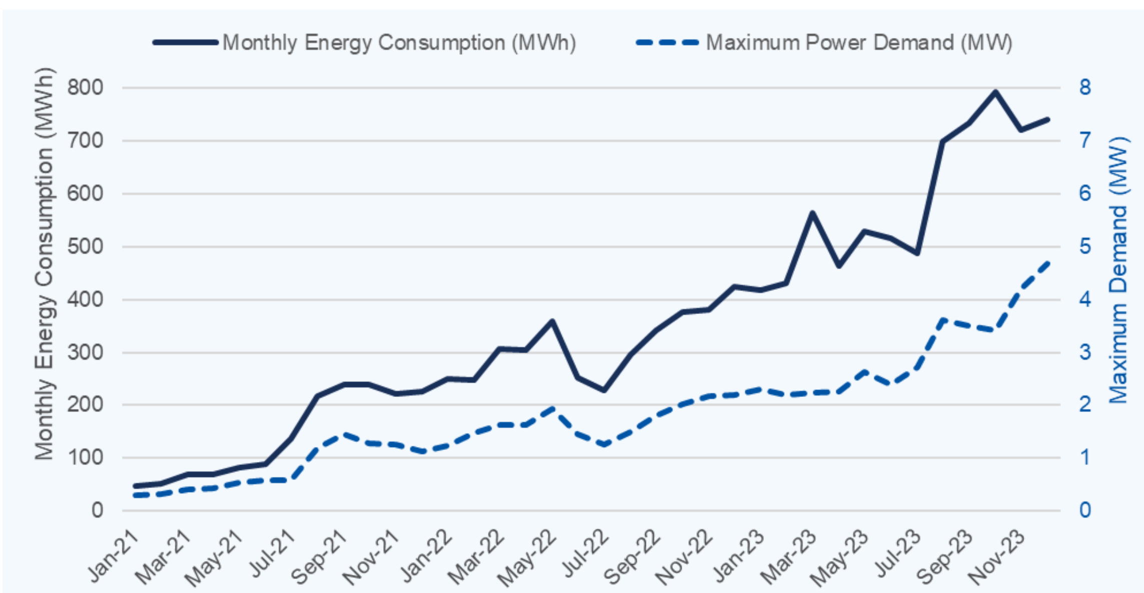


Figure 129 provides insight into monthly energy consumption trends of activated sites by program reporting year. Sites activated in 2021 reach a point of consistent consumption by the end of 2022 that continues throughout 2023. There are significant drops in consumption in the summer, which reflects the large number of school bus sites that have limited operations in the summer. Sites activated in 2022 reach a point of somewhat consistent consumption in late 2023 that continues through the majority of 2023 until the end of the year. Sites activated in 2023 display much greater consumption than 2021 and 2022 activated sites because of new larger sites coming online. We expect that consumption at these sites will become more consistent in EY2024.

Figure 129. PG&E EV Fleet Program Monthly Energy Consumption of Activated Sites Grouped by Initial Reporting Year for PTD Sites

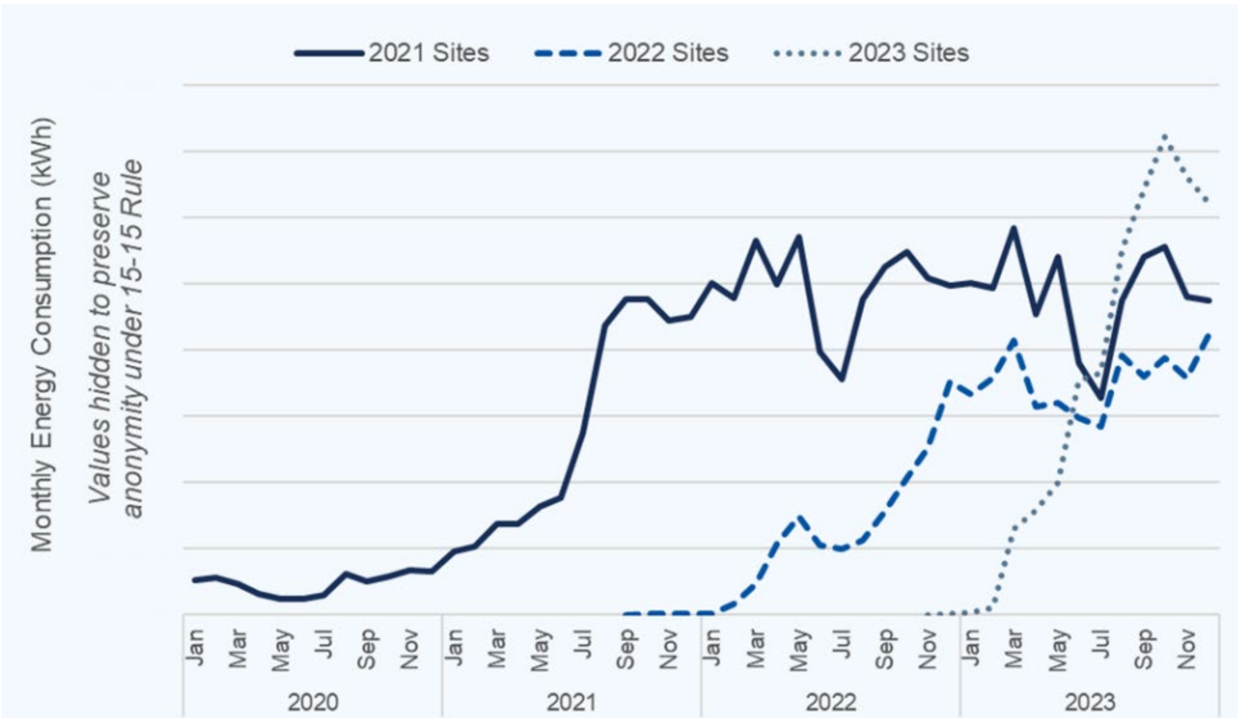


Figure 130 shows wide variations in daily consumption between weekdays and weekends. The high marks typically represent weekday operation, while the low marks typically represent weekend operation. In the final months of 2023, weekday energy uptake typically fluctuated from 30 MWh to 40 MWh, while weekends hovered closer to 10 MWh.

Figure 130. PG&E EV Fleet Program Daily Energy Consumption for PTD Sites

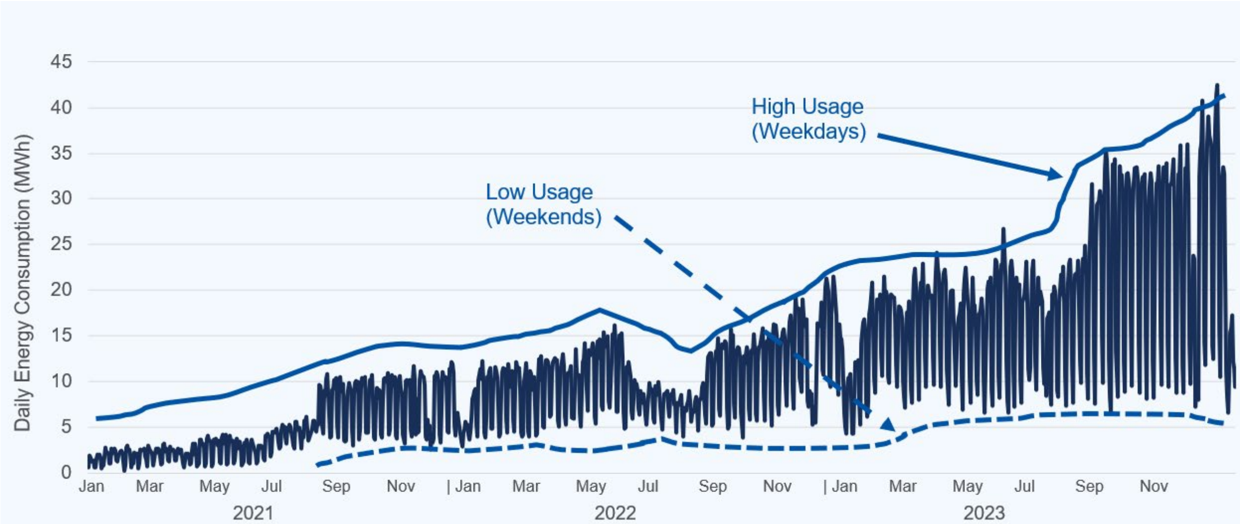
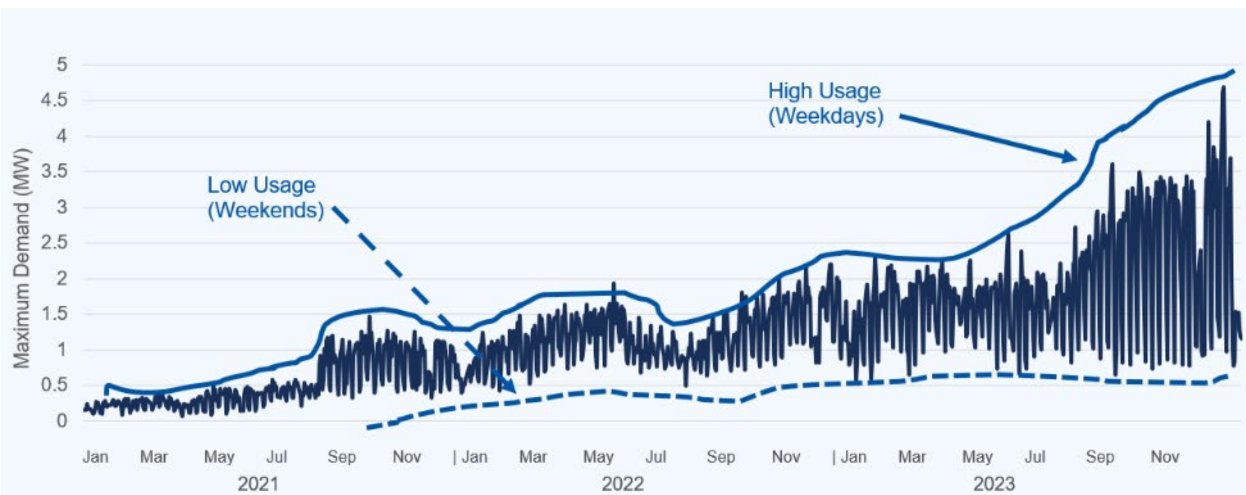


Figure 131 shows daily fluctuations in the maximum demand during the same period. Weekdays hit 3 MW with spiking towards the end of 2023 close to 5 MW. Weekends and low days in general were edging to 1 MW most of the year.

Figure 131. PG&E EV Fleet Program Daily Maximum Demand for PTD Sites



Load Management and Charging Flexibility Analysis

This section describes analyses around load management and load flexibility. Load-managed sites are those that adopt techniques to avoid charging vehicles during periods of peak energy prices. The analyses consider sites to be load managed if they exhibited consistent load management at some point in their operations regardless of when load management was implemented; otherwise, they are labeled as non-load managed. One telltale sign of load management is the 9 p.m. load ramp that results from a site avoiding demand from 4 p.m. to 9 p.m. and shifting loads to periods of lower cost electricity.

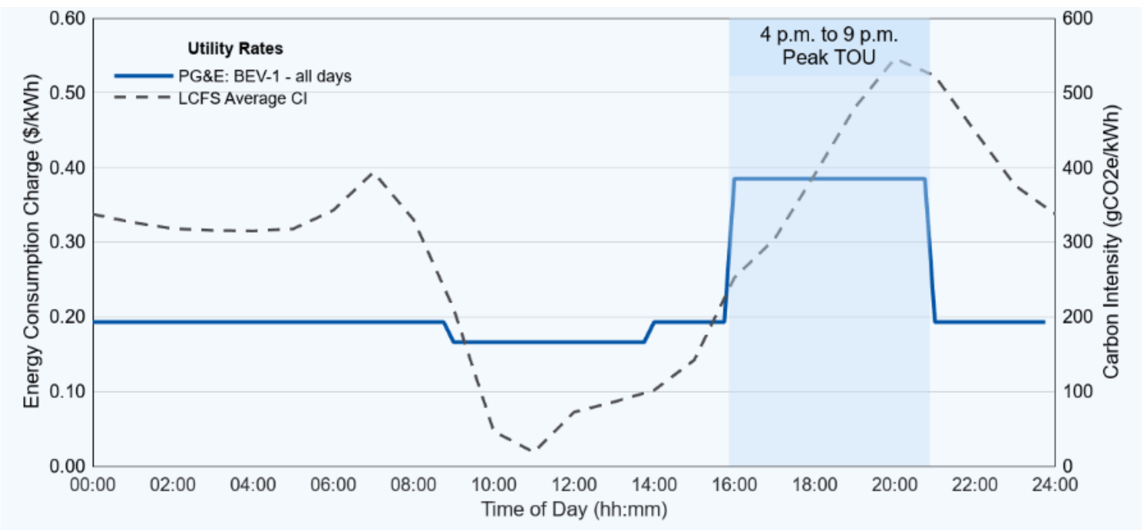
PG&E's peak TOU period occurs each day from 4 p.m. to 9 p.m. During those peak hours, for sites under the BEV-1 rate structure (<100 kW demand) in PG&E's EV Fleet program, the volumetric component of energy costs in 2023 was around $0.385 per kilowatt-hour, versus $0.193 and $0.166 per kilowatt-hour during off-peak and super off-peak TOU periods, respectively. These TOU rates, displayed in Figure 132, apply to all days throughout the year. In many cases, lower-cost TOU periods correlate with relatively lower carbon intensity of the grid. This is indicated by the dashed line, which shows the 2023 annual average carbon intensity (hourly average across Q1–Q4 values) for generating credits by using the LCFS Smart Charging mechanism with grid electricity in California.

What is Load Management?

Load Management is an effort to control vehicle charging for several purposes:

- Mitigation of electricity costs
- Participation in special programs (Demand Response or California Low Carbon Fuel Standard)
- Compensation for limited electrical capacity

Figure 132. PG&E EV Fleet Program Hourly TOU Electricity Rates and Average Carbon Intensity Used for Generating LCFS Credits in 2023



The Evaluation Team periodically reviews data on a site-by-site basis throughout the year to identify load-managed sites. Visiting sites in person and speaking to fleet managers also provides context around load management intent.

Of the 60 operational sites, six sites appeared to be using load management at the start of 2023. Another six sites began this practice in EY2023, comprising a mix of sites that began overall operations in 2023 and sites that were activated in previous years. At least two sites have shown intermittent use of load management, either on a daily basis or for a few months. This was evident in two ways:

- Load spiked quickly around 9 p.m.
- The proportion of total monthly energy consumption used between 4 p.m. and 9 p.m. was often below 10%.

The Evaluation Team assessed consumption trends for sites that had implemented load management and those that had not. Figure 133 compares the average load curves of load-managed sites, non-load-managed sites, and overall site averages.

Since early 2021, the load-managed sites appear to improve at avoiding consumption during the 4 p.m. to 9 p.m. time period. The upward trend in mid-2023 is likely tied to new sites coming online that adopted load management towards the end of the year (or possibly with intermittent interoperability issues). Sites that have not employed load management have a strong influence on the overall portfolio trend and are tracked closely throughout all evaluation years.

Figure 133. PG&E EV Fleet Program Percentage of Monthly Consumption between 4 p.m. and 9 p.m. for PTD Sites

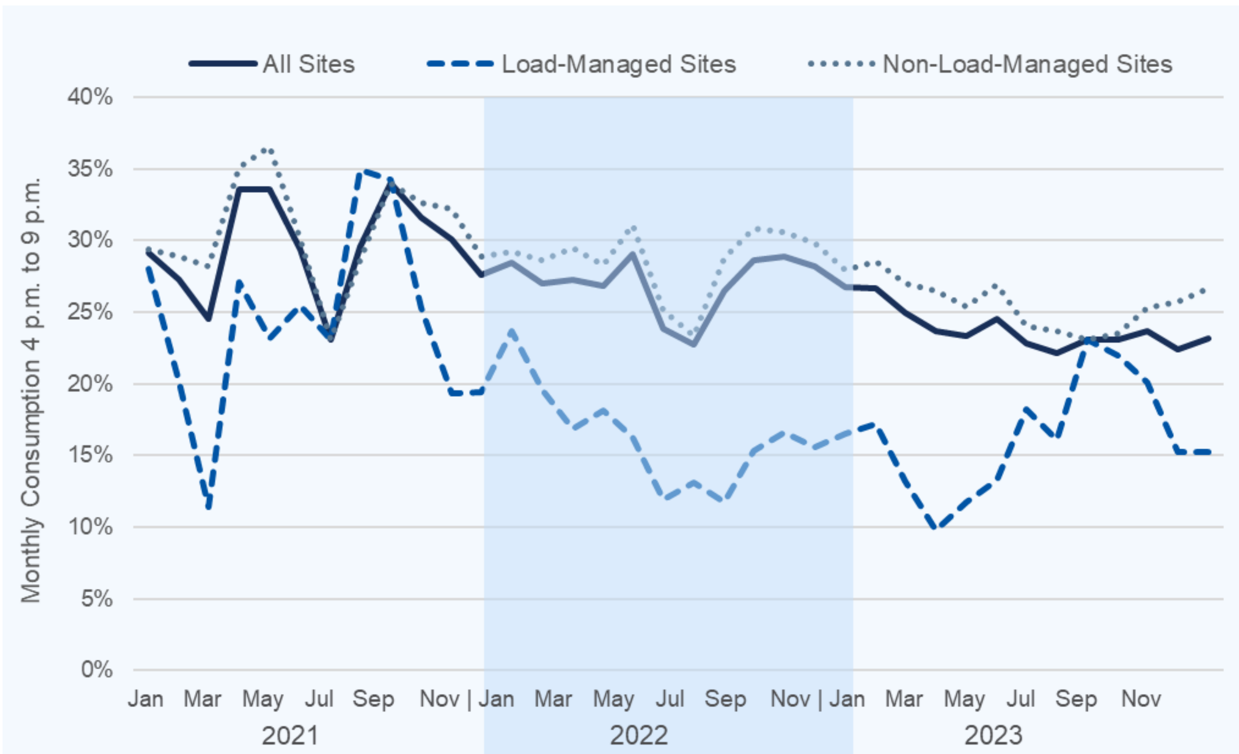


Figure 134 illustrates the differences in peak demand between load-managed and non-load-managed sites (determined using consumption data). Because few sites are currently using load management, the chart compares shapes rather than amplitudes. Figure 134 focuses on the months of August through October when load is highest. Load-managed sites demand nearly reached non-load-managed sites demand around 9:00 p.m. This spike likely could be flattened given that it ramps down after only two hours. Most of these vehicles are believed to have enough charging flexibility that the rate of charging could be decreased to extend the session by several hours. However, this example shows successful curtailment of load from 4 p.m. to 9 p.m. Non-load-managed sites appear to show a small 9 p.m. spike (on average from 1,100 kW to 1,200 kW), indicating that some of these sites enabled or tested load management but did not use it with enough regularity to be captured within the load-managed group.

Figure 134. PG&E EV Fleet Program Load-Managed and Non-Load-Managed Site Demand, August 2023 through October 2023 (High Consumption and Demand Months), PTD Sites

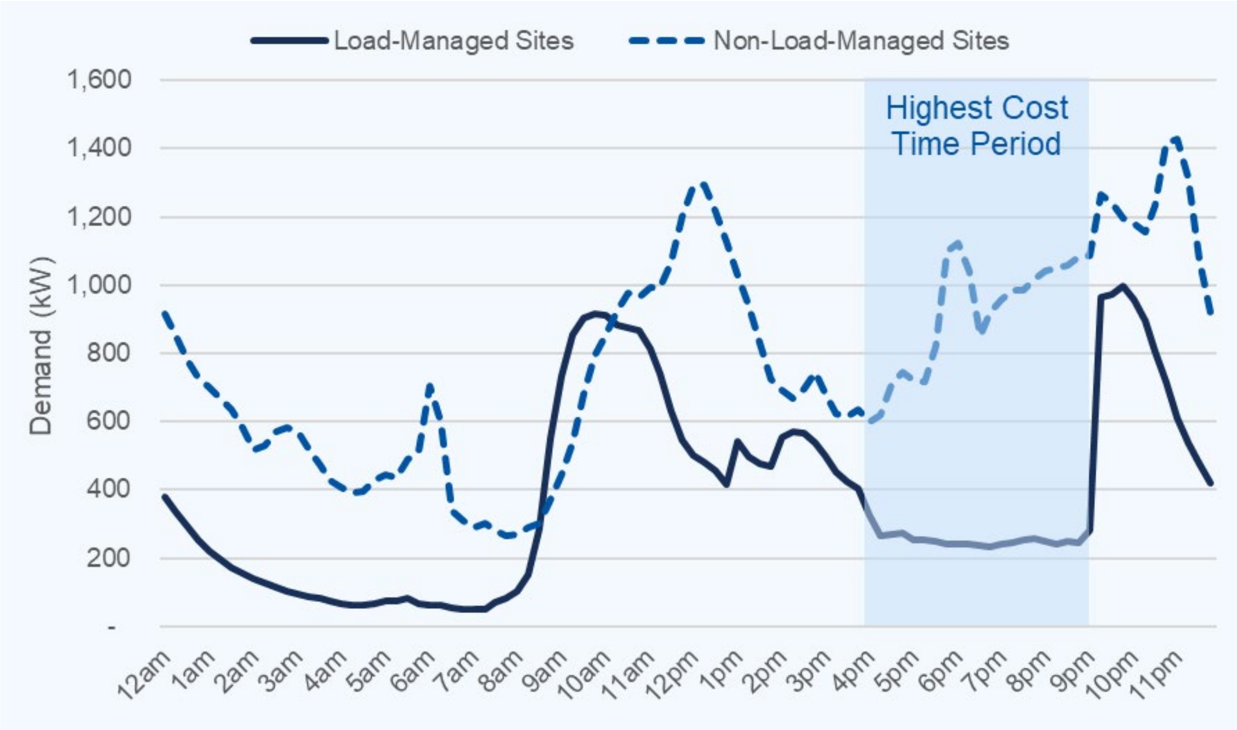


Figure 135 shows the average weekday and weekend daily load across all sites in the EV Fleet program for the months of September through November, which have the highest demand. Most fleets exhibit higher consumption and demand on weekdays than on weekends because most fleets such as school buses and delivery trucks have little to no activity during weekends. Weekday consumption frequently approached 4 MW toward the end of 2023, with consumption on a few days nearing 5 MW. However, some fleets such as transit buses may also operate on weekends, creating more consistent demand. Weekends show much lower activity on average, but many weekend days in 2023 showed 1,500 kW or more.

Figure 135. PG&E EV Fleet Program Weekday and Weekend Daily Average Loads for PTD Sites from September 2023 through November 2023

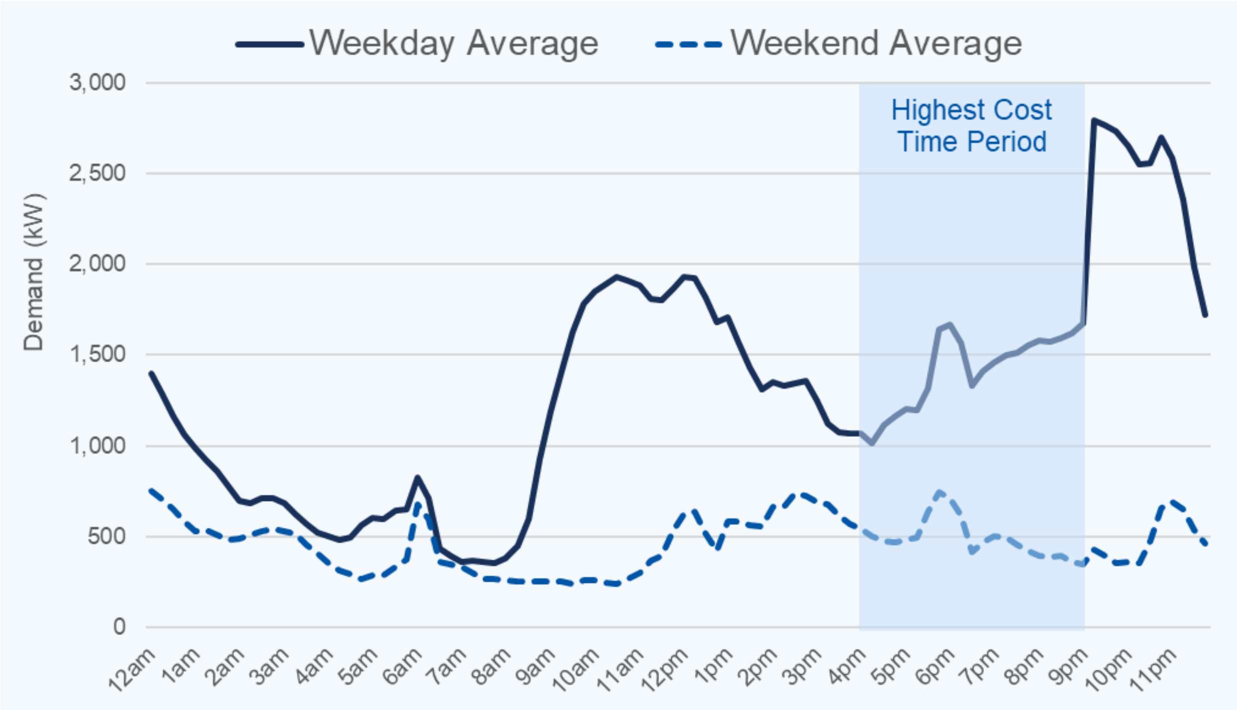


Figure 135 clearly shows a significant increase in demand starting at 9 p.m. for weekday operations, after the highest-cost and highest-demand time period has passed, indicating a portion of program sites are employing load management. At the same time, the lack of a demand peak after 9 p.m. on weekends suggests that most weekend operators are not currently using load management.

Charging Flexibility

The Evaluation Team used site charging data to determine the amount of time vehicles are connected to a charging port but not actively consuming energy. This allowed the Team to assess charging flexibility, or the ability for a vehicle to shift charging from periods of high-cost electricity to low-cost electricity without impacting vehicle operations. In addition, site visits allowed the Evaluation Team to confirm vehicles' make, model, and battery size, all of which affect charging flexibility. For instance, many school bus charging sessions use less than half of the vehicle's battery capacity. Providing feedback to operators about historical usage trends like charging session size in relation to battery size and available time to charge may help inform charging plans.

There are 30 school bus sites out of 60 operational sites in the EV Fleet program. Figure 136 shows the relative charging flexibility of school bus and non-school bus fleets which represents the number of hours that fleet vehicles are connected to a charging port but not consuming electricity. Figure 136 uses only charging sessions that took place partially or entirely during periods of highest-cost electricity and omits charging sessions that did not overlap with the period between 4 p.m. and 9 p.m.

Figure 136. PG&E EV Fleet Program Flexible Charging Availability for PTD Sites in Sessions Overlapping the Time Period Between 4 p.m. and 9 p.m.

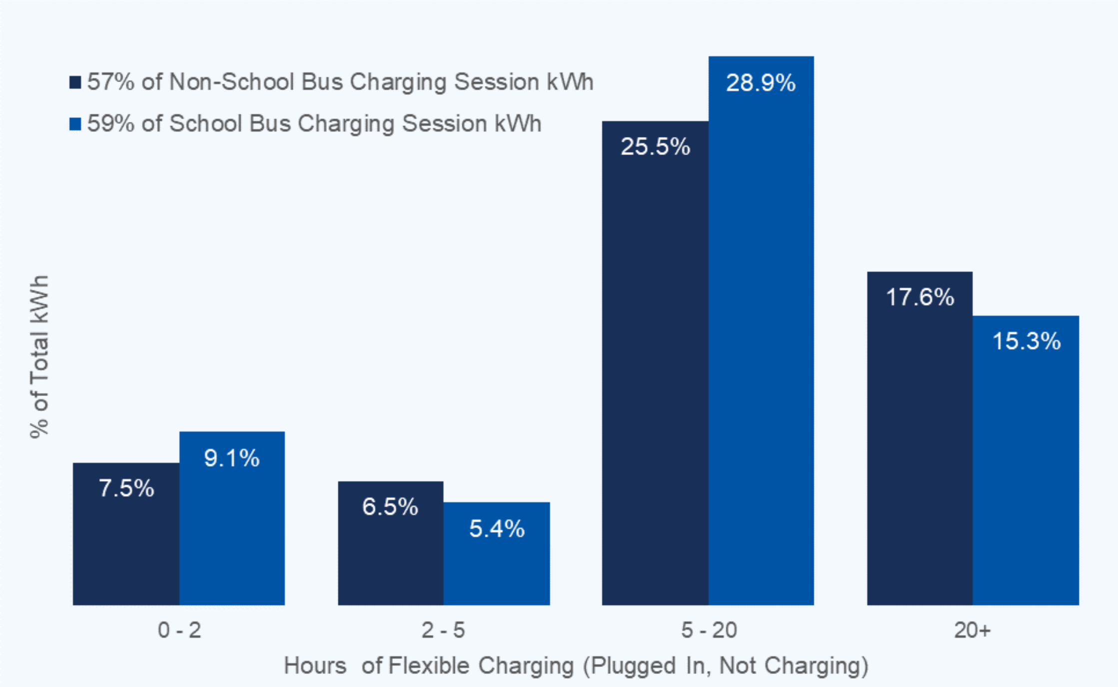


Figure 136 shows that 57% of non-school bus sessions and 59% of school bus sessions either started before and extended past 4 p.m. or started between 4 p.m. and 9 p.m., the period of high-cost charging. Conversely, approximately 40% of all energy from these fleets did not overlap that time period and is not shown in Figure 136. Some of these operators use load management, so their vehicles did not charge during that period; however, these sessions are relevant to the analysis of how much time a vehicle was connected but not drawing power.

Figure 136 shows that a high proportion of energy (over 40% for both school bus and non-school bus) is coming from charging sessions with enough flexibility to entirely avoid the highest-cost time period that have 5 or more hours of flexibility. As the period of highest-cost electricity lasts for five hours (4 p.m. to 9 p.m.), a vehicle with a charging period longer than five hours would need at least five hours of charging flexibility to fully shift consumption from on-peak to off-peak periods. However, vehicles with less than five hours of charging flexibility will benefit from adopting load management by shifting a portion of demand to periods of lower-cost electricity.

PG&E's portfolio of customers shows there is a small amount of charging sessions with little flexibility taking place during the high-cost time period. Though unable to shift all their energy, these sites have some room for improvement; this is limited to below 15% of all sessions.

Fleets operating a single shift are usually able to benefit the most from load management, while fleets operating multiple daily shifts face the most challenges to leveraging load management. However, those with more shifts often have significant energy consumption at all times of day, which somewhat reduces the proportion of charging during 4 p.m. to 9 p.m., resulting in comparatively lower average energy costs.

Costs and Billing

Previous sections have focused on energy trends and on charging flexibility, hinting at how those trends could change in the future. The following sections discuss billing cost trends and to what extent those may improve based on charging flexibility. The Evaluation team's review of billing data focuses on the average unit cost of a kilowatt-hour for a given site-billing month compared to the TOU-based tariff cost of energy.

NSPs' load management capabilities and fleets' adoption rate of load management impact costs and energy trends. Nearly every NSP involved in the EV Fleet program provided reliable data; however, not all of these NSPs offered load management as a service on their platform as of the end of 2023. When provided, load management may be a base offering or tiered-cost package. Interoperability between hardware, software, and vehicles presents challenges that can make load management impractical or difficult to achieve.

Many fleet operators remain unaware of their energy use and charging costs even though most EVSPs make this data available. Often a site host's finance office will receive utility bills but will not share information with fleet operators that would enable them to compare energy costs with other fuel types in their fleets. The Evaluation Team uses energy trends as discussion points during site visits if operations have started. Many fleet operators said they had not seen these data trends prior to the evaluation site visits.

Grid impact trends discussed so far may help the reader to infer utility costs. The Evaluation Team continues to work closely with PG&E staff to identify resources to contribute to the evaluation. The Evaluation Team did not receive complete billing data in time to complete an analysis for this report.

Notably, PG&E has a larger number of customers relying on CCA generation compared to the other utilities. A primary way the Evaluation Team looks at billing is by average unit cost of energy (total monthly bill cost divided by the total consumption in kilowatt-hours). The Evaluation Team had noted a number of PG&E bills missing the CCA generation charges. This was perceived based on average costs per kilowatt-hour below the lowest cost of energy on PG&E BEV-oriented tariffs. After attempting manual review of bills, the PG&E team is believed to have now established a system to automatically include CCA charges in billing data. This data was not provided in time to analyze and include in this report. The Evaluation Team will make every attempt possible to include the data in subsequent evaluation reports.

Electricity Cost and Emissions Optimization Analysis

This section builds upon the grid impact findings above to include an analysis of hypothetical customer bills and emissions. This analysis considered TOU-based load management across sites with enough reliable NSP data. While real-world constraints—such as technology, operations, and education—currently prevent ideal load management, the findings shed light on the long-term potential of load management. To quantify the potential benefits of using load management, the Evaluation Team analyzed observed outcomes of sites with and without existing load management practices and conducted a load-shifting optimization exercise to estimate the total potential cost savings and emissions reductions. This analysis primarily uses NSP data to assess charging flexibility. Future efforts will extend this analysis to fleets without NSPs or load management. *Appendix A* provides additional methodological notes.

Load management outcomes observed in EY2023

The Evaluation Team assessed a subset of all PTD sites that had the necessary AMI and NSP data—a total of 30 EV Fleet program sites. This analysis does not use data for all 62 operational sites in the EV Fleet program to date, but only for those sites with AMI and NSP data that met analysis requirements. Of these 30 sites, 19 were school bus sites and 11 were from other market sectors, including transit bus, medium-duty vehicles, heavy-duty vehicles, and forklifts.

Figure 137 and Figure 138 depict the BAU historical energy consumption of school bus and non-school bus fleets in aggregate during 2023. BAU is the current charging behavior of the 30 sites represented in this analysis. In Figure 137 and Figure 138, the areas with darker shading area indicate those times of day (y-axis) and days throughout the year (x-axis) when charging demand is the highest. Areas with light shading represent little energy demand. School bus fleets show a consistent trend of high consumption from 9 a.m. to 1 p.m. and after 4 p.m., after morning and afternoon routes are complete. Demand is visibly lower during the winter holiday, spring break, and summer vacation periods, when many schools are not in session.

Figure 137. PG&E EV Fleet Program Heatmap of the Collective BAU Charging Demand for All PG&E School Bus Fleets in 2023

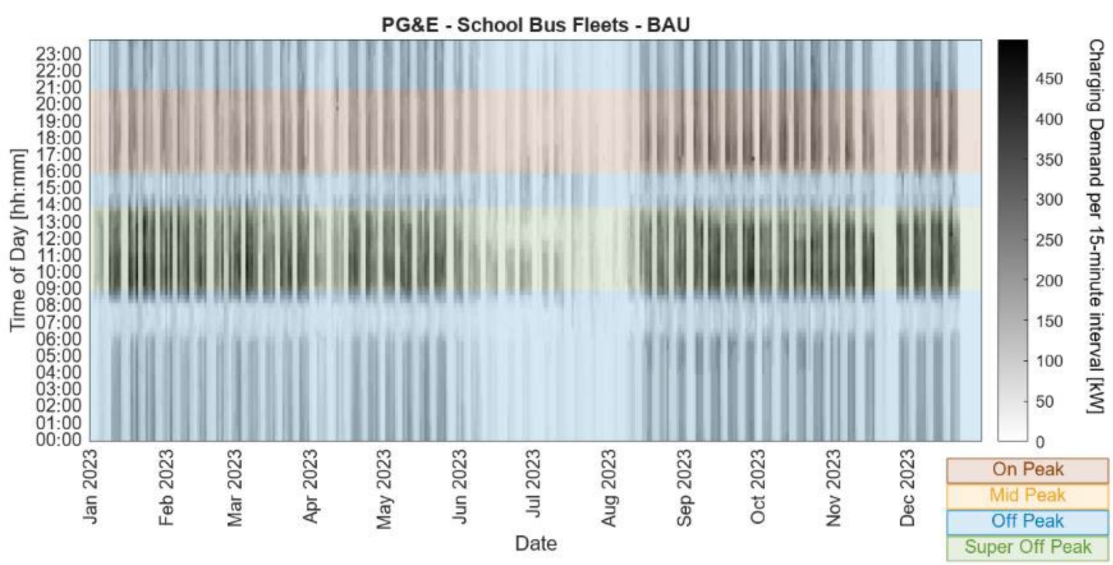
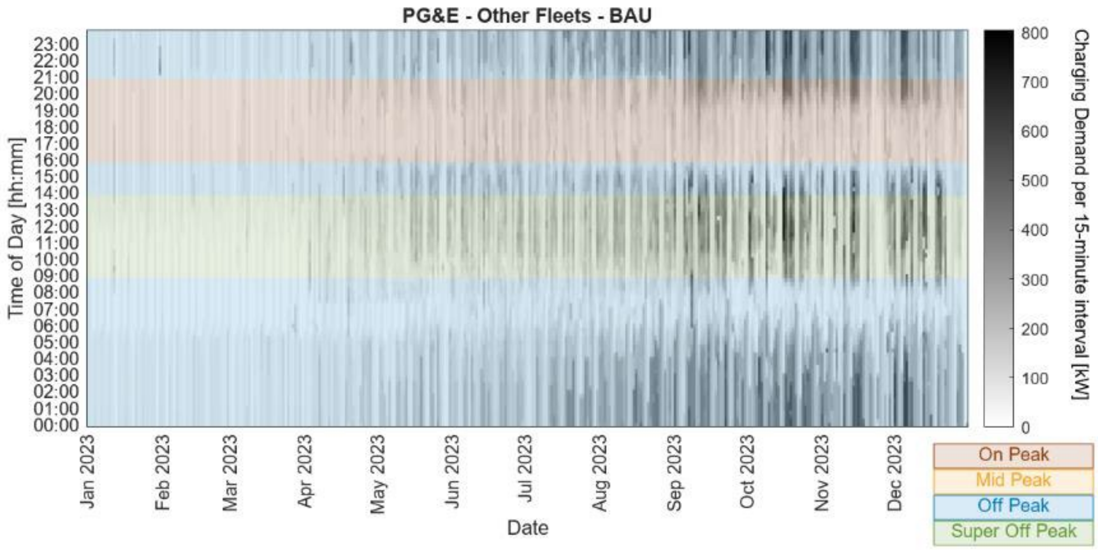


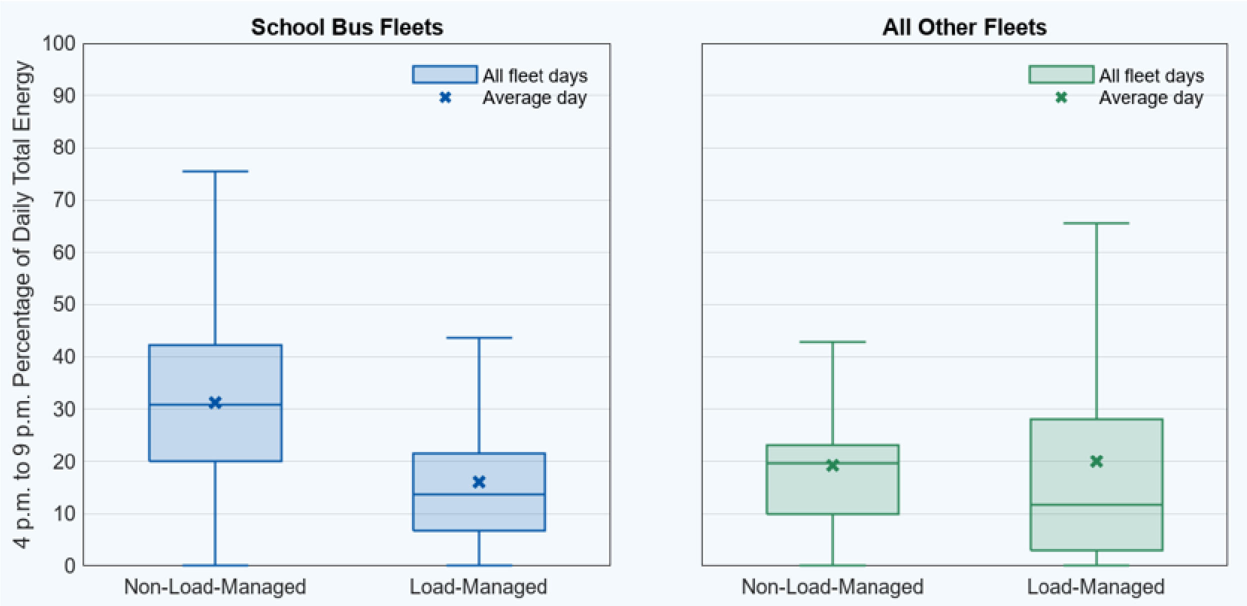
Figure 138. PG&E EV Fleet Program Heatmap of the Collective BAU Charging Demand for All PG&E Non-School Bus Fleets in 2023



The Evaluation Team compared NSP sessions under load management strategies to non-load-managed sessions for school bus and non-school bus fleets in this analysis. This helps to identify how effective existing load management strategies are at shifting energy use away from the period between 4 p.m. and 9 p.m.

Figure 139 shows the percentage of each day's energy consumption that occurs during the high-cost TOU period. For school buses, on the average non-load-managed day, 31% of EV charging energy consumption occurs in the peak TOU period. On the average load-managed day, that peak consumption fraction drops to 16%. For other market sectors, the average non-load-managed day has 19% of consumption occurring in the high-cost TOU period, versus 20% for load-managed days.

Figure 139. PG&E EV Fleet Program Distribution of the Fraction of Daily EV Charging Load Occurring in the Peak TOU Period



The box and whisker plot represents the distribution of daily total energy consumed from 4 p.m. to 9 p.m. across one operating day by group, and diamonds indicate the average value for all operating days per group.

This comparison suggests that existing load management programs reduce the fraction of energy consumed during peak hours and therefore reduce the energy costs. However, outcomes vary substantially across sites (both load-managed and non-load-managed), suggesting that the value of load management depends on each site's operating patterns, charging flexibility, and on the chosen implementation of load management controls.

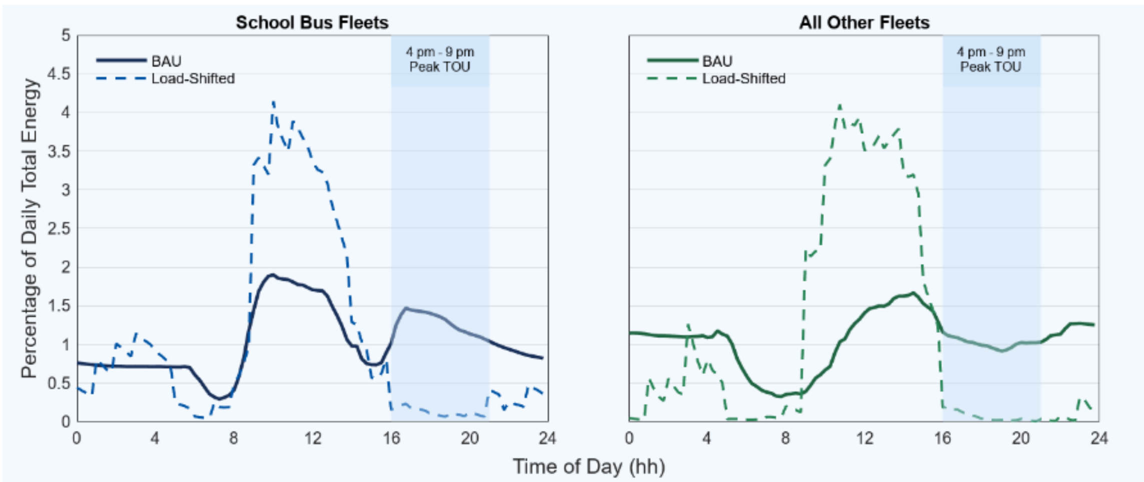
Potential benefits of optimal load management

The Evaluation Team analyzed AMI and NSP data to estimate the potential value of optimal load management, considering each site's observed operating patterns and potential ability to shift vehicle charging loads. This analysis included only days with energy consumption recorded in NSP charging session data. On average, each PG&E school bus site had 305 such days, while each PG&E site from other market sectors had 220 such days (reflecting the fact that vehicle fleets operate only on certain days and that some sites had only partial-year data).

The Evaluation Team developed and executed an optimization routine for each included operating day. This optimization shifted each site's energy consumption from the 4 p.m. to 9 p.m. high-cost time period into the lowest-cost hours of the day whenever there was both unused charging capacity and vehicle charging availability during those hours. For hours in the same TOU rate period, the Team used emissions intensity (measured as CARB LCFS carbon intensity factors for smart charging programs) and BAU charging load as tiebreakers. The Evaluation Team used NSP charging session data to ascertain how many vehicles were plugged in and how many kilowatt-hours of energy could be shifted during each time period.

Figure 140 illustrates how optimally shifted loads differ from BAU loads, averaged across EY2023. For school bus and other market sector sites, the average day's load can be fully shifted out of the 4 p.m. to 9 p.m. window. This results in a large portion of load being shifted into the 9 a.m.to 2 p.m. super off-peak TOU period (which offers the lowest costs for energy consumption and roughly corresponds to the lowest average carbon intensity of grid electricity), with the remainder of load contained in the off-peak TOU period.

Figure 140. PG&E EV Fleet Program Fraction of Daily EV Charging Load Occurring at Each 15-Minute Interval for the Average Day in this Analysis



Note: Line color indicates site market sector and dashed versus solid lines indicate whether the load is BAU or shifted.

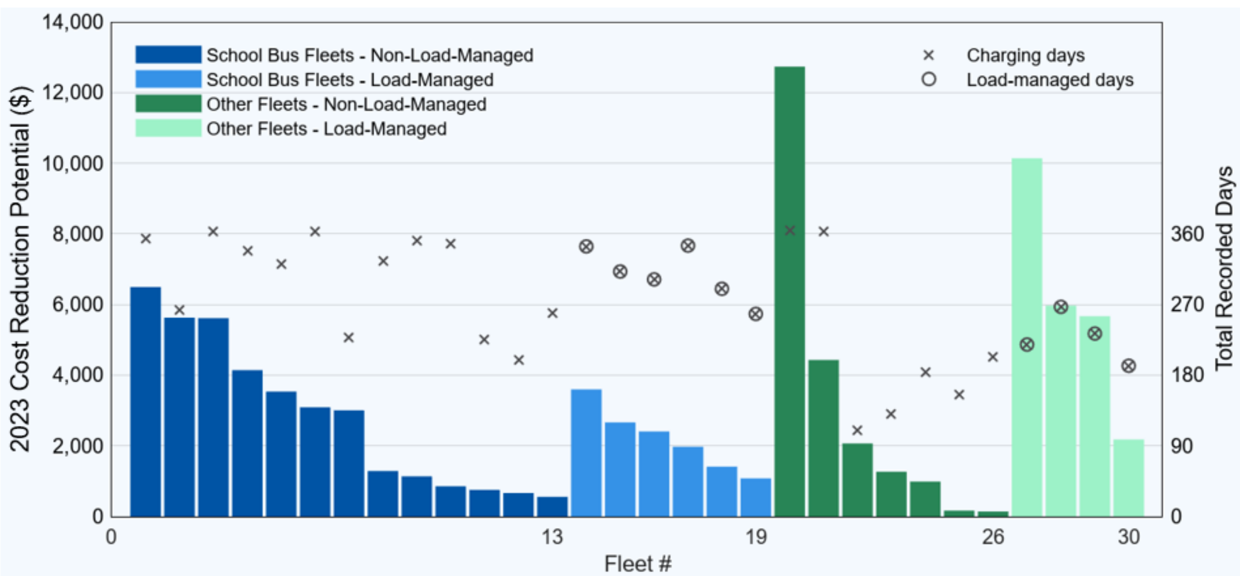
The Evaluation Team estimated the cost reduction potential of this daily load-shifting, with the following context:

- This analysis considers only the volumetric (cost per kilowatt-hour) component of each site's electricity costs. Optimal load management has the potential to also reduce demand charge subscriptions, which could impact costs especially in lower-volume months. The cost-minimization approach developed in this analysis ensures that peak demand does not increase but does not yet consider potential cost savings resulting from demand reduction.
- These results reflect only the portion of the year in which each fleet operated and provided charging data; annualized projections of these cost reductions could be substantially higher for fleets that have less than a full year of charging data included in this analysis or that have not yet reached mature operations.
- These results reflect only the portion of each site's vehicle fleet that was electrified in EY2023. A fully electrified vehicle fleet would see higher cost reduction potential from load management.
- This analysis considers the cost-saving potential of load management, but it does not yet consider the potential of load management to generate revenue via LCFS Smart Charging credits.
- This analysis examined the actual charging behavior at each site (using actual recorded plug-in and unplug times) to determine charging opportunities and does not account for other operational or

scheduling improvements for charging electrified fleets, which could enable more-effective load management, resulting in higher potential cost reduction.

Figure 141 shows the cost reduction potential for each site in total dollars per year. Potential reductions in annual energy costs range from $600 to $6,500 for non-load-managed school bus sites and from $100 to $12,700 for non-load-managed sites in other market sectors. Sites with load management still have cost reduction potential ranging from $1,100 to $3,600 in the school bus market sector and from $2,200 to $10,100 in other market sectors. This unrealized potential may reflect inconsistent use of load management controls by fleets, variation in effectiveness of load management controls across vendors, or risk-averse preferences of fleet managers to charge as soon as possible upon each vehicle's return to base. This analysis suggests room for improvement in realizing the full benefits of smart charge management.

Figure 141. PG&E EV Fleet Program 2023 Cost Reduction Potential of Each Site if it Used Optimal Load Management



Each bar represents one site. Bar colors indicate the site's market sector and whether it uses load management.

Because lower-cost TOU periods often correspond to periods with relatively low carbon intensity estimates for grid electricity, optimizing load management for energy cost savings can have a secondary effect of reducing the resulting carbon emissions. Figure 142 shows estimated cost reductions and corresponding GHG emissions reductions for each site resulting from a cost-minimizing load management strategy (considering carbon intensity only as a tie-breaking factor when there is sufficient charging flexibility). In general, across sites, shifting charging load to reduce costs shows the potential to reduce GHG emissions by an even greater percentage than costs. Table 77 aggregates these results across the included sites. Overall, optimal load-shifting could reduce school bus sites' collective energy consumption costs by 20.8% and attributed electricity grid GHG emissions by 54.1%; for other market sectors, it could reduce energy consumption costs by 17.9% and attributed electricity grid GHG emissions by 47.3%.

Figure 142. PG&E EV Fleet Program Potential 2023 Percentage Cost Reduction and Attributed GHG Emissions Reduction of Optimal Load Management

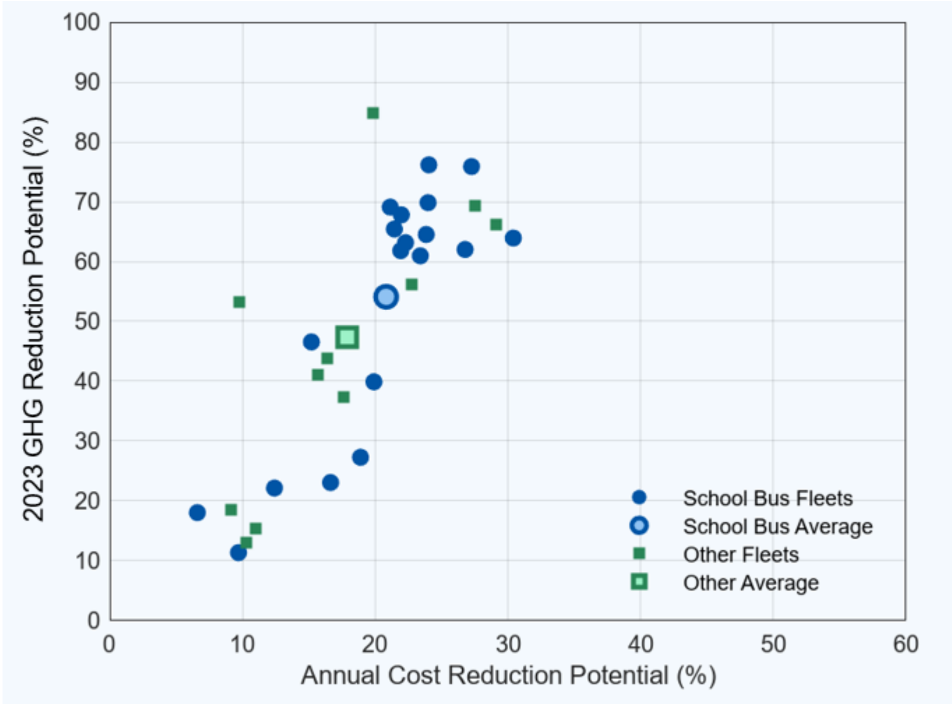


Table 77. PG&E EV Fleet Program Summary of Potential Cost and Attributed GHG Emissions Reductions, Aggregated Across All Included Fleets

PG&E	School Bus Fleets	All Other Fleets	All Fleets Combined
Total number of fleets	19	11	30
Total count of 2023 operating days	5,790	2,420	8,210
Cost Reduction Potential [%]	20.8 %	17.9 %	19.3 %
GHG Reduction Potential [%]	54.1 %	47.3 %	50.3 %

Highlights

- Charging data indicates that there is significant opportunity for most fleets to shift their charging energy use to lower-cost time periods.
- Both load-managed and non-load-managed sites have a demand spike around 9 p.m., potentially creating a problematic off-peak fast ramp and secondary peak.
- Approximately 60% of all charging sessions overlapped the 4 p.m. to 9 p.m. peak-rate period while nearly 45% have enough flexibility to delay charging to lower-cost time periods with effective load management.
- Sites activated in EY2021 have displayed somewhat consistent operations in 2022 and 2023, showing familiarity if not maturity with operations.
- EY2022 sites showed tapered off but continuing growth in 2023 while EY2023 sites are still in the early stages of operations.
- Interoperability between hardware, software, and vehicles presents significant challenges to load management as lack of education and awareness.
- The number of load-managed sites grew from 6 in EY2022 to 12 in EY2023, creating a mix of new and old sites.
- While more than 50% of sites began vehicle charging within 30 days of power availability, nearly 30% took over 120 days, with the delay often driven by supply chain issues.

Petroleum Displacement

The Evaluation Team estimated the petroleum displacement attributable to vehicle electrification enabled by PG&E's EV Fleet program. The Team used DGE for reporting purposes. However, as the Transit Bus market sector primarily uses compressed natural gas (CNG) fuel, the Team needed to convert transit bus natural gas consumption into DGE units based on the CNG fuel's energy content.

Table 78 presents petroleum displacement for the EV Fleet program through 2023, including estimated actual impacts for 2023, actual impact for all sites PTD, and a 10-year forecast for PTD sites. The results include the five market sectors represented in the program, with the majority of vehicles in the heavy-duty vehicles sector followed by the school bus sector. The PTD usage is over 6 million electric miles, estimated based on electricity consumption of 13,000 kWh. This translates into the displacement of over 1.3M DGE.

Table 78. PG&E EV Fleet Program Petroleum Displacement Summary

Market Sector	Usage (n=60)				Petroleum Displacement (DGE)		
	2023 Actual[a] kwh	PTD Actual[b] kWh	2023 Actual Use	PTD Actual Use	2023 Actual	PTD Actual	10-Year Projection
Forklift					17,177	47,005	122,847
Heavy-Duty Vehicle					359,980	713,976	3,599,572
Medium-Duty Vehicle					36,344	66,104	498,139
School Bus	1,664,357	4,051,614	1,289,647 miles	3,141,267 miles	141,534	345,251	1,003,916

Market Sector	Usage (n=60)				Petroleum Displacement (DGE)		
	2023 Actual[a] kwh	PTD Actual[b] kWh	2023 Actual Use	PTD Actual Use	2023 Actual	PTD Actual	10-Year Projection
Transit Bus					171,881	189,946	2,415,529
TRU					876	876	15,453
Total	**7,255,902**	**13,019,050**	**3,708,644 miles 10,110 hours**	**6,384,880 miles 25,538 hours**	**727,792**	**1,363,157**	**7,655,456**

[a] "2023 Actual" represents the data from all activated sites from program inception for the calendar year 2023.

[b] "PTD Actual" represents the data from all activated sites from program inception for all program years.

Highlights

- All operational sites in 2023 collectively achieved a PTD impact of more than 1.3 million gallons of petroleum displaced.
- The heavy-duty vehicle sector accounted for more than half of the petroleum displaced in 2023 and is projected to account for nearly half of the petroleum displaced over 10 years.
- Over a 10-year period, the currently operational sites will displace more than 7.5 million gallons of petroleum.

Greenhouse Gas and Criteria Pollutant Impacts

The Evaluation Team calculated reduced emissions from displaced fossil fuel use from ICE vehicles that were not in service because of the EV Fleet program. First, we developed ICE counterfactuals for each market sectors, then the Team calculated the emissions associated with these vehicles under conditions that otherwise matched the EVs, which provided a baseline. Although EVs have no tailpipe emissions, the mix of generation sources from the electric grid includes renewable as well as fossil fuel power to supply electricity to the charging stations, with the latter primarily responsible for emitting GHGs and criteria pollutants into the atmosphere.

Table 79 summarizes GHG impacts for the EV Fleet program for three time periods: (1) estimated reductions that reflect what program sites saved in 2023, (2) PTD reductions from all sites, and (3) a 10-year projection based on annualized data from all sites.

Table 79. PG&E EV Program Fleet GHG Reductions Summary

Market Sector	Usage (n=60)				GHG Reduction (MT)		
	2023 Actual[a] kWh	PTD Actual kWh	2023 Actual Use	PTD Actual Use	2023 Actual	PTD Actual	10-Year Projection
Forklifts					81	222	595
Heavy-Duty Vehicles					1,135	1,079	18,243
Medium-Duty Vehicles					290	535	4,000
School Bus					1,200	2,927	8,795
Transit Bus					1,166	1,289	17,173
TRU					8	8	144
Total	**7,255,902**	**13,019,050**	**3,708,644 miles**	**6,384,880 miles**	**3,880**	**6,060**	**48,950**

Market Sector	Usage (n=60)				GHG Reduction (MT)		
	2023 Actual[a] kWh	PTD Actual kWh	2023 Actual Use	PTD Actual Use	2023 Actual	PTD Actual	10-Year Projection
			10,110 hours	**25,539 hours**			

[a] "2023 Actual" represents the data for EY2023 from all sites activated in the program to date. "PTD Actual" represents the data from all activated sites from program inception for all program years.

Table 80 shows the estimated reductions in local emissions from the tailpipes of ICE vehicles that were displaced through this program, including hydrocarbons (HC) from off-road forklifts and heavy-duty vehicles. Forklifts showed the highest reduction in CO emissions due to the poor emissions performance of conventional forklifts. Transit bus followed, driven by the assumption that the displaced transit bus ran on CNG.

Table 80. PG&E EV Fleet Program Local Emissions Reductions, PTD Actual

Market Sector	PTD Actual[a] (n=60)				
	HC (kg)	PM_{10} (kg)	$PM_{2.5}$ (kg)	ROG (kg)	CO (kg)
Forklift	411.3	18.5	14.2	378.6	41,487.9
Heavy-Duty Vehicle	–	8.8	8.4	41.2	14,898.2
Medium-Duty Vehicle	–	1.5	1.4	12.3	369.5
School Bus	–	7.1	6.8	31.5	902.9
Transit Bus	–	1.1	1.0	37.8	27,698.6
TRU	2.8	0.3	0.3	24.3	3.1
Total	414.2	37.3	32.1	525.8	85,360.2

[a] "PTD Actual" represents the data from all activated sites from program inception for all program years.

Table 81 shows the same information as above, but only for 2023 actuals. These are the localized emissions reductions that occurred based on their actual fleet operations this year.

Table 81. PG&E EV Fleet Program Local Emissions Reductions Summary, 2023 Actual

Market Sector	2023 Actual (n=60)				
	HC (kg)	PM_{10} (kg)	$PM_{2.5}$ (kg)	ROG (kg)	CO (kg)
Forklift	176.0	6.9	5.3	162.0	19,160.8
Heavy-Duty Vehicle	–	8.4	8.0	32.7	8,844.0
Medium-Duty Vehicle	–	0.8	0.8	7.3	224.8
School Bus	–	3.0	2.8	13.2	374.2
Transit Bus	–	0.8	0.8	35.7	26,856.0
TRU	2.8	0.3	0.3	24.3	3.1
Total	**178.8**	**20.1**	**17.9**	**275.2**	**55,463.0**

[a] "2023 Actual" represents the data for EY2023 from all sites activated in the program to date.

Table 82 provides an estimate of savings over the 10-year period. These are the annualized reductions from all sites to date extended over a decade.

Table 82. PG&E EV Fleet Program Local Emissions Reductions Summary, 10 Year Projection for PTD Sites

Market Sector	PTD Sites 10-Year Projected Impact (n=60)				
	HC (kg)	PM_{10} (kg)	$PM_{2.5}$ (kg)	ROG (kg)	CO (kg)
Forklift	2,137.3	50.1	38.7	1,967.5	273,263.3
Heavy-Duty Vehicle	–	209.9	200.8	474.9	75,176.8
Medium-Duty Vehicle	–	12.8	12.1	174.0	5,226.1
School Bus	–	23.8	22.8	103.2	2,825.4
Transit Bus	–	14.7	13.6	464.6	335,883.6
TRU	125.9	7.6	7.0	1,234.6	139.8
Total	2,263.2	318.9	294.9	4,418.8	692,515.0

Table 83 shows counterfactual vehicle GHG emissions, emissions from the electricity used to charge the EVs, and GHG emissions reductions and percentage change. Table 84 shows the net reductions of NO_x emissions from using EVs based on the counterfactual and Utility emissions. The Evaluation Team estimated a total annualized GHG reduction of 76% and a NO_X reduction of 47% from the use of EVs compared to counterfactual vehicles for EY2023 sites. Reviewing the program to date reveals an estimated 72% actual reduction in GHG emissions and 63% reduction in NO_x emissions.

Table 83. PG&E EV Fleet Program Counterfactual GHG Reductions

Market Sector	EY2023 Sites (n=18) Annualized GHG (MT)				Program-to-Date Sites (n=60) GHG (MT)			
	Counter factual	Utility	Reduction	% GHG Reduction	Counter factual	Utility	Reduction	% GHG Reduction
Forklift	–	–	–	–	258.7	36.6	222.1	86%
Heavy-Duty Vehicle	1,441.8	371.4	1,070.4	74%	2,212.9	1,133.6	1,079.3	49%
Medium-Duty Vehicle	255.5	54.3	201.2	79%	664.8	129.9	534.9	80%
School Bus	32.5	6.0	26.6	82%	3,652.6	725.7	2,927.0	80%
Transit Bus	1,328.6	312.2	1,016.4	77%	1,645.0	355.9	1,289.1	78%
TRU	–	–	–	–	9.8	2.1	7.7	79%
Total	3,058.5	744.0	2,314.5	76%	8,443.9	2,383.8	6,060.1	72%

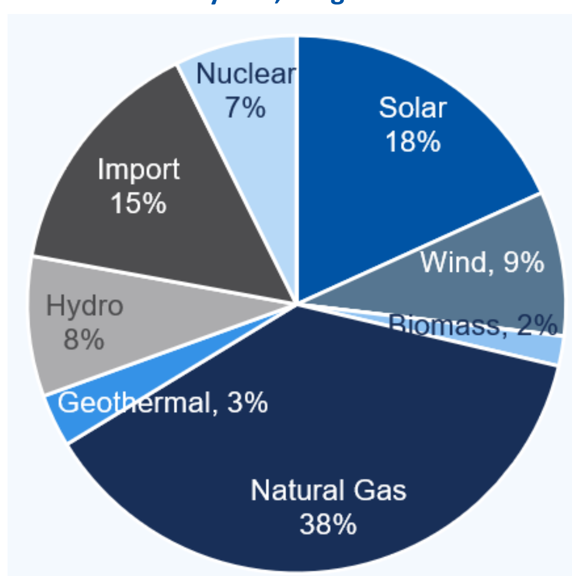
Table 84. PG&E EV Fleet Program Counterfactual NO_x Reductions

Market Sector	EY2023Sites (n=18) Annualized NO_x (kg)				Program-to-Date Sites (n=60) NO_x (kg)			
	Counter factual	Utility	Reduction	% NO_x Reduction	Counter factual	Utility	Reduction	% NO_x Reduction
Forklift	–	–	–	–	932.0	34.9	897.1	96%
Heavy-Duty Vehicle	1,149	347	802	70%	1,315.8	1,068.2	247.6	19%
Medium-Duty Vehicle	57	51	6	10%	464.7	123.0	341.7	74%
School Bus	28	6	23	80%	3,263.8	685.2	2,578.6	79%
Transit Bus	83	292	(210)	None	94.0	331.5	(237.6)	None
TRU	–	–	–	None	39.1	1.9	37.2	95%
Total	1,316.5	695.7	620.8	47%	6,109.3	2,244.7	3,864.6	63%

Figure 143 shows the program net electricity generation mix matched with the hours that the EVs were charging. The CAISO grid mix continually changes depending on factors such as the level of total demand for power on the grid and the availability of fossil generation and variable renewable resources such as solar.

At this stage of the program, it appears that the vehicles were not predominantly charging during the peak hours of solar output when grid emissions were the lowest. Approximately 15% of the grid mix comprises electricity imports, which do not vary by time of day for analysis purposes but match the resource mix purchased for the California grid.[86]

Figure 143. PG&E EV Fleet Program Net Electricity Mix, Program to Date



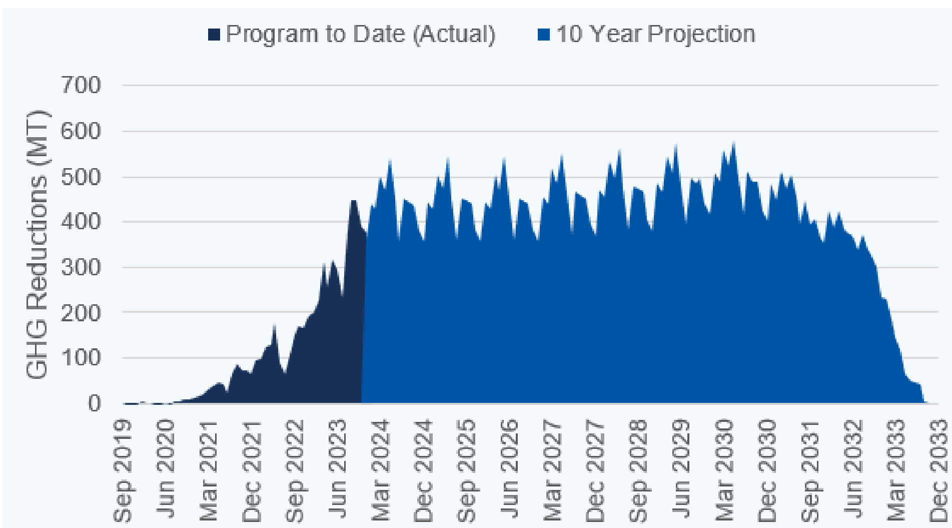
Based on the real-time grid conditions when the charging occurred, the overall energy mix was about 47% zero-emission or renewable sources of electricity (including solar, wind, hydro, geothermal, biomass, and nuclear) and 38% natural gas. Emissions reductions from these sites over 10 years should increase as the grid becomes cleaner. Additionally, the increased use of managed charging will reduce emissions as more EVs charge during off-peak times and when the grid is supplied with more renewable resources such as solar. Additionally, the increased use of managed charging, where possible, will reduce emissions as EVs charge at off-peak times and when the grid is supplied with greater

86 The power associated with imports comes from a mixture of renewables, hydro, nuclear, and natural gas power plants located outside of California (https://www.energy.ca.gov/data-reports/energy-almanac/california-electricity-data/2021-total-system-electric-generation).

amounts of renewable generation. Emissions will further decrease as more charging sites and EVs are added in future evaluation years.

Figure 144 shows how program GHG reductions have increased to date and are expected to grow over time for all activated sites. The analysis period ranges from the date that the first site in the program was activated through the end of EY2023. The analysis incorporates the net reduction (counterfactual emissions minus utility emissions) for each fleet within the PG&E EV Fleet program. PTD emissions reductions appear in dark navy while anticipated benefits based on annualization appear in royal blue. As each site has its own starting date of operation, the 10-year sunset for each site is observed as a gradual tapering off of program benefits between 2029 and 2032. While each year's operations appear similar, there are several key factors driving the variations such as seasonality of utility generation sources (high utility emissions will appear as a dip on the curves), holidays occurring on weekends versus weekdays, and sites that became operational late in 2023 having predicted operations year-round in future years.

Figure 144. PG&E EV Fleet Program Historical and Forecasted GHG Reductions for PTD Sites



Highlights

- PTD results show a 72% reduction of GHGs and a 63% reduction in NOX emissions.
- The greatest reduction in local emissions was CO with more than 55,000 kg in 2023 and a projected 10-year reduction of more than 690,000 kg.
- Based on the real-time grid conditions when the EV charging occurred, the overall energy mix contained about 47% zero-emission or renewable sources of electricity (including solar, wind, hydro, geothermal, biomass, and nuclear) and 38% natural gas.

Health Impacts

The Evaluation Team calculated public health impacts (as benefits and costs) of reductions in criteria pollutants from vehicle electrification. The pollutants we included in the analysis are primary $PM_{2.5}$ and precursors of secondary $PM_{2.5}$, including NO_x, SO_2, NH_3, and VOCs. The analysis considers only tailpipe emissions reductions rather than full lifecycle emissions (such as power plant emissions). The Evaluation Team used the EPA COBRA to evaluate the health benefits associated with emissions reductions. COBRA estimates the county-level benefits for the county in which emissions are reduced. It also estimates the effect of the transport of emissions on all counties in the United States; however, this analysis includes only the effects of the emissions reductions in California. The Evaluation Team disaggregated the county-level effects to estimate the potential health benefits of sites for DACs and non-DACs. [87]

Economic value depends on the health effects associated with the emissions, that is, whether they are associated with illnesses or death. The monetary value of the morbidity reductions associated with emissions reductions include avoided lost wages, avoided medical costs, and the amount of money people are willing to pay to avoid an illness or condition like respiratory disease. The value of the reduced mortality associated with emissions reduction is measured by the value of a statistical life, which uses value-of-life studies to determine a monetary value of preventing premature mortality. COBRA reports both a low and high impact, representing the uncertainties in the estimates.

The total value of the health benefits associated with emissions reductions is between $3,665 and $8,245. Table 85 shows the cumulative health benefits in California associated with the emissions reductions realized by the electrification of PG&E EV Fleet program sites in EY2023.

Table 85. PG&E EV Fleet Program California Health Benefits for EY2023 Sites

Health Endpoint	Change in Incidence (Annual Cases)		Monetary Value (Annual, 2023 dollars)	
	Low	High	Low	High
Mortality	< 0.000	0.001	$3,589	$8,137
Avoided Medical Care				
Nonfatal Heart Attacks	< 0.000	< 0.000	$4	$35
Infant Mortality	< 0.000	< 0.000	$28	$28
Hospital Admits, All Respiratory	< 0.000	< 0.000	$2	$2
Hospital Admits, Cardiovascular	< 0.000	< 0.000	$3	$3
Acute Bronchitis	0.001	0.001	$0	$0
Upper Respiratory Symptoms	0.009	0.009	$0	$0
Lower Respiratory Symptoms	0.006	0.006	$0	$0
Emergency Room Visits, Asthma	< 0.000	< 0.000	$0	$0
Asthma Exacerbation	0.788	0.788	$1	$1
Lost Productivity				
Minor Restricted Activity Days	0.240	0.240	$26	$26
Work Loss Days	0.041	0.041	$10	$10
Total Health Effects	–	–	**$3,665**	**$8,245**

[87] DAC Census Tracts are defined as those included in in the SB 535 Disadvantaged Communities List (2022), this includes the DAC categories for CalEnviroScreen 4.0 Top 25%, CalEnviroScreen 4.0 High Pollution Burden Score and Low Population Count, and 2017 Disadvantaged Community (CalEnviroScreen 3.0 only).

At the site level, the medium-duty vehicle market sector had the highest health benefits overall (48%), followed by the school bus (31%) and heavy-duty vehicle (21%) market sectors.

As part of this analysis, the Evaluation Team also examined health benefits within DACs, which may be disproportionately burdened by sources of pollution (including air pollution from ICE vehicles). Because COBRA estimates effects only at the county level, the Evaluation Team disaggregated the health impacts by census tract using the relative population of each tract from the most recent American Community Survey. For example, we allocated 10% of the value of the health benefits to a census tract with 10% of the county's population. The Evaluation Team then estimated the total benefits allocated to DACs and non-DACs[88]. The approach assumes that the benefits of emissions reductions are distributed evenly throughout the county. If the sites are located in DACs, and the emissions reductions are greater in the tracts near the sites, this approach understates the potential benefit to DACs. Additional information about emissions dispersion within counties would provide more-precise estimates of the health benefits to DACs and non-DACs.

In our analysis, the largest portion of health benefits were in San Joaquin County, which had 24% of the total benefits, followed by Fresno County (21%), Los Angeles County (9%), Santa Clara County (6%), and Stanislaus County (6%). Overall, 31% of the total benefits were in DACs.

Highlights

- Cumulative health impact results for California counties realized by the electrification of EY2023 EV Fleet program sites in terms of monetary benefits range from $3,665 for the low estimate and $8,245 for the high estimate.
- Sites in the medium-duty vehicle market sector had the highest health benefits overall.
- The largest health benefits were in San Joaquin County, which had 24% of the total benefits, followed by Fresno County (21%), Los Angeles County (9%),[89] Santa Clara County (6%), and Stanislaus County (6%).
- The proportion of overall benefits attributed to DACs is 31%.

Net Impacts

As part of the net impacts analysis, the Evaluation Team estimated program effects on participants to exclude impacts from actions that participants would have taken without the program (freeridership) and to include any program-attributable indirect impacts on participants (participant spillover) and

[88] DAC census tracts are defined as those included in in the SB 535 Disadvantaged Communities List (2022), which includes DAC categories for CalEnviroScreen 4.0 Top 25%, CalEnviroScreen 4.0 High Pollution Burden Score and Low Population Count, and 2017 Disadvantaged Community (CalEnviroScreen 3.0 only).

[89] Although Los Angeles County is not in PG&E territory, the COBRA tool accounts for the dispersion of pollutants and the impact of pollutants on health outcomes, which means counties outside of sites impact counties outside of their Utility service territory.

nonparticipants (market effects). The Evaluation Team conducted three separate analyses to assess net impacts from the MDHD programs.

Enhanced Self-Report

The Evaluation Team based our approach for the MDHD program enhanced self-report NTG analysis on information obtained as part of in-depth surveys with participating fleet managers. The Evaluation Team conducted the survey via an online survey platform, Qualtrics, and delivered the survey using email contact information provided by PG&E. The Evaluation Team used the CPUC nonresidential customer self-report NTG framework as the base to develop the MDHD fleet manager NTG methodology approach.[90] *Appendix A* details the MDHD fleet manager self-report NTG methodology. The Evaluation Team estimated the core component of the CPUC NTG methodology through three separate program PAI site scores. The Evaluation Team used three separate sets of questions to assess the three components of the core NTG ratio, with each PAI score on a scale of 0.0 to 1.0 representing a different way of characterizing the PG&E EV Fleet program influence. The analysis included fleet manager responses from 4 of the 15 participating sites that were sent the survey.[91]

The Evaluation Team calculated the resulting self-report NTG for each site, prior to accounting for participant spillover, as the average of the PAI-1A, PAI-2, and PAI-3 score values. One minus the final core NTG ratio of 0.48 equals the 0.52 freeridership ratio for the EV Fleet program. The participant spillover analysis found that none of the surveyed sites reported electrifying more of their fleet since participating in the EV Fleet program, without the benefit of funding from the PG&E program or where their PG&E program participation was important in this additional purchasing decision. The resulting participant spillover ratio is 0.00. The final program level NTG ratio of 0.46 equals one minus the freeridership ratio plus the participant spillover ratio. Table 86 presents these scores along with the average final score NTG for the surveyed PG&E EV Fleet program sites.

Table 86. PG&E EV Fleet Program NTG Fleet Manager Analysis Results in EY2023

Fleet Manager Survey Completes (n)	Average of PAI-1A Score NTG	Average of PAI-2 Score NTG	Average of PAI-3 Score NTG	Average of Final Core NTG	Freeridership Ratio	Participant Spillover Ratio	Final NTG Ratio
4	0.58	0.43	0.45	0.48	0.52	0.00	0.48

Highlight

- EY2023 program-level freeridership ratio is 0.52 with a 0.00 participant spillover ratio, which resulted in a program level NTG ratio of 0.48.

90 California Public Utilities Commission, Energy Division. February 20, 2015. *Methodological Framework for Using the Self-Report Approach to Estimating Net-to-Gross Ratios for Nonresidential Customers.*

91 Two transit sites, one heavy-duty site, and one school bus site completed the survey.

5.1.3. Lessons Learned

The Evaluation Team identified a number of lessons learned. These lessons, presented below with key supporting findings and recommendations, may be applied to future program years and to other similar efforts. Note that these lessons and findings were derived from a limited number of program participants across most but not all market sectors. Additional insights will be gained as more sites are completed in the coming years.

Although site costs and delays continue to challenge implementation, staff are committed to continued program adaptation to reflect the current market conditions.

Similar to previous evaluation years, site costs continue to be a challenge for both TTM and BTM. PG&E staff face challenges even after contracts are signed including customer equipment and design changes and delays, which contribute to increased costs. To adjust to market forces, in 2022, PGE&E and SCE jointly filed AL 6546-E for program metrics and changes but received a protest from the CPUC. In response, PG&E filed AL 6524-E-A in April 2023 to address CPUC concerns. Although the CPUC granted the timeline extension in August 2023, it denied PG&E's proposal to eliminate the site requirements and to modify the vehicle purchase and conversion requirements. Therefore, PG&E filed AL 7121-E which proposes a reduction of the site goal minimum to between 370 and 420 sites.

While customer uncertainty around electrification has caused challenges, it has also provided PG&E with the opportunity to build trust, as customers value PG&E's third-party position. In 2023, PG&E received national and international interest in the EV Fleet program because of the Utility's creativity in meeting customer needs even for niche industries, such as electrification of water vehicles. In addition, to mitigate the number of customer withdrawals and secure interested customers, PG&E staff adjusted customer engagement to focus on finding customers that are near-term on electrification, started connecting with customers using other efforts focused on raising customer awareness such as the TEAS program, and began requiring customers to secure a vendor for construction before signing a contract for the program.

Site activation timelines have gotten longer in EY2023 relative to earlier evaluation years for a multitude of reasons.

The timeline for site application to activation was 663 days on average in EY2023 compared to 570 days in EY2022 and 410 days in EY2021. The Design and Permitting phase has been the longest in duration across all evaluation years. However, this phase increased to 446 days in EY2023, rising from 374 days in EY2022 and 252 days in EY2021. This represents a 19% increase over EY2022 and accounts for 67% of the total average activation timeline. Other program phases also increased significantly including Application Reviewal rising from 17 days to 45 days in EY2023 and Activation rising from 14 days to 39 days in EY2023. Conversely, both the Site Assessment and Contract Issuance phases were more efficient, dropping from 56 to 41 days and 60 to 43 days, respectively.

The extension of site activation timelines has been attributed to a number of factors, most prominently supply chain delays with switchgear presenting the greatest difficulty for procurement. PG&E has also noted the long lead time required for permit approvals and changes to customer site designs causing significant delays. As PG&E shifts to smaller sites in the next year of the EV Fleet program, it is expected that activation timelines may decrease from EY2023.

The EV Fleet program is progressing well towards its EV-supported goal but lags behind its number of sites goal.

In EY2023, 20 sites with 250 charging ports were activated supporting 352 vehicles, based on VAPs of activated sites. Six market sectors are now supported by the program, with school bus fleets representing the highest participation (48% of sites) and TRUs representing the lowest (2% of sites). The 62 total activated sites (630 charging ports) in the program to date meets 9% of the program's *per se reasonableness* goal of 700 sites and support 874 vehicles which meets 13% of the program's *per se reasonableness* goal of 6,500 additional vehicles electrified.

The EV Fleet program will make additional progress towards these goals as more sites reach activation. For example, the 239 contracts signed in the EV Fleet program to date support 4,942 MDHD vehicles, which would meet 34% of the program's site goal and 76% of the program's vehicle goal. The total 455 customer applications received in the program to date (including canceled and on hold applications) could satisfy approximately 65% of the program's site goal and surpass the vehicle goal. With the program currently on track to meet vehicle goals, PG&E staff started to focus on smaller sites that would overall cost the program less to reach current site goals.

Although cost remains a barrier, fleet managers are satisfied with their program experience and may be positively influenced to take further action.

Surveyed fleet managers were motivated to participate in the program primarily because of corporate/organizational sustainability goals or initiatives (three of four fleet managers), expected fuel cost savings, environmental benefits, and rebates/incentives (two of four fleet managers). Although the primary barriers to fleet electrification both before and after program participation were routes being too long for EVs (three before; two after), cost continued to be a concern with the cost of EV charging infrastructure (two before; two after), and the cost of EVs (two before; one after) coming in second as a barrier to adoption.[92] In addition, the two fleet managers who withdrew from the EV Fleet program cited insufficient incentives.[93] Despite these remaining cost concerns, four of four responding fleet managers rated themselves as very satisfied or somewhat satisfied with their experience participating in the EV Fleet program. In addition, three of four responding fleet managers said EVs are somewhat, or very reliable and four of four said charging equipment is somewhat or very reliable. Finally, three of four responding fleet managers do not plan to accelerate procurement; however, all four of these fleet managers plan to acquire more EVs/equipment in the next 5 and 10 years.

92 N=4

93 N=2

Overall program spending is ramping up slowly, however program spending on DAC sites exceeds targets.

PG&E spent $13.7 million of the EV Fleet program budget in EY2023, bringing total spending to $49.5 million out of $236.3 million of the approved program budget, or 21% of available funding. Forty-three percent of PG&E EV Fleet program spending on infrastructure for financially closed out sites to date has been on DAC sites, exceeding the 25% program target. Additionally, in the PTD sites, 44% of sites, 49% of charging ports, and 55% of vehicles are in DACs.

> **Recommendation:** The Evaluation Team found that the vehicle counts observed during site visits tend to be significantly lower than customers' VAPs (even when compared with the expected annual procurement). Taking a proactive approach to tracking progress towards the VAP (with an annual customer contact about vehicle procurement, for example), would allow Utilities to ensure that customers are following their VAP, which could contribute to improved program performance with respect to energy consumption, petroleum displacement, emissions reductions, and health impacts.

> **Recommendation:** Utilities are significantly lagging in their progress toward site goals and are spending their allocated budgets more slowly than expected. Ongoing lessons learned by Utility staff and from evaluation findings should be incorporated into programs to promote improvements. To ensure changes can be implemented in a timely manner, Utilities should continue to communicate recommendations for updates to program design and metrics to regulators and other stakeholders. For many changes, regulatory support will be needed to implement these recommendations. An example of a potential barrier is the cost threshold metric the Utilities use to determine whether to accept or reject a site into the programs. These metrics are in terms of dollars per charging port and dollars per vehicle—based on CPUC decisions—and vary by Utility. Ultimately, the thresholds reduce the number and diversity of participants which is an unnecessary constraint in the current early market stage of electric MDHD vehicles. Utilities need greater flexibility in program design to meet the overarching goals of the SRP related to advancing TE.

The EV Fleet program sites are helping to displace petroleum, reduce GHG and local emissions, and achieve health impacts overall and within DACs.

The EV Fleet program sites accounted for an PTD impact of more than 1.3 million gallons of petroleum with the heavy-duty vehicle sector accounting for nearly half of the petroleum displaced in EY2023. In addition, the Program resulted in a reduction of over 6,000 MT of GHGs PTD. These sites all positively contributed to lowering local emissions, with CO reduction being the most prominent, achieving a reduction of over 55,000 kg in EY2023. Overall, 31% of the health benefits are in DACs with the monetary health benefits in EY2023 from sites ranging from $3,665 to $8,245.

Though overall demand increased significantly, installed EV ports are underutilized, and the majority of fleet operators are not implementing load management.

Across EY2023 operational sites, 11,000 kW of new charging capacity was installed, bringing total capacity for the PTD sites to 23,000 kW. Overall demand increased from 2 MW in EY2022 to 4.9 MW in EY2023, or an increase of 150% from EY2022. However, peak demand never exceeded 4,947 kW in EY2023, or 21.5% of installed capacity in the program to date. Many fleet operators said they had not yet received some or all of their vehicles, to a lower overall demand across sites.

Only twelve of 60 operational sites (20%) in the program-to-date exhibited the use of load management, up from only eight through 2022. Larger sites are more likely to implement charge management due to the increased financial benefit of reducing peak demand in comparison to smaller sites. Therefore, because these load-managed sites are high consumers of energy, on an energy-use basis, the overall impact of load management at these sites is greater on peak demand. On a monthly basis, 59% of school bus charging and 57% of non-school bus charging took place during the peak rate time period between 4 p.m. and 9 p.m., resulting in negative impacts on operational costs and grid congestion. However, over 40% of school bus and non-school bus charging sessions have enough flexibility to avoid charging during that peak rate time-period.

Not all EVSPs offer load management capability, and utility bills may not be available to fleet operators so they can understand TOU cost impacts. During site visits most operators had a disconnect between what they expected the electricity to cost versus their actual costs. However, most fleet operators were aware of TOU pricing, regardless of knowing usage trends and costs.

> **Recommendation**: Utilities should continue to contact customers on an annual basis (at minimum) following site activation to ensure that sites are proactively identifying load management opportunities. The Evaluation Team recommends focusing on school bus sites—which typically do not manage load—and large sites such as those with greater than 1 MW installed capacity—which have the greatest opportunity to manage load. By identifying and documenting reasons why customers are not actively managing load, program staff and the Evaluation Team can build more-targeted recommendations for addressing load management barriers.

TTM and BTM infrastructure costs continue to vary widely between sites. Program participants continue needing Utility infrastructure support.

Across 52 financially closed out sites, Utility spending resulted in an average infrastructure cost of $273,450 per site, $23,881 per vehicle, and $1,576 per kilowatt when including TTM and BTM infrastructure but excluding EVSE cost. These values include both L2 and DCFC sites and aggregate multiple market sectors across EY2021 and EY2022. This is similar to EY2022 costs of $266,217 per site, $1,504 per kilowatt and $40,471 per vehicle. All-in costs paid by the customer and PG&E vary widely between sites, with an average of $551,757 per site. The cost for EVSE was the highest across the sites, followed by BTM and then TTM.

5.2. Schools and Parks Pilots

5.2.1. Overview

This overview provides a detailed description of the PG&E Schools and Parks Pilots as well as summaries of the Pilots' implementation process, performance metrics, program materials and budget summary, and a major milestone timeline. Following the overview are detailed findings, highlights, and lessons learned.

Pilot Description

Schools Pilot: Through its Schools Pilot, PG&E has offered the direct installation of and incentives for installing six L2 charging ports at K–12 schools within its service territory. The Pilot is designed to offer L2 charging infrastructure at schools and educational facilities in support of California's electrification goals. In the original Decision 19-11-017, PG&E projected to install these chargers across 22 sites.[94] While PG&E will build and maintain the EV service connection and supply infrastructure for all sites, the equipment can be owned by either PG&E or the site host. Where PG&E owns the equipment, the site works with a pre-approved EVSP to help manage equipment operations. Where the site host chooses to own the equipment, they receive a rebate of up to $11,500 (L2 single) or $15,500 (L2 dual) for the charger purchase. In all cases, the site host must enroll in a TOU rate. PG&E also provides educational materials to promote awareness of the newly installed EVSE and benefits of EVs, available to all schools in PG&E's service area.

Schools Pilot Targets

- Four or six L2 charging ports at each site
- 22 schools
- 40% in DAC locations

Schools Pilot Design Goal

Offer L2 charging infrastructure at schools and educational facilities.

Parks Pilot: Through its Parks Pilot, PG&E offers direct installation of L2 chargers and DCFC in state parks and beaches within its service territory. Staff designed the Pilot to install new chargers that enable state parks and beaches to charge the EVs in their own fleet in addition to staff and patron LDVs. In Decision 19-11-017, PG&E projected two standard site designs: one with four L2 charging ports at three locations and one with two L2 ports and two DCFC ports at two locations. Per the Decision, PG&E expected to offer off-grid charging at five sites that have sufficient capacity to support charging but upgrading the existing electric infrastructure would be cost-prohibitive given the distance from electric infrastructure. For all sites, PG&E is the owner of the chargers but will contract with the customer of record to maintain the equipment and manage the charger electricity costs. PG&E will also post educational signs around the chargers to

Parks Pilot Design Goal

Encourage state parks and beaches to charge their own EV fleets and to offer charging to staff and patrons with LDVs.

[94] In the EY2023 closeout interview, PG&E staff reported that although they would not achieve the 22-site goal, since they are installing more ports than expected and will still reach the port goal of 88 –132 ports, there was no formal regulatory filing to change the Schools Pilot goals.

raise awareness among park and beach patrons that they can charge EVs at state park and beach locations across the state.

Implementation

As interested customers became aware of either Pilot—through PG&E marketing efforts, solicitations from EVSPs, word of mouth, or directly from a PG&E account manager—they could choose to apply as the first step in the implementation process (instead of applying as the first step of Parks program participation, PG&E coordinated directly with the DPR to initiate program participation). Figure 145 provides detail on the process of taking a site from application to construction. Note that the Contract Issuance step is slightly different for the Parks Pilot, since the DPR expects to approve an MPA that will apply to all state parks in PG&E service territory participating in the Parks Pilot. Each individual site will have site addendums to the master agreement based on specific site needs and designs.

Figure 145. PG&E Schools and Parks Pilot Implementation Process

APPLICATION RECEIVED

1. PG&E reviews site for initial program viability
2. PG&E sends informational program materials

IN-DEPTH VALIDITY REVIEW

1. PG&E Project Delivery team conducts desktop review
2. PG&E program team decides whether to move site forward in process
3. If favorable site validity review outcome, PG&E requests initial meeting with customer

PRELIMINARY SITE DESIGN

1. PG&E coordinates with engineering contractor to schedule site walk with customer
2. Engineering contractor drafts preliminary design
3. PG&E conducts internal stakeholder meeting to determine if site should move forward in program

CONTRACT ISSUANCE

1. If favorable internal stakeholder meeting, PG&E issues contract and preliminary site design to customer
2. Parties sign contract and site moved to PG&E's Project Delivery team

SITE DESIGN

1. PG&E's Project Delivery team oversees design contractor throughout final design process

PRE-CONSTRUCTION

1. Design contractor works with PG&E's Project Delivery team and customer to apply for TTM and BTM permits
2. PG&E and customer execute easement
3. PG&E orders long-lead material

CONSTRUCTION

1. PG&E and construction contractor host pre-construction meeting
2. Contractor breaks ground on site

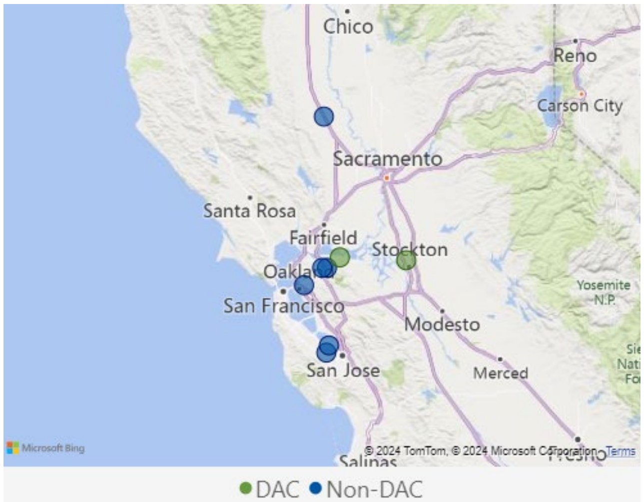
Program Performance Metrics

The Evaluation Team reviewed sites participating in PG&E's Schools Pilot and analyzed them by Pilot status. Table 87 provides the count of PG&E Schools Pilot sites by completion status in EY2023 and for the Pilot to date. PG&E did not have any Parks Pilot sites activated or constructed in 2023.

Table 87. PG&E Schools Pilot Complete Site Count by Status

Site Status	EY2023	Pilot to Date
Utility Construction Complete	10	11
Activated	10	11
Operational	10	11
Closed Out	7	7

Figure 146. PG&E Schools Pilot EY2023 Activated Charging Stations



In EY2023 all 10 sites activated in the PG&E's Schools Pilot were operational. Four of the 10 activated sites in EY2023 (40%) are located inside a DAC, as shown in Figure 146. Note that multiple sites in a single location appear as a single point on the map. The Pilot has 13 contracts signed to date, none of which were signed in EY2023.

Table 88 presents site-level data for PG&E's Schools Pilot, showing DAC status and the number of ports for the activated sites in EY2023 and in the Pilot to date. In EY2023, 40% of activated sites were in a DAC, lowering the cumulative percentage of DAC sites to 45% which still exceeds the Pilot's *per se reasonableness* goal of 40% DAC. The Pilot deployed 60 additional L2 charging ports in EY2023, raising the total number of L2 ports installed to date to 66.

Table 88. PG&E Schools Pilot Activated Site Data in EY2023 and Pilot to Date

EY2023			Pilot to Date		
Number of Activated Sites inside DAC	Number of Activated Sites outside DAC	Number of L2 Charging Ports	Number of Activated Sites inside DAC	Number of Activated Sites outside DAC	Number of L2 Charging Ports
4	6	60	5	6	66

As shown in Table 89, the 11 activated sites to date in the PG&E Schools Pilot meet 50% of the Pilot's *per se reasonableness* goal of 22 sites and support 66 L2 ports, meeting 75% of the Pilot's *per se reasonableness* minimum goal of 88 L2 ports and 50% of the Pilot's maximum port goal of 132 L2 ports.[95] The 13 customer contracts signed to date could satisfy 59% of the Pilot's site goal and would support 78 L2 ports, which could meet 89% of the Pilot's minimum port goal and 59% of the maximum port goal.

Table 89. PG&E Schools Pilot Site and Port *Per se Reasonableness* Goal Progress

Pilot Metric	*Per se Reasonableness* Goal	Pilot to Date
Activated Sites	22	11
L2 Ports	8–132	66

95 Whereas SCE and SDG&E proposed overall port deployment goals for their Schools Pilots, the port goal for PG&E's Schools Pilot is based on its decision to allow participating schools the option of installing either four or six L2 charging ports, which will result in between 88 and 132 ports installed in total.

The CPUC established six phases in the program timeline per the SB 350 reporting template. Table 90 shows the median durations by program phase for EY2023 and PTD activated sites. The median number of calendar days per phase for EY2023 sites in PG&E's Schools Pilot ranged from 14 days for Application Review to 463 days for Design and Permitting. Overall, median durations across phases in EY2023 were similar to those for the Pilot to date.

Table 90. PG&E Schools Pilot, Median Calendar Days per Phase

CPUC Program Phase	Median Calendar Days	
	EY2023	Pilot to Date
Application Review	14	17
Site Assessment	16	18
Contract Issuance	32	32
Design and Permitting	463	456
Construction Complete	42	39
Activation	46	45

Program Materials Summary

Schools and Parks Pilots: PG&E staff maintains information about the Pilots on the PG&E website,[96] which includes several types of relevant information about the two Pilots for prospective site hosts:

- Pilot program summary
- Ownership options and rebates
- Vendor information
- Rebate information
- Criteria for participation
- Partnerships
- Contact information

[96] Information is included in the "Electric Vehicle Programs and Resources" section of PG&E's website: https://www.pge.com/en_US/small-medium-business/energy-alternatives/clean-vehicles/ev-charge-network/electric-vehicle-charging/electric-vehicle-programs-and-resources.page

The webpage also includes frequently asked questions from prospective EV users. According to key web activities related to the Schools and Parks Pilots that PG&E staff tracked in 2023, there were 1,167 site visits and 1,021 unique visitors to the website.

Schools Pilot: As a result of a healthy pipeline of applications, EVSP promotion, and word-of-mouth program promotion, PG&E staff conducted only minor outreach for the Schools Pilot in 2023 and continued to promote the curriculum that was developed and rolled out in 2022:

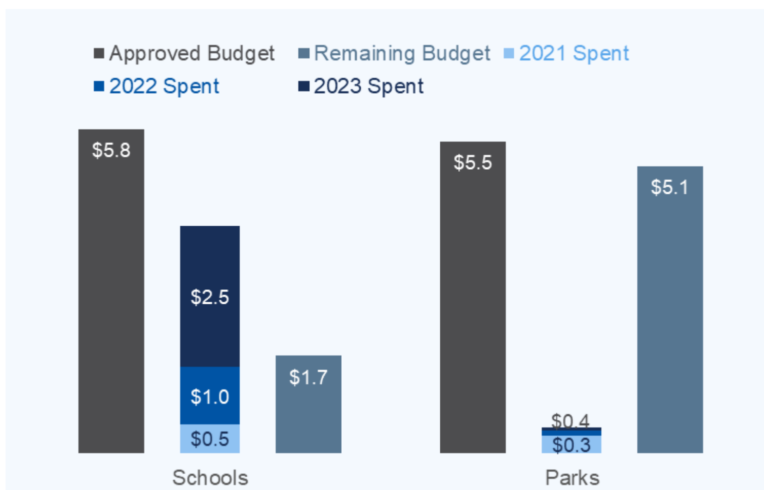
- **Targeted Outreach.** Schools Pilot staff engaged PG&E account staff managers who work with school districts on other, non-TE projects to help identify schools that could be good potential candidates for light-duty EV charging.
- **Curriculum Promotion.** PG&E continued to partner with Strategic Energy Innovations (SEI) to roll out the Schools Pilot curriculum.[97] SEI led these initiatives, which included giving presentations to potential districts to help them understand the curriculum and promote it further.

Parks Pilot: PG&E staff did not develop any specific marketing materials for the Parks Pilot during 2023 as they focused their efforts on working directly with California State Parks.

Budget Summary

As shown in Figure 147, from program inception through 2023, PG&E spent $4.0 million out of the $5.76 million approved for the Schools Pilot and about $450,000 out of the $5.54 million approved for the Parks Pilot. Schools Pilot spending continues to outpace Parks Pilot spending, as a number of Schools Pilot are activated and several sites are under construction, while PG&E staff are still negotiating terms of the MPA with DPR staff.

Figure 147. PG&E Schools and Parks Pilot Budget (Millions USD) as of Dec. 31, 2023



Timeline

PG&E submitted two Advice Letters in 2023. PG&E filed AL 6969-E in June 2023 to provide a one-year post-implementation update on the site assessments and Pilot programming for the Schools and Parks Program. AL 6969-E was accepted in July 2023. In December 2023, PG&E filed AL 7110-E to provide a description of the efforts to comply with the Safety Requirements Checklist for the Schools Program. AL 7110-E was accepted in December 2023. Figure 148 presents key milestones for the PG&E Schools and Parks Pilots.

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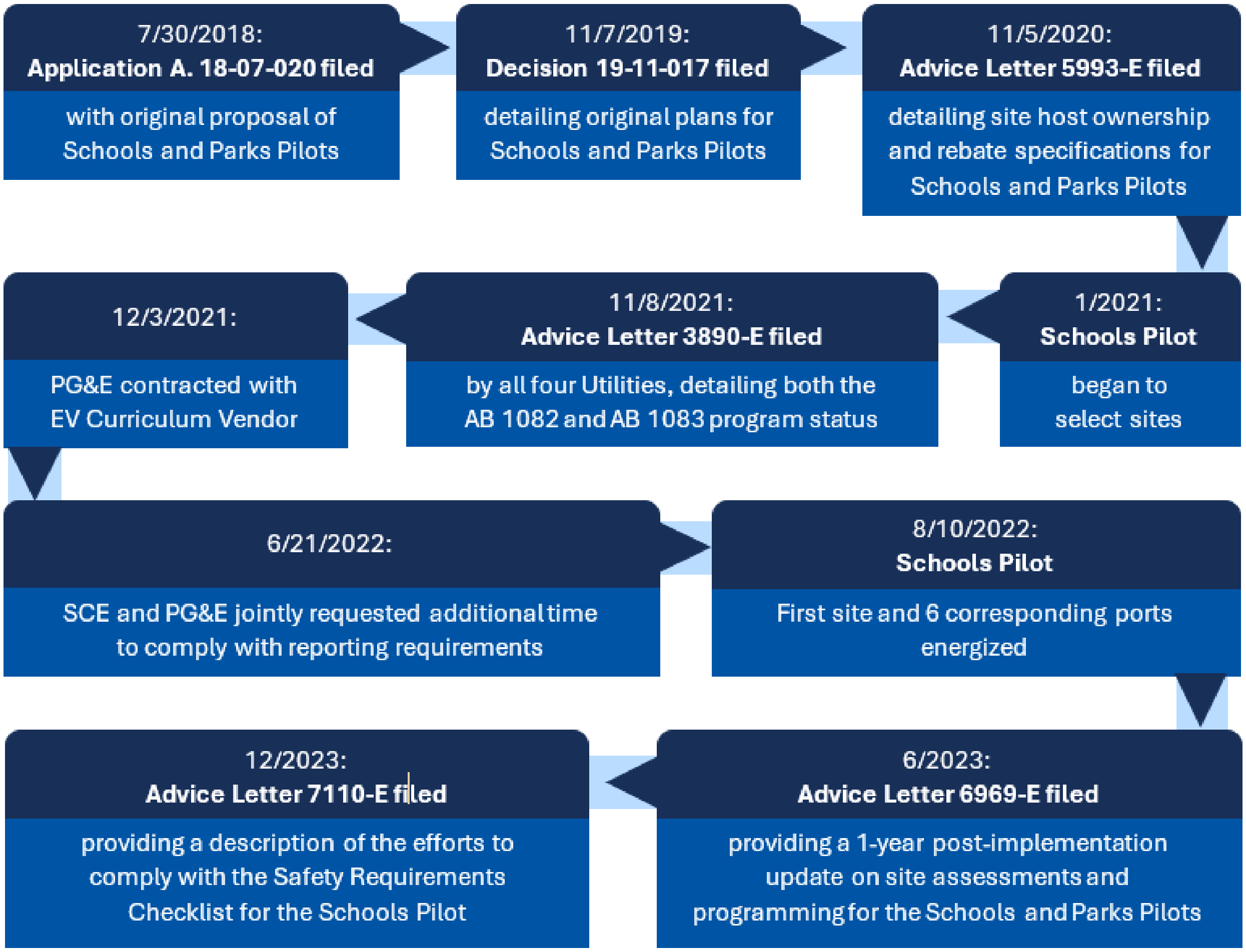
97 The PG&E curriculum was originally launched in PY2022. A more detailed write-up of the contents of the curriculum can be found in the publicly available PY2022 report: https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/sb-350-te/publicjoint-iou-annual-srp-and-ab108283-evaluation-report-for-py-2022.pdf

Figure 148. PG&E Schools and Parks Pilots Key Milestones



5.2.2. Findings

This section provides findings from analyses of the incremental EV adoptions, site visits, grid impacts, petroleum displacement, GHG and criteria pollutant reductions, and health impacts, as well as insights from Utility staff interviews. Only insights from Utility staff cover both the Schools and Parks Pilots, as only the Schools Pilot has sites in 2023.

Table 91 summarizes key impact parameters for the Schools Pilot in EY2023 and for the Pilot to date. Annual estimates of impacts are provided for metrics calculated as part of the impact evaluation. Additionally, the table provides estimates of impacts across all sites included in the program population through the end of 2023.

Table 91. PG&E Schools Pilot Impacts Summary

Impact Parameter	EY2023 Sites[a]	EY2023 Sites Percentage in DAC	Pilot-to-Date Sites Actual	Pilot-to-Date Sites Actual Percentage in DAC
Population of Activated Sites	10	40%	11	45%
Sites included in analysis (#)	10	40%	11	45%

Impact Parameter	EY2023 Sites[a]	EY2023 Sites Percentage in DAC	Pilot-to-Date Sites Actual	Pilot-to-Date Sites Actual Percentage in DAC
Charging Ports Installed (#)	60	40%	66	45%
Electric Energy Consumption (MWh)		23%		32%
Petroleum Displacement (GGE)	14,126	23%	6,721	33%
GHG Emission Reduction (MT GHG) [b]	110	24%	50	33%
PM_{10} Reduction (kg)	0.60	23%	0.28	33%
$PM_{2.5}$ Reduction (kg)	0.55	23%	0.26	33%
ROG Reduction (kg)	8.5	23%	4.10	33%
CO Reduction (kg)	302	23%	143	33%

[a] Energy consumption, petroleum displacement, and emissions reductions are based on annualized data. Pilot to date results in the table are based on actual data (see *Appendix A* for more details).

[b] GHGs include CO_2, CH_4, and N_2O multiplied by their respective GWPs as defined by IPCC AR5 (see *Appendix A* for more details).

Incremental EVs Adoption

The Evaluation Team estimated the effect of the public charging stations on household EV adoption for neighboring populations[98] with a two-stage analysis: the Team first performed an historical analysis of public EV charging impacts on vehicle ownership and then performed an analysis of EV ownership attributable to SCE Schools Pilot investments. See *Appendix A* for the details of the Stage 1 analysis.

Using the impact estimates from the Stage 1 analysis,[99] the Evaluation Team estimated the impact of PG&E investments in public charging on EV ownership. By the end of EY2023, 11 charging sites in PG&E's Schools Pilot were activated. We estimated the impact of these stations based on annual EV registrations as well as PTD cumulative EV registrations driven by the program.

Based on the composite measure of public charging access, the Evaluation Team calculated the change in access to public charging due to PG&E's Schools Pilot investment for each CBG where the investments affected access. Table 92 shows that the pilot-to-date average change in access across all affected CBG

98 There are two main avenues through which the availability of public charging networks may affect EV purchases. The first is a network effect, through which EV owners gain increased access to the public charging stations because of the stations' placement at destinations such as workplaces, commercial establishments, schools, and parks. The Evaluation Team expects the availability of EV charging equipment at convenient locations (for midday charging away from home) to increase the convenience of owning an EV (such as lessening range anxiety) and to increase the probability of EV ownership. The second avenue is a neighborhood effect on the driving population living in areas neighboring the public EV charging stations. The availability of nearby charging infrastructure is expected to lower the cost of EV ownership by providing alternatives to home charging. The Evaluation Team expects that public EV charging will have the biggest impact on residents of multifamily buildings, many of whom will have limited access to EV charging equipment, or on low-income households, who may be unable to afford home EV charging equipment. Public charging access may boost EV ownership through both channels and there may be positive interactive effects between the channels that boost the overall impact of public charging networks. The Evaluation Team focused on analyzing the second channel. We will analyze impacts for the first channel separately when data become available.

99 The State 1 analysis used vehicle registration data from 2015 to 2020, the most recent period with complete information at the CBG level. The EY2023 estimates assume the impact of Utility-specific stations remains unchanged over time, which may not reflect actual market and technological changes.

was 4.4, and the average change in the number of chargers (ports) was 6.3 per affected CBG. For reference, the average change in access across all CBGs in California was 0.57 between 2015 and 2020. The average normalized EV annual registration per 1,000 households was 55.3 in the affected CBGs in 2020.

Table 92. PG&E Schools Pilot Summary Statistics of Effects on CBGs

	CBG Mean (Standard Deviation)			
	Change in Composite Measure of Access[a]	Change in Number of Chargers[a]	Normalized Annual EV Registrations[b]	Number of Households[c]
PG&E Schools Pilot	4.36	3.72	55.35	439.90
	(3.71)	(2.96)	(53.91)	(217.50)
CBGs (N)	29	29	29	29

These values are averages for the CBGs whose access to public charging was affected by PG&E's investments.

[a] Change in composite measure of access and number of chargers is from 2020 to 2023.

[b] Normalized annual EV registrations are average annual values in the affected CBGs in 2020 per 1,000 households.

[c] Number of households is based on 2015–2019 American Community Survey (ACS).

Sample standard deviations are in parentheses.

The Evaluation Team calculated the impact of the Schools Pilot Utility charging investments on neighboring EV ownership. This involved combining the OLS and IV-2SLS regression estimates of the impact of public charging access on EV registrations from Stage 1 with the estimates of the CBG changes in public charging access and household counts.[100] The impacts of the PG&E investments on EV registrations will depend on the extent to which the investments increased access in the affected CBGs and the number of neighboring households in the CBGs.

Table 93 shows estimates of the annual and PTD EV registrations attributable to the PG&E Schools Pilot charging investments. Based on the OLS long differences model,[101] PG&E School Pilot investments in charging facilities increased EY2023 annual EV registrations by two vehicles. Because the Schools Pilot charging facilities were not fully operational in the past evaluation years, the PTD impacts were the same as the EY2023 annual impact. Based on the IV-2SLS long differences model[102], the School Pilot investments increased annual EV registrations by 9.3 vehicles. The Evaluation Team prefers the IV-2SLS-based estimates because they account for the potential endogenous siting decisions of public charging

100 In Stage 1, the Evaluation Team estimated the impact of public EV charging access on EV ownership. Stage 2 built on the Stage 1 analysis and was an attribution analysis for Utility-specific investments. A notable benefit of this approach is that it can be applied to evaluations of other programs increasing EV charging access as well, which ensures methodological consistency.

101 The long differences model estimates indicate the impact of public charging on EV registration over five years. The team annualized these estimates by dividing the results by five.

102 The IV-2SLS long difference model can be used to address situations in which the main explanatory variable is influenced by unobserved factors, which can cause bias. This model involves two stages: first an instrumental variable (a variable related to the explanatory variable but not directly to the outcome) is used to predict the explanatory variable, and then these predicted values are used to estimate the final relationship, which helps improve accuracy.

(i.e., siting public charging infrastructure in locations likely to have above- or below-average rates of EV adoption). These estimates reflect the 11 activated Schools Pilot facilities operating for a whole year.

Table 93. PG&E Schools Pilot EV Registrations Attribution

EY2023 Annual Increase of EV Registrations Driven by the Utility Program		PTD Cumulative Increase of EV Registrations Driven by the Utility Program	
OLS	IV-2SLS	OLS	IV-2SLS
2.00	9.32	2.00	9.32
(0.26)	(1.28)	(0.26)	(1.28)

Note: The table shows the EV registrations attributable to the utility investments in public charging infrastructure. The left panel shows the impacts of utility investments since 2020 on registrations in EY2023. The right panel shows the cumulative impacts of Utility investments since 2020 on EV registrations in EY2021, EY2022, and EY2023. The Evaluation Team based these estimates on the OLS and IV-2SLS long differences models. The Team estimated the OLS long differences model using data for all CBGs in the analysis sample. We estimated the IV-2SLS long differences model for CBGs in the 20 largest California cities. The long differences are five-year estimates, which the Evaluation Team annualized by dividing the results by five. For each affected CBG, the Team calculated the increase in annual registrations as the product of the regression-based access coefficient divided by five, multiplied by the change in composite public charging access from utility investments (between baseline 2020 and EY2023), multiplied by the number of CBG households (in thousands). Robust standard errors clustered at the block group level are in parentheses.

The PG&E Schools Pilot investments in public charging had relatively small impacts on EV ownership in EY2023. Across all 29 affected CBGs, the total annual number of EV registrations is about 1,605 (29 * 55.35), so the preferred IV-2SLS regression estimates the PTD cumulative impact (same as annual impact in EY2023) of the PG&E Schools Pilot to be an increase in EV registrations of about 0.6% (9.32 / 1,605). An average of 55 EV registrations per CBG puts these CBGs in the 60th percentile of the EV registration distribution of CBGs, implying a relatively high level of baseline EV registration.

Highlights

- In EY2023, the Schools Pilot contributed to increased EV adoption by 9 EVs for households neighboring the infrastructure.
- The impact of the PG&E Schools Pilot on EV adoption was small, largely due to the limited number of active charging stations and the small number of affected CBGs.

Site Visits

The Evaluation Team visited all ten Schools Pilot sites activated in 2023 and the first and only site activated in a previous year. During these site visits, the Team documented the number of ports installed in EY2023 (60 L2), and installed charging capacity (396 kW) along with the total ports (66 L2) and total installed charging capacity (436 kW). Figure 149 and Table 94 show ports and capacity at site the Team visited in 2023 and prior years.

Figure 149. PG&E Schools Pilot L2 Ports and Capacity Observed in 2023 and Prior Years

Table 94. PG&E Schools Pilot Summary of Ports and Capacity Observed during Site Visits

Site Visit	Ports	Installed Capacity	Number of Sites
2023 Site Visits	60	396	10
Prior Years	6	40	1

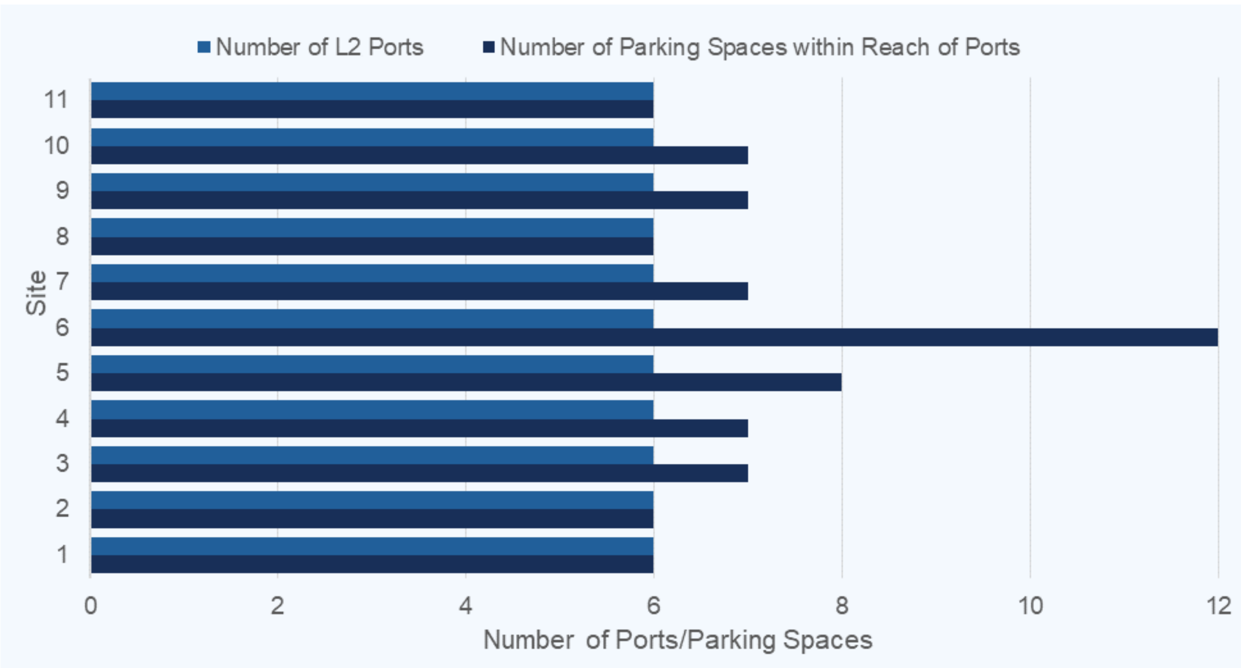
The Team assessed how these new sites fit within the workplace (and to some extent within the public-charging) ecosystem. This is partially a function of the number of parking spaces within reach of a charging cord regardless of whether they are designated as EV charging spaces. Typically, head-to-head parking offers high access if charging stations are not adjacent to one another. Figure 150 shows an example of site layout for potentially a high-access charging facility. This site has two spaces located within reach of each port pending the charging inlet location on a vehicle. Although a fence currently separates the head-to-head parking spaces, this configuration has the potential to allow many more spaces to reach charging ports than the other sites we visited. As demand at this site grows, charging cords can theoretically be moved from one parked vehicle to another. At other sites with less access, the site host and the EV drivers who use the charging ports will bear more responsibility for ensuring turnover so multiple vehicles can access the charging stations. This

Figure 150. PG&E Schools Pilot Example of High-Access Charging Layout

becomes more pertinent if any of the charging stations have technical issues that may artificially increase demand in addition to more people at those locations adopting EVs.

To highlight the value of having multiple parking spaces within reach of cords, Figure 151 shows the number of ports and the number of spaces that can access these ports for the sites the Evaluation Team visited. As illustrated by the figure, most sites offer closer to a one-to-one ratio of parking spaces-to-charging ports, with one exception where each charging port can reach two parking spaces. PG&E's program was driven by installing EVSEs with dual ports in order to minimize infrastructure costs, but improved siting practices (i.e. placing stations in medians at head-to-head spaces, longer cords, etc.) may further increase the number of spaces served by each port.

Figure 151. PG&E Schools Pilot Charging Port Availability by Site



The Evaluation Team reviewed the pricing structure available to EV drivers relative to turnover and VGI (where possible). We were not able to confirm pricing for most of these sites on site or through public means such as Plugshare.com or websites specific to NSPs. However, three sites show use of TOU pricing and one site appears to be providing free charging. One school had signage restricting public charging during the regular school hours but allowing it before and after.

Highlights

- Of the 11 sites visited, seven sites had more than one-to-one parking spots to ports ratio, with one site having a two-to-one ratio.
- L2 port count totaled 66, providing more than 400 kW of installed charging capacity.
- Three sites are passing along TOU pricing to drivers and one site appears to provide free charging.

Site Costs

The EY2023 report does not include a site cost analysis for these programs because of insufficient data (there are fewer than 15 sites with finalized cost data and therefore the 15-15 Rule metric was not met).

Grid Impacts

The Evaluation Team determined grid impacts for the PG&E Schools Pilot based on the analysis of energy consumed by operational charging stations installed by the program through the end of 2023, combined with charging session data from the NSPs.

Data Sources

The primary data source for the analyses detailed in this section is the energy usage–related data provided in regular 15-minute intervals from the AMI. Other data sources include charging session-specific data provided by NSPs. There are several important differences between AMI and NSP data. While AMI data includes only energy usage, NSP data also includes session start and stop time, the duration of a vehicle's connection to a charging port, the duration of a vehicle actively pulling power, and the specific port used for a session. AMI meters track standing loads (such as those the EVSE uses for communications, cooling, active power converters, solenoids, and screens), which NSP data typically cannot do. When AMI data is missing from the dataset, the Evaluation Team uses NSP data to fill in the gaps.

Summary of Grid Impacts

Table 95 presents the estimated PG&E Schools Pilot grid impacts summary.

Table 95. PG&E Schools Pilot Grid Impacts

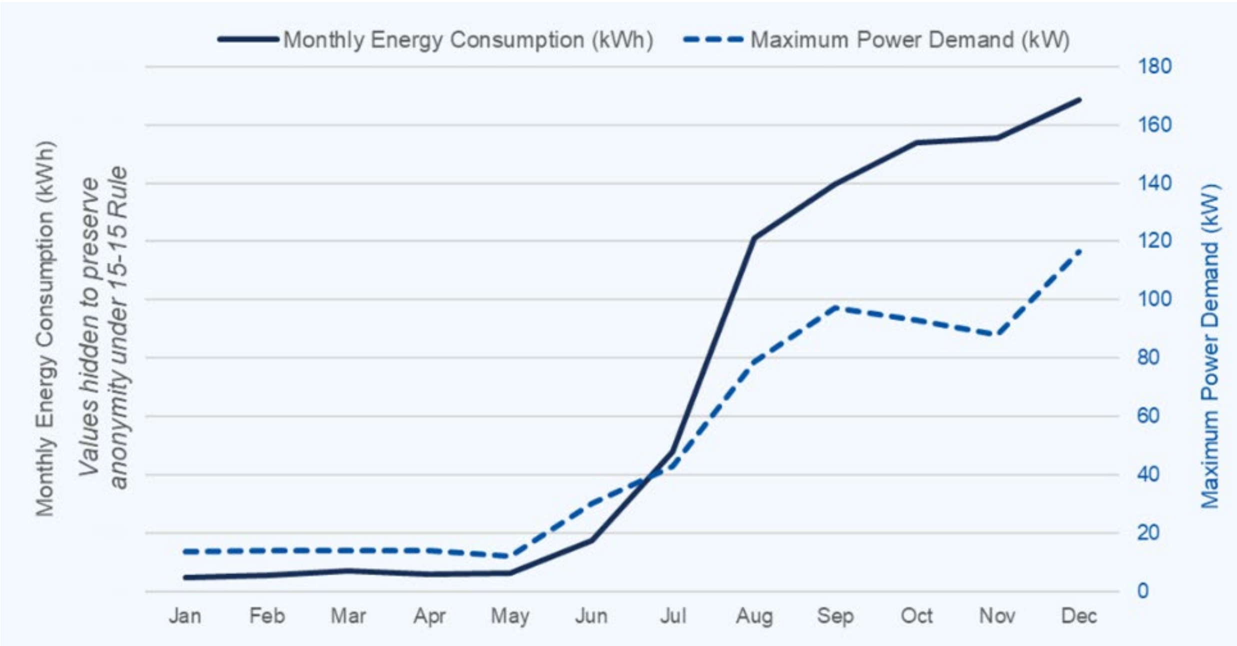
Impact Parameter	2023 Actual	PTD Actual	10-Year Projection
Operational Sites	11	11	11
Installed Charging Capacity, kW	396	436	436
Electric Energy Consumption, MWh	[redacted]	[redacted]	1,834
On-Peak (4 p.m. to 9 p.m.) MWh (percentage of total)	[redacted] (20%)	[redacted] (20%)	N/A
Maximum Demand, kW (date and time)	116 (12/15/23: 9:15 a.m.)	116 (12/15/23: 9:15 a.m.)	N/A
Maximum On-Peak Demand, kW (date and time)	69.9 (9/28/23: 7 p.m.)	69.9 (9/28/23: 7 p.m.)	N/A

The remainder of this section offers detailed findings on actual consumption, demand, and charging session–oriented trends of the combined sites for calendar year 2023.

Energy Trends

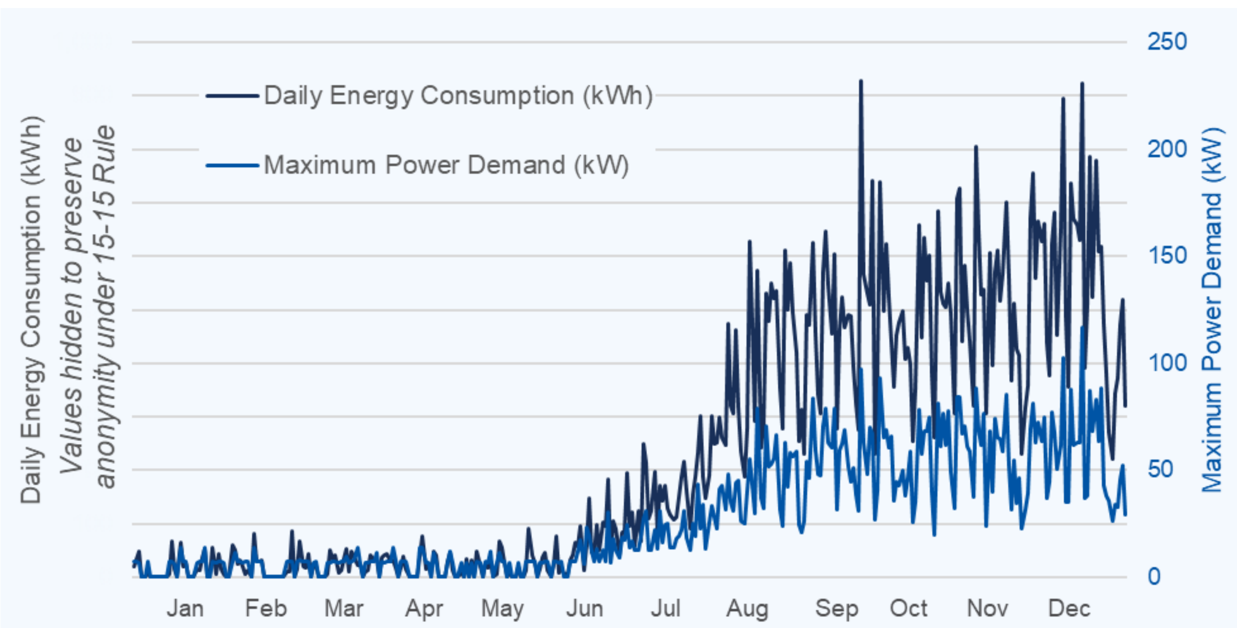
Sites in the PG&E Schools Pilot reached a total consumption of over 80 MWh in 2023. Ten sites were activated in 2023, yielding 11 total activated sites through the end of December 2023. Demand peaked at 9:15 a.m. on December 15, 2023, at a total of 116 kW across all sites, nearly a third of the installed capacity of 396 kW. Consumption trended up steeply in the summer then tapered to a slower rate through the end of the year, with similar trends for demand. Figure 152 plots daily energy consumption and maximum demand values for the Pilot.

Figure 152. PG&E Schools Pilot Monthly Energy Consumption and Maximum Demand in 2023



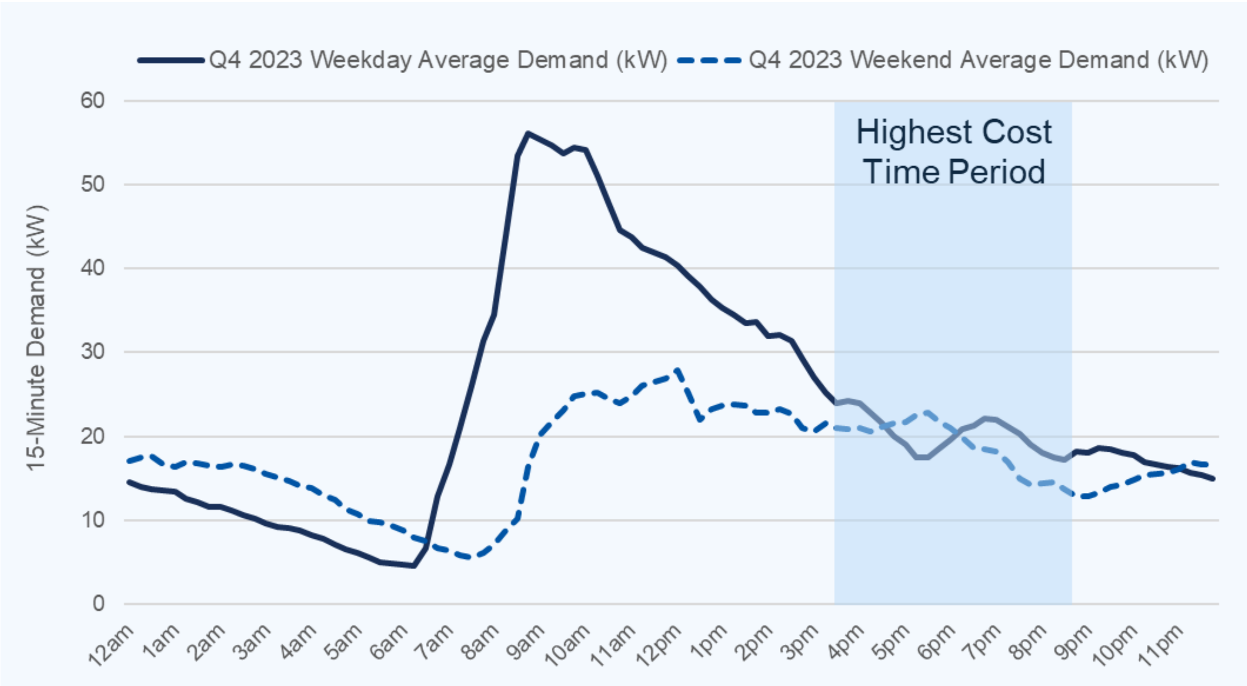
Energy consumption on few high-consumption days surpassed 900 kWh (Figure 153). Lows typically occurred on the weekend, though consumption dropped to less than 300 kWh on multiple weekdays.

Figure 153. PG&E Schools Pilot Daily 2023 Consumption and Maximum Demand – All Sites



The average weekday load shape of sites in the Schools Pilot is representative of typical workplace charging. This pattern consists of a load that ramps up between 6 a.m. and 9 a.m. as drivers arrive, peaks between 9 a.m. to 11 a.m. as all connected vehicles are charging and tapers off over the rest of the day as individual vehicles complete their charge. On average, weekends are much flatter and show slightly higher average charging demand than weekdays late at night and in the early morning, which may represent charging during events outside of regular school hours. Figure 154 shows the average demand on weekdays and weekends in Q4 2023 for the Schools Pilot.

Figure 154. PG&E Schools Pilot Average Weekday and Weekend Q4 2023 Load Curves

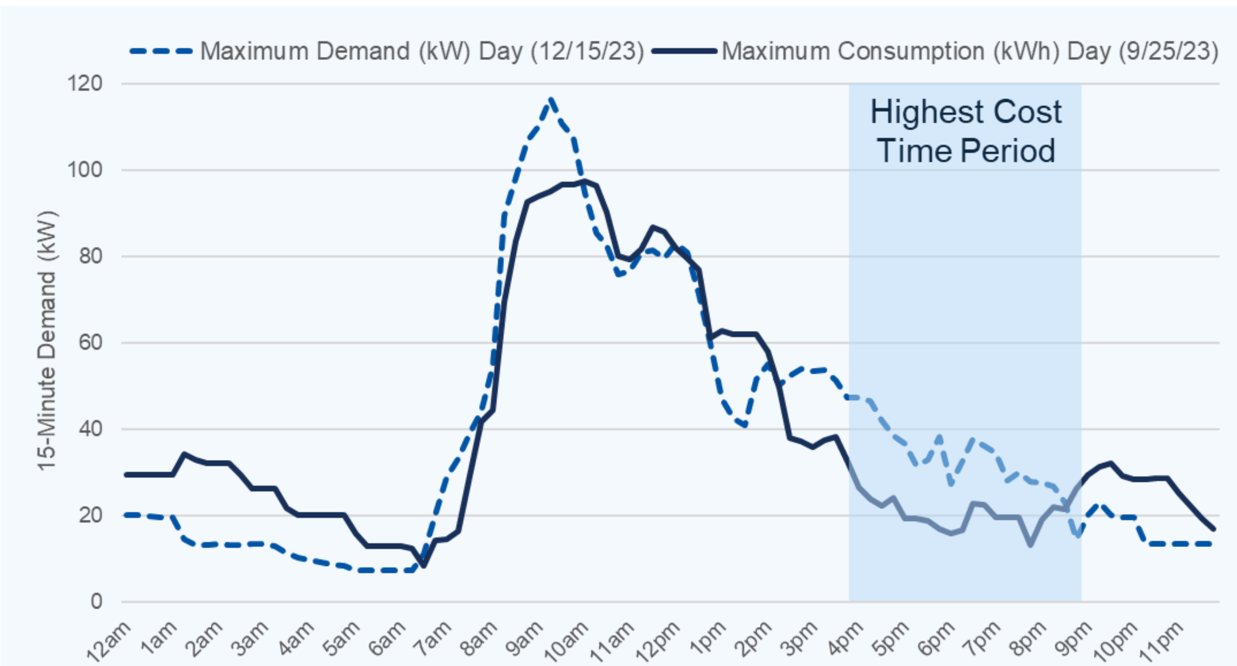


The highest days of demand (12/15/23) and consumption (9/25/23) are weekdays (Figure 155). The supporting data for individual sites show charging activity outside of traditional 8 a.m. to 5 p.m. work hours and on weekends, which may indicate that EV drivers who may not work on site are charging their EVs while using on-site sports fields or other amenities. There is also evidence of sporadic usage at a few sites from late evening into early morning, which may represent nearby residents using the charging infrastructure instead of at-home charging. Given the typical workplace trends, sites in the Schools Pilot leave many hours each day, each weekend, and throughout the year with little demand or opportunity to improve utilization. One feature of note (not shown in Figure 155) is that the average weekday and weekend day have nearly the same average demand from roughly 10 p.m. to 7 a.m. outside normal working hours potentially indicating consistent usage of nearby residents for sites open to public charging during those times.

The effect of pricing on grid impacts for these sites—such as how and to what extent EV drivers use energy—remains inconclusive. Surveying these drivers may reveal whether the price they pay for energy influences their patterns. For instance, we might anticipate an EV driver using less energy between

4 p.m. and 9 p.m. if they receive TOU signals indicating higher energy cost during this period. During site visits, the Evaluation Team can typically determine what pricing EV drivers receive. However, many of these sites did not provide a reliable pricing plan in EY2023, often due to sites deliberating extensively over energy pricing or stations being in extended free-vend mode or even offline while awaiting commissioning from NSPs. Workplaces tend to see correlation of more charging activity when TOU rates are lowest throughout the day (late morning into early afternoon), which also typically aligns with a higher proportion of renewable energy on the grid, even if pricing available to EV drivers does not represent this.

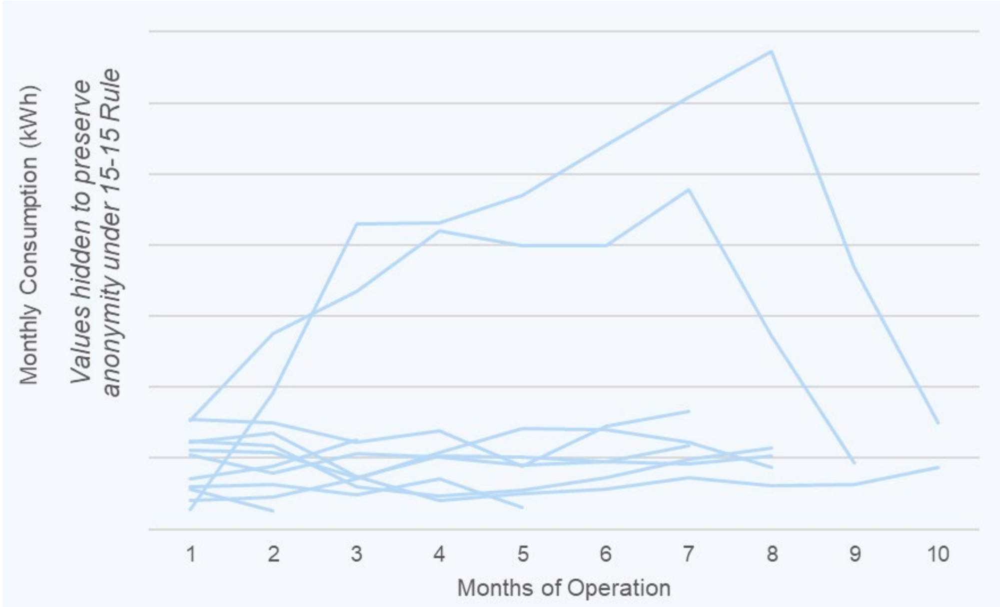
Figure 155. PG&E Schools Pilot Load Curves on Day of Maximum Demand and Consumption



Usage Trends

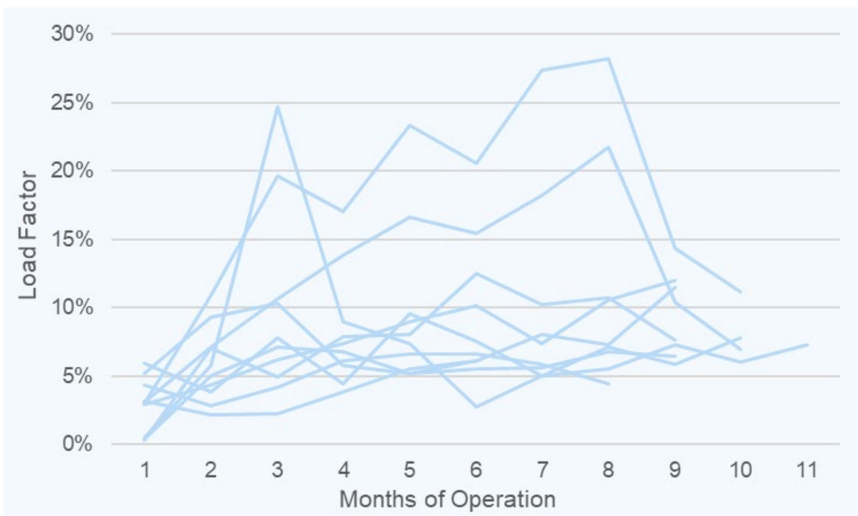
The AB 1082 Schools Pilot initiative and other public-facing projects across the state may provide additional insight into how long similar sites take to reach operational maturity. Factors that affect sites' timelines may include how EV drivers gain access to chargers, and how workplace charging may influence drivers to trade their conventional vehicle for an EV. Figure 156 displays monthly energy consumption trends for each site based on number of months from activation. All sites have the same number of charging ports and capacity, allowing for a direct comparison on a site-by-site basis. Most sites see fairly uniform growth of monthly consumption during their first year of operation. However, two standout sites have seen much greater consumption, partly because the location of these sites has some of the highest EV registration rates in the state.

Figure 156. PG&E Schools Pilot Monthly Energy



Similarly, Figure 157 shows the monthly load factor of each site based on number of months from activation. Load factor compares a site's actual monthly energy consumption to what its consumption might be if the maximum-demand was maintained throughout the entire month. To an extent this looks at consistency of operations. A constant demand (if max-demand interval was the average), for example, would result in 100% load factor (which is highly unlikely in practice). Figure 157 shows that the load factor for most of these sites currently hovers between 5% and 10%. This load factor suggests that maximum demand is very inconsistent at most sites and may reflect low current levels of site use. Such data may help sites and Utility pilot staff better understand the level of demand at a workplace charging site and how long it will take a site to reach full operation and utility.

Figure 157. PG&E Schools Pilot Monthly Load Factor Across Pilot Sites



The two sites showing the highest load factors are unique in that their weekend and weekday consumptions are similar. This may suggest a combination of staff having their own EVs that regularly use the stations and reliable public access at these sites.

Figure 158 presents the total number of daily charging sessions in the Schools Pilot. The highest day of demand also correlated with the day with most sessions (45). Figure 158 shows a significant increase in charging sessions mid-summer, possibly related to PG&E completing sites in time for school district staff to return for the start of the school year. While not highlighted in the figure, Mondays and Fridays generally exhibit larger consumption than other days.

Figure 158. PG&E Schools Pilot Daily Charging Sessions in 2023

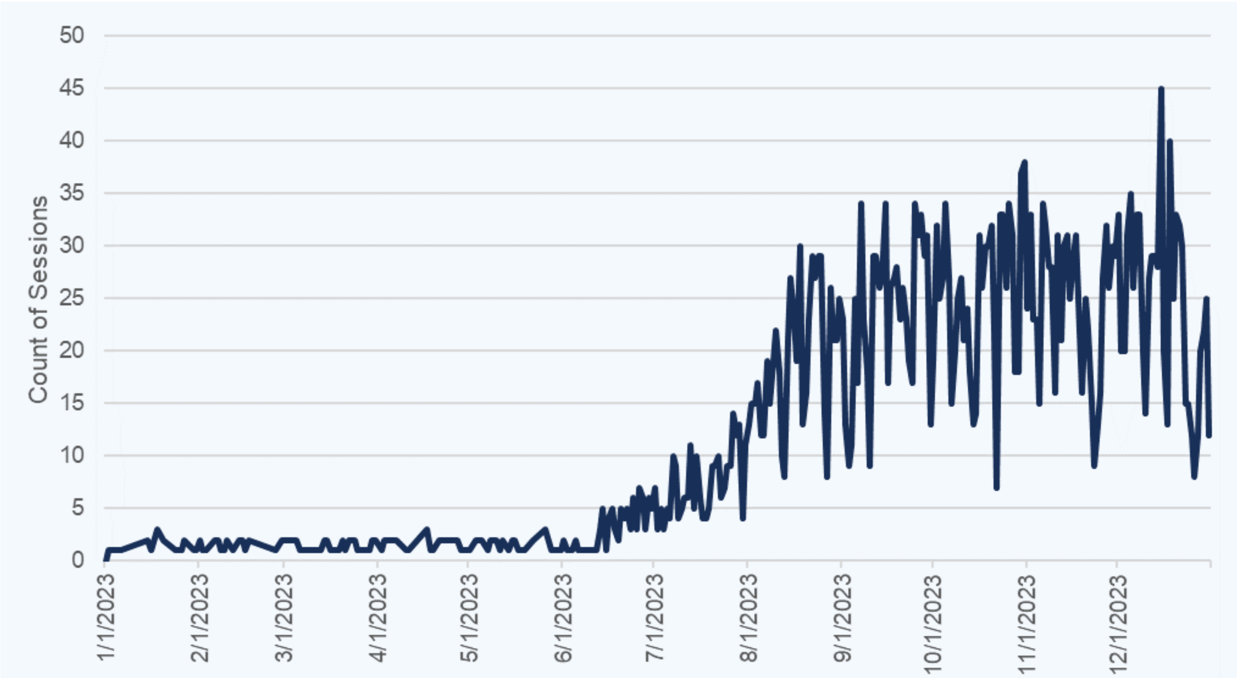


Figure 159. PG&E Schools Pilot Charging Session Count by Consumption Size

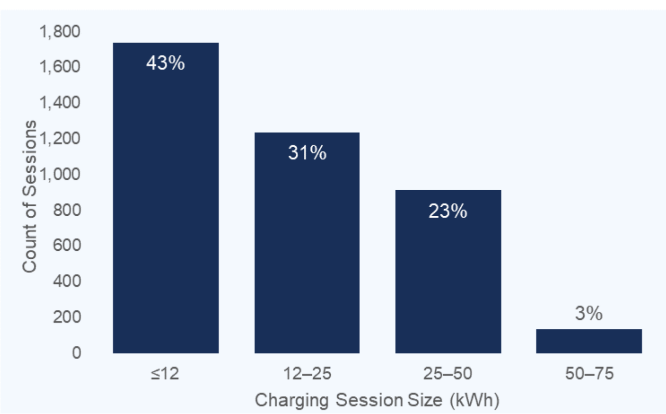


Figure 159 presents the distribution of charging sessions by kilowatt hours consumed for sites in the School Pilot. Nearly half of all charging sessions are 12 kWh or less, while approximately 25% are larger sessions over 25 kWh. Note that Figure 159 does not include erratic charging sessions (below 1 kWh or less than 0.1 hours).

Highlights

- Consumption data indicates that most Schools Pilot sites are still growing their user base.
- The impact of these sites may take many months or several years to influence people turning over their vehicle ownership or leases of conventional vehicles for EVs.
- Daily charging sessions increased two-fold between the beginning and end of August, coinciding with new sites coming online.
- Over 70% of charging sessions are less than 25 kWh.

Petroleum Displacement

The Evaluation Team estimated Pilot-induced petroleum displacement related to the 11 PG&E Schools Pilot sites using three key pieces of information: electricity used for vehicle charging, EV annual miles traveled, and annual counterfactual vehicle fuel consumption. From this information we estimated the reduction in equivalent gallons of petroleum as a result of the PG&E Schools Pilot. Table 96 presents petroleum displacement impacts for the Schools Pilot sites through 2023, including estimated actual impacts for 2023, actual impacts for all sites in the Pilot to date, and a 10-year forecast for pilot-to-date sites.

Table 96. PG&E Schools Pilot Petroleum Displacement

DAC	Usage				Petroleum Displacement (GGE)		
	2023 Actual[a] (kWh)	PTD Actual[b] (kWh)	2023 Actual Use (miles)	PTD Actual Use (miles)	2023 Actual	PTD Actual	10-Year Projection
Inside DAC							
Outside DAC							
Total	**83,439**	**87,595**	**248,584**	**261,012**	**6,375**	**6,721**	**139,283**

[a] "2023 Actual" represents the data from all activated sites from program inception for the calendar year 2023.

[b] "PTD Actual" represents the data from all activated sites from program inception for all program years.

Highlights

- All operational sites in 2023 collectively achieved a pilot-to-date impact of more than 6,700 gallons of petroleum, with 33% within DACs.
- Over a 10-year period, the sites will result in displacing nearly 140,000 gallons of petroleum.

Greenhouse Gas and Criteria Pollutants

The Evaluation Team calculated reduced emissions from displaced fossil fuel use from ICE vehicles that were not in service as a result of the PG&E Schools Pilot. The Team first developed one ICE counterfactual, then calculated the emissions associated with these vehicles under conditions that otherwise matched the EVs in order to provide a baseline. Although EVs have no tailpipe emissions, the fossil-fuel power plants that supply electricity to the vehicle chargers still release some GHGs and criteria pollutants.

Table 97 presents the GHG reduction resulting from the School Pilot for all activated sites in 2023, Pilot to date and 10-year projection, by impact location. Overall, the Pilot resulted in a 75% reduction of GHG emissions (48 MT total) relative to the counterfactual to date (64 MT total, not shown in table), with just over 29% of the impact within DACs.

Table 97. PG&E Schools Pilot GHG Reductions

DAC	Usage				GHG Reduction (MT)		
	2023 Actual[a] (kWh)	PTD Actual[b] (kWh)	2023 Actual Use (miles)	PTD Actual Use (miles)	2023 Actual	PTD Actual	10-Year Projection
Inside DAC							
Outside DAC							
Total	**83,439**	**87,595**	**248,584**	**261,012**	48	50	1,149

[a] "2023 Actual" represents the data from all activated sites from program inception for the calendar year 2023.

[b] "PTD Actual" represents the data from all activated sites from program inception for all program years.

Overall, of the local emissions, the Schools Pilot had the highest impact in reducing CO, resulting in an estimated annualized reduction of 301 kg (see Table 98).

Table 98. PG&E Schools Pilot Local Emissions Net Reductions

Emissions	EY2023 Sites (n=10)			PTD Sites (n=11)	
	Inside DAC	Outside DAC	Total	Actual	10-Year Projected Impact
PM_{10} (kg)			0.60	0.28	5.94
$PM_{2.5}$ (kg)			0.55	0.26	5.46
ROG (kg)			8.56	4.10	112.0
CO (kg)			302	143	3,865

[a] Columns may not sum to total due to rounding.

Figure 160 shows the current mix of electricity from the CAISO grid used to support the PG&E Schools Pilot sites.[103] Based on the real-time grid conditions when the EV charging occurred, the overall energy mix contained about 49% zero-emission or renewable sources of electricity (including solar, wind, hydro, geothermal, biomass, and nuclear) and 41% natural gas. With the CAISO grid adding more renewables to meet the Renewable Portfolio Standard, the GHG and criteria pollutant emissions will continue to decrease.

Figure 160. PG&E Schools Pilot Net Electricity Mix, Pilot to Date

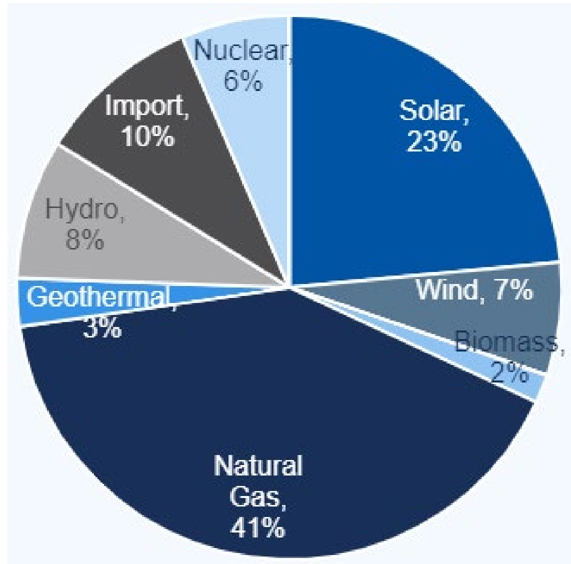
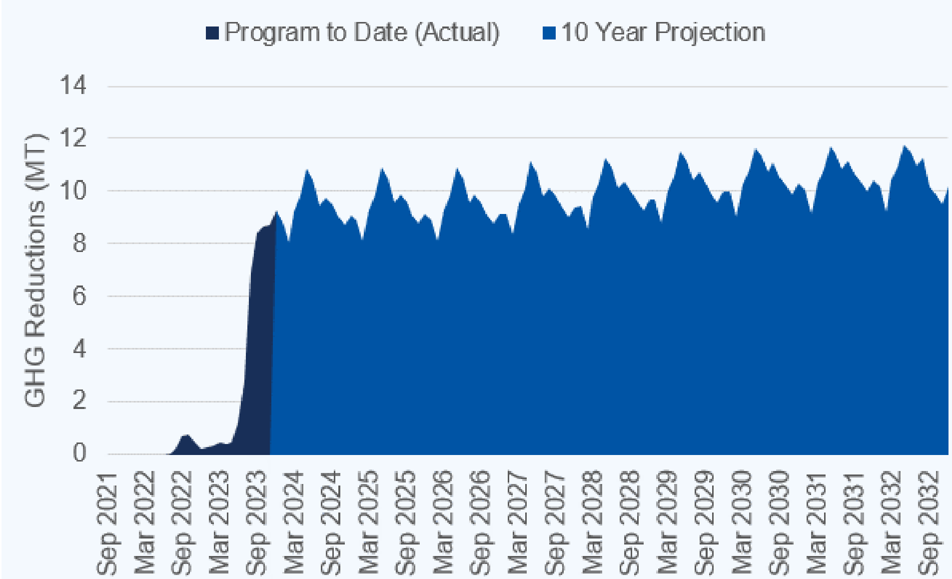


Figure 161 shows how Pilot GHG reductions have increased to date and are expected to grow over time for all sites. The analysis period ranges from the date that the first site in the program was activated through the end of 2023. The analysis incorporates the net reduction (counterfactual emissions minus utility emissions) for each Pilot site. Pilot-to-date emissions reductions appear in dark navy while anticipated benefits based on annualization appear in royal blue. As each site has its own starting date of operation, the 10-year sunset for each site is observed as a gradual tapering off of Pilot benefits in 2032. While each year's operations appear similar, there are several key factors driving the variations such as seasonality of utility generation sources (high utility emissions will appear as a dip on the curves), holidays occurring on weekends versus weekdays, and sites that became operational late in 2023 having predicted operations year-round in future years.

[103] The power associated with imports comes from a mixture of hydro, nuclear, and natural gas plants located outside the CAISO grid.

Figure 161. PG&E Schools Pilot Historical and Forecasted GHG Reductions for PTD Sites



Highlights

- The Schools Pilot has resulted in a 75% reduction of GHG to date with 29% of the impact occurring within DACs.
- The greatest reduction in local emissions was CO with more than 300 kg in 2023 and a projected 10-year period reduction of more than 3,800 kg.
- Based on the real-time grid conditions when the EV charging occurred, the overall energy mix contained about 49% zero-emission or renewable sources of electricity (including solar, wind, hydro, geothermal, biomass, and nuclear) and 41% natural gas.

Health Impacts

The Evaluation Team calculated public health impacts (as benefits and costs) of reductions in criteria pollutants from vehicle electrification. Pollutants included in the analysis are primary $PM_{2.5}$ and precursors of secondary $PM_{2.5}$, including NO_x, SO_2, NH_3, and VOCs. This analysis considered only tailpipe emissions reductions rather than full lifecycle emissions (such as power plant emissions). We used the U.S. EPA's COBRA to evaluate the health benefits associated with emissions reductions. COBRA estimates the county-level benefits for the county in which emissions are reduced. It also estimates the effect of the transport of emissions on all counties in the United States; however, this analysis includes only the effects of the emissions reductions in California. The Evaluation Team disaggregated the county-level effects to estimate the potential health benefits of sites for DACs and non-DACs.

Economic value depends on the health effects associated with the emissions, that is, whether they are associated with illnesses or death. The monetary value of the morbidity reductions associated with emissions reductions include avoided lost wages, avoided medical costs, and the amount of money people are willing to pay to avoid an illness or condition like respiratory disease. The value of the reduced mortality associated with emissions reduction is measured by the value of a statistical life, which uses value-of-life studies to determine a monetary value of preventing premature mortality. COBRA reports both a low and high impact, representing the uncertainties in the estimates.

The total value of the health benefits associated with the emissions reductions is small, between $860 and $1,932. Table 99 shows the cumulative health benefits in California associated with the emissions reductions realized by the electrification of EY2023 PG&E Schools Pilot sites.

Table 99. PG&E Schools Pilot California Health Benefits for EY2023 Sites

Health Endpoint	Change in Incidence (Annual Cases)		Monetary Value (Annual, 2023 Dollars)	
	Low	High	Low	High
Mortality	0.0001	0.0001	$843	$1,908
Avoided Medical Care				
Nonfatal Heart Attacks	< 0.0000	< 0.0000	$1	$9
Infant Mortality	< 0.0000	< 0.0000	$5	$5
Hospital Admits, All Respiratory	< 0.0000	< 0.0000	$1	$1
Hospital Admits, Cardiovascular	< 0.0000	< 0.0000	$1	$1
Acute Bronchitis	0.0001	0.0001	< $0	< $0
Upper Respiratory Symptoms	0.0020	0.0020	< $0	< $0
Lower Respiratory Symptoms	0.0014	0.0014	< $0	< $0
Emergency Room Visits, Asthma	< 0.0000	< 0.0000	< $0	< $0
Lost Productivity				
Asthma Exacerbation	0.7859	0.7859	< $0	< $0
Minor Restricted Activity Days	0.0615	0.0615	$7	$7
Work Loss Days	0.0104	0.0104	$3	$3
Total Health Effects	-	-	**$860**	**$1,932**

As part of this analysis, the Evaluation Team also examined health benefits within DACs, which may be disproportionately burdened by sources of pollution (including air pollution from ICE vehicles). Because COBRA estimates effects only at the county level, the Evaluation Team disaggregated the health benefits by census tract using the relative population of each tract from the most recent American Community Survey. For example, we allocated 10% of the value of the health benefits to a census tract with 10% of the county's population. The Evaluation Team then estimated the total benefits allocated to DACs and non-DACs. This approach assumes that the benefits of emissions reductions are distributed evenly throughout the county. If the sites are located in DACs, and the emissions reductions are greater in the tracts near the sites, this approach understates the potential benefit to DACs. Additional information about emissions dispersion within counties would provide more-precise estimates of the health benefits to DACs and non-DACs.

Santa Clara County had the highest proportion of overall benefits with 32% of the total, followed by Contra Costa County (18%), Alameda County (9%), San Joaquin County (9%), and San Mateo County (4%). Overall, 17% of the benefits were in DACs.

Highlights

- The annual monetary health benefits from EY2023 for PG&E Schools Pilot sites range from a low estimate of $860 to a high estimate of $1,932.
- Santa Clara County has the highest proportion of overall benefits with 32% of the total, followed by Contra Costa County (18%), Alameda County (9%), San Joaquin County (9%), and San Mateo County (4%).
- Overall, 17% of the benefits are in DACs.

Utility Staff Insights

In addition to monthly check-in calls with key PG&E staff to discuss the status of the Schools and Parks Pilots, the Evaluation Team conducted a close-out interview with staff in March 2024 to review overall Pilot challenges and successes in 2023. The following section groups these challenges and successes into those that apply to both Pilots, and those that only apply to one Pilot.

Schools Pilot and Parks Pilot

Starting in 2021 and through 2023, PG&E staff reported a continued challenge of site construction costs exceeding expectations, driven partly by labor constraints, material costs, and supply chain delays. As the Pilot staff are several years into implementation and have learned to account for these increased costs when planning. However, these challenges continue to strain program budgets:

- **Construction Labor Costs and Supply.** Construction labor costs have increased more than expected (per the original Decision 19-11-017 from 2019) each year. Though the strain has primarily impacted the Schools Pilot prior to 2023, the continually increasing labor costs are placing increasing strain on the Parks Pilot budget as contract negotiations continue.
- **Additional Design Considerations.** Compliance with external regulations, such as the ADA, required design aspects that made sites more costly to construct (such as ramps or wider parking spaces than originally designed). In 2023, staff reported that these considerations continued to be a primary budget strain and add time to site development. Additionally, staff articulated how other fixed costs, like addressing transformer differences and upgrading transformers, could significantly affect the cost-effectiveness of a site.

Schools Pilot

Despite ongoing budget strains, PG&E staff have adapted their processes and forecasts to anticipate these increased costs. PG&E identified several key strategies as effective in 2023 for keeping costs low, including pre-desktop reviews, regular reviews of actual costs, and open communication during construction, described in more detail as follows:

- **Early Internal Reviews.** Staff noted that the later a site application makes it into the process, the more expensive it is if the applicant must drop out. Though some participant drop-outs are beyond the Utility's control and impossible to predict (e.g., decision-makers changing their minds), the Utility can catch some obstacles in the early stages of review, such as an irreconcilable environmental hazard that prevents site development. To minimize the chance of this happening late in the design stages, PG&E staff have implemented several steps early in the application process to try and catch any red flags before investing too much time and money in a site. For example, they began assigning PG&E engineers to complete a high-level engineering review before contracting designs out to more expensive, external consultants or design firms.

- **Regular Reviews of Actual Costs.** As the Schools Pilot is now several years into implementation, PG&E staff have had the opportunity to reflect on actual program spending to better understand site costs and the variability among sites. PG&E staff not only review overall costs for completed sites, but also conduct regular reviews for costs at other steps of the process, such as design (for example, for every 10 sites that apply to the program, PG&E staff examines the rate of application acceptance and staff time spent on each review component). PG&E staff indicated that these additional reviews, though time consuming, have improved staff ability to estimate future site costs and plan program spending as a result.
- **Continual Customer Engagement.** Staff acknowledged that once site design work is largely complete and equipment and labor are secured, the bulk of the work falls on construction crews to actualize the planned work. To ensure that these steps go smoothly, PG&E staff keep lines of communication open with the contractors and site hosts. Keeping all involved stakeholders on the same page has helped PG&E staff easily navigate bumps in construction and/or clearly address concerns about extraneous factors, such as safety. Additionally, maintaining open lines of communication has ensured that when customers need additional support (such as last-minute site changes), solutions are readily available.

Beyond site construction, another key component of the Schools Pilot in 2023 was the curriculum. PG&E staff designed the curriculum in 2022 in partnership with SEI and rolled it out fully in 2022 and 2023. Though schools and teachers that received the curriculum have generally understood it and received it well, PG&E staff noted difficulties in promoting adoption:

- **Limited Time for New Curriculum.** Many schools and teachers must focus their time on covering the Common Core. If a teacher wants to adopt a curriculum outside of the Common Core, they must prepare for it on their own time and be confident that their students are already on-track to meet Common Core standards. To minimize the burden on teachers, the Schools Pilot curriculum aims to provide all materials to the teacher, and SEI provides training to participating district teachers as needed. However, these measures do not alleviate the overall additional time a teacher needs to spend independently preparing and teaching the curriculum, leading to little curriculum adoption in 2023.

Parks Pilot

As noted in the 2021 and 2022 reports, PG&E staff have been negotiating with the DPR on the MPA that will cover general terms of participation and will next negotiate site selection and site-specific participation agreement addendums. In addition to the concerns of increasing costs mentioned above, PG&E staff noted additional negotiation coordination challenges that continue into 2023:

- **Negotiations Between Legal Teams.** Continued from 2022, in EY2023 the PG&E and DPR legal teams were still finalizing decisions about which parties are responsible for costs, liabilities, and risks. Despite ongoing negotiations in 2023, PG&E and the DPR were unable to reach an agreement but were hopeful about signing one in 2024.

- **Staff Alignment.** In 2023, PG&E staff noted that the negotiation process faced delays when input from additional DPR staff and departments became necessary, and those staff needed to get up to speed on the process. PG&E staff needed time to orient these new staff to the purpose of the Pilot, all steps completed to date, and next steps needed.

Though negotiations are still ongoing, PG&E felt that 2023 was a productive year for progress towards a signed MPA. Relationships with DPR staff and interest in EVs continue to grow:

- **Relationship Building.** As more senior DPR staff become familiar with the Pilot and involved in negotiations, PG&E staff have noticed the process moving along faster than in previous years.
- **Increasing Interest from State Parties in EVs and EV Infrastructure.** As the state develops and rolls out more EV-focused legislation, interest in EV charging in state parks has risen, ultimately driving more interest in this existing Pilot as well.

Highlights

- **Schools & Parks:** Similar to previous evaluation years, site costs continue to be a challenge. In particular, securing construction labor as well as the rising labor and materials costs, which continue to be compounded by supply chain delays and additional design consideration such as ADA requirements.
- **Schools**: PG&E identified several key strategies as effective in 2023 for keeping costs low, including pre-desktop reviews, regular reviews of actual costs, and open communication during construction.
- **Schools:** Although staff rolled out curriculum in 2023, staff indicated that many teachers have limited time to expand teaching topics due to needed focus on Common Core Curriculum.
- **Parks:** Though multiorganizational coordination remained a challenge, PG&E is optimistic that it will secure a master agreement in 2024, partly as a result of building positive relationships with DPS staff and an increasing interest from state parties in EVs and charging Infrastructure.

5.2.3. Lessons Learned

The Evaluation Team identified a number of lessons learned. These lessons, presented with key supporting findings and recommendations, may be applied to future Pilot years and to other similar efforts.

The Schools Pilot sites are helping to displace petroleum, reduce GHG and local emissions, and achieve nominal health impacts overall and within DACs.

The Schools Pilot sites accounted for a pilot-to-date impact of over 6,700 gallons of petroleum, with 33% of the impact within DACs. In addition, the Pilot resulted in a reduction of 50 MT of GHGs, with 33% occurring within DACs to date. These sites all positively contributed to lowering local emissions, with CO reduction being the most prominent, achieving a reduction of 143 kg. Overall, 17% of the health benefits are in DACs with the monetary health benefits in EY2023 PG&E school sites ranging from $860 to $1,932.

Although higher-than-expected site costs and delays continue to be a challenge for implementation, PG&E staff have adapted Pilot processes to mitigate cost impacts.

PG&E began the Schools and Parks Pilots during the COVID-19 pandemic, which caused unprecedented economic impacts across nearly every market. These changes were so significant that the estimates PG&E had created for Decision 19-11-017 (which mandated the Schools and Parks Pilots at their determined funding levels) did not reflect actual costs for implementation. Similar to previous evaluation years, in 2023 school site costs continued to present a challenge. Securing construction labor and absorbing rising labor and materials costs were compounded by supply chain delays and additional design consideration such as ADA requirements. However, in 2023 PG&E identified several key strategies as effective for keeping costs low, including pre-desktop reviews, regular reviews of actual costs, and open communication during construction.

Competing priorities may limit use of Pilot curriculum in the classroom.

Although PG&E rolled out curriculum in 2023, staff indicated that many teachers have limited time for expanded teaching topics as they must focus their time on covering the Common Core. To minimize the burden on teachers, SEI provides training to participating district teachers as appropriate. However, these measures do not reduce the time teachers must spend preparing and teaching the curriculum, leading to little curriculum adoption in 2023.

PG&E's Schools Pilot has a nominal influence on neighborhood EV adoption.

In 2023, the Schools Pilot increased the number of operational sites by one to bring the pilot-to-date total to 11. While the Schools Pilot positively influenced EV adoption in households neighboring the infrastructure, the overall impact was modest with an increase of only nine EVs. Our analysis indicates that the increase was small mostly because of the few active charging stations and the small number of affected CBGs.

Parks Pilot

Although cross-jurisdiction coordination remains a challenge, the PG&E staff's commitment to the development of the Parks Pilot is starting to show progress.

The original plan for the Parks Pilot in 2021 was for all Utilities to enter into a collective participation agreement with the DPR. However, in 2023—like in 2022—the PG&E and DPR legal teams were still finalizing decisions about which parties would be responsible for costs, liabilities, and risks. PG&E staff noted that the negotiation process also faced delays when, because of staff turnover, new DPR staff joined the negotiations. PG&E staff needed time to orient these new staff to the purpose of the Pilot, all steps completed to date, and next steps. Ultimately, PG&E staff are optimistic about securing a master agreement in 2024, partly as a result of positive relationships with DPS staff and an increase in interest from state parties in EVs and EV infrastructure.

5.3. EV Fast Charge Program

5.3.1. Overview

This overview provides a detailed description of the PG&E EV Fast Charge program; summaries of the program implementation process, performance metrics, materials, and budget; and a timeline of major milestones. Following the overview are detailed findings, highlights, and lessons learned.

Program Description

Per Decision 18-05-040, PG&E staff designed the EV Fast Charge program to support the installation of DCFCs at high-priority locations to encourage TE and minimize grid impacts. Staff designed the program to support PG&E customers, and EV drivers in general, by providing fast charging make-ready infrastructure, to ultimately accelerate the adoption of EVs. Specifically, staff designed the program to help meet a portion of PG&E's estimated need for fast chargers in its service area by 2025, reduce driver range anxiety, and increase access to charging for all customers, especially those who lack ready access to home charging, need charging stations in transportation corridors for longer trips, or participate in ridesharing. In 2022, PG&E staff revised the original goal of 52 sites to between 30 and 40 EV Fast Charge sites to reflect the rising costs per site and revised the port count forecast to between 156 and 200. PG&E staff met with the CPUC Energy Division in February of 2022 to discuss the revision, which was accepted.

Original EV Fast Charge Targets

- 52 sites
- 25% in DAC locations

2022 Revised EV Fast Charge Targets

- 30 to 40 sites
- 25% in DAC locations

Through the program, PG&E provides turnkey make-ready EVSE. This make-ready buildout includes design, permitting, construction, and installation of all electric infrastructure from the Utility connection point to the charger stub. PG&E owns and maintains the infrastructure on the Utility side of the customer meter (electrical infrastructure to the meter panel), also known as TTM infrastructure. PG&E also designs, constructs, installs, owns, and maintains the customer side of the meter infrastructure (electrical infrastructure from the panel to the EV charging interconnection point), also known as BTM infrastructure. PG&E will not install, own, or maintain DCFCs. In addition, the program design provides multiple business models and flexibility for site hosts and operators: PG&E's customer of record at fast charge sites may be the site host, an EVSP, or another third party. To be eligible for the program, a site must be available 24x7 and install chargers with a minimum output of 50 kW. Customers must cover the cost of the charger, installation, and all ongoing O&M related to the charger for a minimum of five years from the time of activation. Finally, to encourage equitable EVSE installation, sites located in DACs are eligible for a rebate of up to $25,000 for EVSE.

EV Fast Charge Design Goal

Support installation of DCFCs at high-priority locations.

Implementation

Most site solicitations for the program occurred in 2019 and 2021; there were no additional solicitations in 2022. In 2023, staff analyzed the program's budget and learned that the program was forecasted to be underspent. Staff then conducted an additional partial solicitation for the program in 2023, targeting customers who had already engaged with the program and were likely to execute contracts quickly.

Example Screening Questions

- "Do you understand what the program is and what it will—and will not—provide?"
- "Who is getting the Low Carbon Fuel Standard credits?"
- "Which stakeholders will need to review the contract? Have they been engaged?"
- "How long will it take to sign the contract?"

PG&E uses an online application platform to facilitate the selection process. The application portal requests detailed information about the site, the site host, and the EVSE owner. The information in the application allows PG&E to verify basic eligibility requirements, apply initial scoring of the site against the program's scorecard, and start infrastructure assessments. As part of the eligibility screening process, PG&E staff conducted a phone screen with each potential site host. Staff refined the phone screening process over the course of implementing the program by adding questions or making sure site host decision-makers were included in the call (not just a potential contact at the actual site).

Starting in 2022, PG&E provided the opportunity for site hosts to contribute funding if the site exceeded PG&E's funding limits. After an EVSP engages with a potential customer, the implementation process begins, as detailed in Figure 162.

Figure 162. PG&E EV Fast Charge Program Implementation Process

APPLICATION AND INITIAL AGREEMENT

1. EVSP partner applies on behalf of customer via the online portal
2. Site host submits a consent form
3. PG&E reviews paper application materials

DETAILED ELIGIBILITY SCREENING

1. PG&E scores the eligibility of each site on a standard scorecard
2. PG&E, property owner, site host decision-maker, and EVSP partner join screening call to discuss additional details
3. PG&E selects the top sites to move forward in the program

SITE WALK AND DESIGN

1. PG&E conducts site walk
2. PG&E determines if the site can be completed within the budget cap
3. PG&E completes site preliminary design
4. Site host reviews and approves the preliminary design

CONTRACTING

1. PG&E issues a contract
2. Site host reviews and commits to the contract
3. PG&E finalizes site design

CONSTRUCTION AND ACTIVATION

Program Performance Metrics

The Evaluation Team reviewed sites participating in PG&E's EV Fast Charge Program and analyzed them by program status. Table 100 provides the count of sites by completion status in EY2023 and for the program to date.

Table 100. PG&E EV Fast Charge Program Complete Site Count by Status

Site Status	EY2023	Program to Date
Utility Construction Complete	12[a]	21
Activated	9	18
Operational	9	18
Closed Out	5	11

[a] Includes 9 sites completed in 2023 and 3 sites that were construction complete in late 2022 but not included in EY2022 reporting.

In EY2023, all nine sites activated in the EV Fast Charge Program were operational. Only three of the nine EY2023 activated sites (33%) are located inside DACs, as shown in Figure 163. The program signed two additional contracts with customers in EY2023, bringing the total number of contracts signed to date to 35.

Figure 163. PG&E EV Fast Charge Program EY2023 Activated Charging Stations

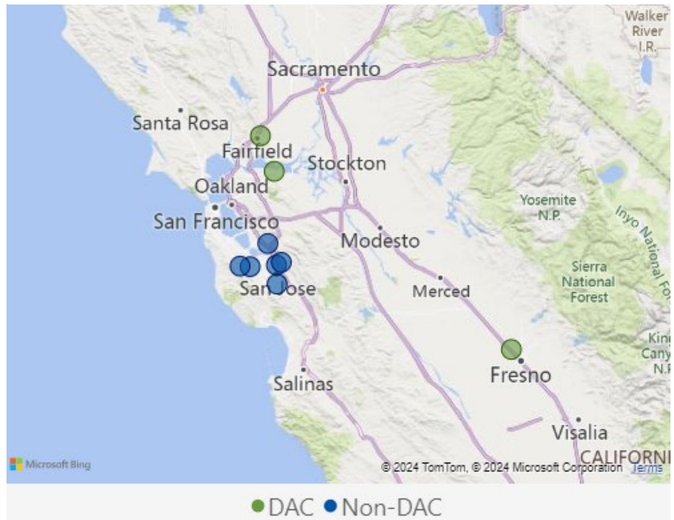


Table 101 presents site-level data for PG&E's EV Fast Charge program, showing DAC status and the number of DCFC ports for the activated sites in EY2023 and in the program to date. In EY2023, 33% of activated sites were in a DAC, bringing the cumulative percentage of DAC sites to 44%, which exceeds the program's *per se reasonableness* DAC goal of 25% of sites. The program deployed 45 additional ports in EY2023, raising the total number of DCFC ports installed to date to 84, with the number of ports per site ranging from 4 to 8 ports.

Table 101. PG&E EV Fast Charge Program Activated Site Data in EY2023 and PTD

EY2023			Program to Date		
Number of Activated Sites inside DAC	Number of Activated Sites outside DAC	Number of DCFC Charging Ports	Number of Activated Sites inside DAC	Number of Activated Sites outside DAC	Number of DCFC Charging Ports
3	6	45	8	10	84

As shown in Table 102, the 18 activated sites to date in PG&E's EV Fast Charge Program achieve 35% of the program's *per se reasonableness* goal of 52 sites and support 84 DCFC ports, which meets 36% of the program's *per se reasonableness* goal of 234 charging ports. The 35 customer contracts signed to date could satisfy 67% of the program's site goal and would support 188 DCFC ports, which could meet 89% of the program's DCFC port goal.

Table 102. PG&E EV Fast Charge Program Site and Port *Per se Reasonableness* Goal Progress

Pilot Metric	*Per se Reasonableness* Goal	Program to Date
Activated Sites	52	18
DCFC Ports	234	84

The CPUC established six phases in the program timeline per the SB 350 reporting template. Table 103 shows the median number of calendar days per phase for EY2023 and PTD activated sites. The median number of calendar days per program phase for EY2023 sites in the EV Fast Charge Program ranged from 43 days for Contract Issuance to 409 days for Design and Permitting. In general, the median durations across program phases in EY2023 were similar in magnitude to those for the program to date.

The EY2023 medians for the first three program phases were slightly shorter than their PTD counterparts, while the final three phases' EY2023 medians were marginally longer than the corresponding PTD medians.

Table 103. PG&E EV Fast Charge Program, Median Calendar Days per Phase

CPUC Program Phase	Median Calendar Days	
	EY2023	Program to Date
Application Review	73	74
Site Assessment	54	55
Contract Issuance	43	71
Design and Permitting	409	394
Construction Complete	77	59
Activation	82	65

Program Materials Summary

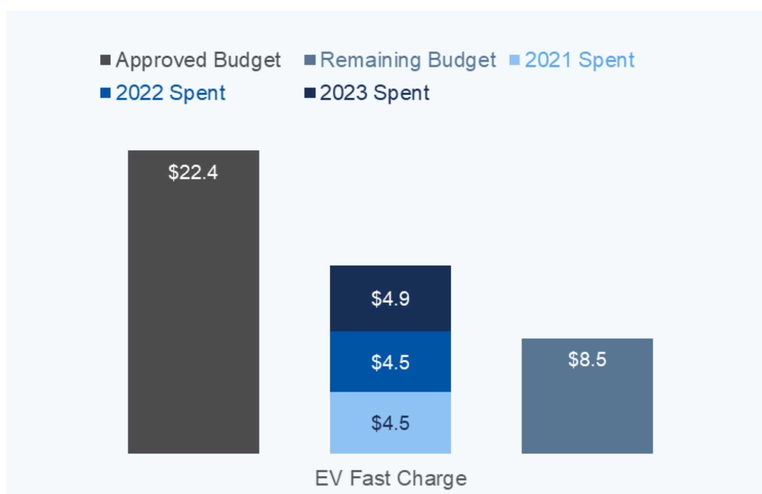
In 2023, PG&E staff maintained a webpage outlining details of the EV Fast Charge program. The webpage provides a program overview and information for site hosts and vendors. PG&E staff tracked key activities related to the EV Fast Charge webpage, which had 8,652 site visits and 7,358 unique visitors in 2023. The site includes answers to frequently asked questions about program participation and costs. PG&E also maintained on the website several varied types of ME&O materials, created in 2021 for both potential site hosts and EVSP partners. For EVSP partners in particular, PG&E EV Fast Charge staff developed summaries for each solicitation with key information and an onboarding presentation with program details.

Several items were available to both site hosts and EVSPs including information sheets about the program, approved products, and an application preparation sheet.

Budget Summary

As shown in Figure 164, from program inception through 2023, PG&E spent $13.9 million of the $22.4 million EV Fast Charge program budget. Program spending totaled $4.5 million in 2021, $4.5 million in 2022, and $4.9 million in 2023.

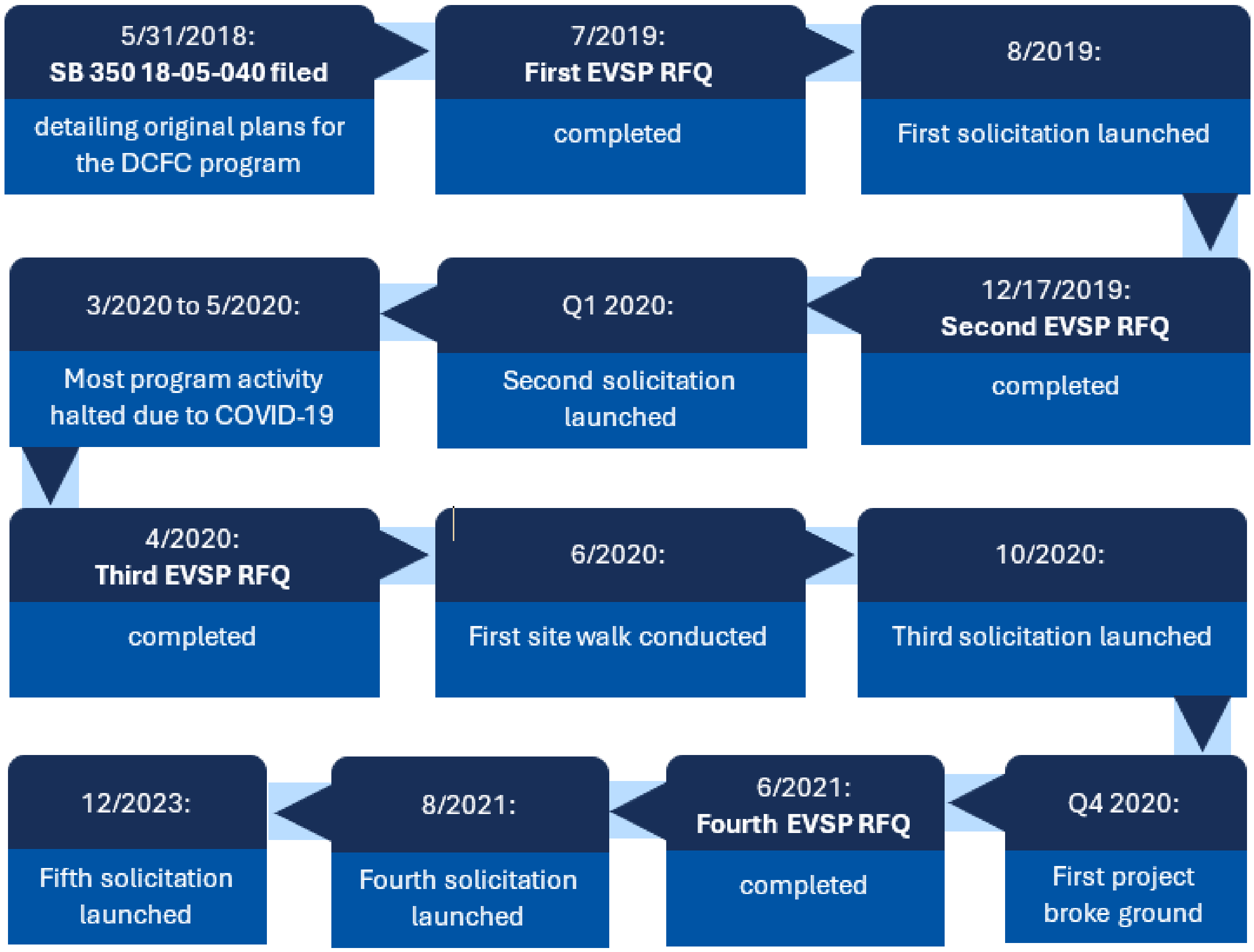
Figure 164. PG&E EV Fast Charge Program Budget (Million USD) as of Dec. 31, 2023



Timeline

In 2023, program staff were focused on constructing and activating sites and there were no formal Advice Letters or other regulatory milestones. However, as noted and detailed in the *Implementation* section above, the program did open a partial fifth solicitation in December 2023. Figure 165 illustrates key program milestones from the inception to end of 2023.

Figure 165. PG&E EV Fast Charge Program Key Milestones



5.3.2. Findings

This section provides findings from analyses of incremental EV adoptions, site visits and site costs, grid impacts, petroleum displacement, GHG and criteria pollutant reductions, and health impacts, and from insights collected during Utility staff interviews.

Table 104 summarizes key impact parameters for EY2023 as well as for the program to date. Annual estimates of impacts are provided for metrics calculated as part of the impact evaluation. Additionally, the table provides estimates of impacts across all sites included in the program population through the end of 2023.

Table 104. PG&E EV Fast Charge Program Impacts Summary

Impact Parameter	EY2021 [a]	EY2022 [a]	EY2023 [a]	EY2023 Percentage in DAC	PTD Actual	PTD Actual Percentage in DAC
Population of Activated Sites (#)	4	5	9	33%	18	44%
Sites Included in Analysis (#)	4	5	9	33%	18	44%
Charging Ports Installed (#)	16	23	45	29%	84	39%
Electric Energy Consumption (MWh)	83	248		7%	1,222	33%
Petroleum Displacement (GGE)	7,319	20,384	36,682	31%	101,976	33%
GHG Emissions Reductions (MT GHG) [b]	50	157	286	31%	745	32%
PM_{10} Reduction (kg)	0.27	0.80	1.56	31%	3.93	32%
$PM_{2.5}$ Reduction (kg)	0.24	0.74	1.44	31%	3.61	32%
ROG Reduction (kg)	4.7	12.7	22.22	31%	65.92	34%
CO Reduction (kg)	149	423	783	31%	2,195.5	33%

[a] Energy consumption, petroleum displacement, and emissions reductions are based on annualized data. PTD results in the table are based on actual data (see *Appendix A* for more details).

[b] GHGs include CO_2, CH_4, and N_2O multiplied by their respective global warming potentials (GWP) as defined by IPCC AR5 (see *Appendix A* for more details).

Incremental EVs Adoption

The Evaluation Team estimated the effect of the public charging stations on EV adoption for neighboring populations[104] with a two-stage analysis: (1) historical analysis of public EV charging impacts on vehicle ownership; and (2) analysis of ownership attributable to PG&E EV Fast Charge program investments. See *Appendix A* for the details of the Stage 1 analysis.

Using the impact estimates from the Stage 1 analysis,[105] the Evaluation Team estimated the impact of PG&E investments in public charging on EV ownership. By the end of 2023, 18 charging stations in

104 There are two main channels through which the availability of public charging networks may affect EV purchases. The first is a network effect, through which EV owners gain increased access to the public charging stations because of the stations' placement at destinations such as workplaces, commercial establishments, schools, and parks. The Evaluation Team expects the availability of EV charging equipment at convenient locations (for midday charging away from home) to increase the convenience of owning an EV (such as lessening range anxiety) and to increase the probability of EV ownership. The second channel is a neighborhood effect on the driving population living in areas neighboring the public EV charging stations. The Evaluation Team expects the availability of nearby charging infrastructure to reduce the cost of EV ownership by providing alternatives to home charging. The Team expects that public EV charging will have the biggest impact on residents of multifamily buildings, many of whom will have limited access to EV charging equipment, or on low-income households, who may be unable to afford home EV charging equipment. We note that public charging access may boost EV ownership through both channels and that there may be positive interactive effects between the channels that boost the overall impact of public charging networks. The Evaluation Team focused on analyzing the second channel. We will analyze the impacts for the first channel separately when data become available.

105 The State 1 analysis was based on vehicle registration data from 2015 to 2020, the most recent period with complete information at the CBG level. The EY2023 estimates assume the impact of utility-specific stations remains unchanged over time, which may not reflect actual market and technological changes.

PG&E's EV Fast Charge program were active. The Evaluation Team estimated the impact of these stations on annual EV registrations as well as on PTD cumulative EV registrations.

Based on the composite measure of public charging access, the Evaluation Team calculated the change in access to public charging due to PG&E's investments for each CBG where access was affected by the investments. As shown in Table 105, the PTD average change in access per affected CBG was 3.8, and the average increase in number of chargers (ports) was 3.2. For reference, the average change in access across all CBGs in California was 0.57 between 2015 and 2020. The average normalized EV annual registration per 1,000 households was 81.5 in the affected CBGs in 2020.

Table 105. PG&E EV Fast Charge Program Summary Statistics of Effects on CBGs

	CBG Mean (Standard Deviation)			
	Change in Composite Measure of Access[a]	Change in Number of Chargers[a]	Normalized Annual EV Registrations[b]	Number of Households[c]
EV Fast Charge program	3.81	3.15	81.48	472.20
	(3.06)	(2.62)	(84.97)	(261.83)
CBGs (N)	48	48	48	48

These values are averages for the CBGs whose access to public charging was affected by PG&E's investments.
[a] Change in composite measure of access and number of chargers is from 2020 to 2023.
[b] Normalized annual EV registrations are average annual values in the affected CBGs in 2020 per 1,000 households.
[c] Number of households is based on 2015–2019 American Community Survey (ACS).
Sample standard deviations are in parentheses.

The Evaluation Team calculated the impact of PG&E'S EV Fast Charge investment on neighboring EV ownership.[106] The calculation combined the OLS and IV-2SLS regression estimates of the impact of public charging access from Stage 1 with the estimates of the CBG changes in public charging access and household counts. The impacts of PG&E's investments in fast charging on EV registrations depends on how much the investments increased access in affected CBGs and the number of households in the CBGs.

Table 106 presents the estimates of annual and PTD EV registrations attributable to PG&E'S EV Fast Charge program investments.[107] Based on the OLS long differences model, PG&E's investments in the EV Fast Charge program stations increased EY2023 annual EV registrations by 2.9 vehicles and PTD cumulative EV registrations by 3.7 vehicles. Based on the IV-2SLS long differences model, PG&E's investments increased EY2023 annual EV registrations by 13.7 vehicles and PTD cumulative EV registrations by 16.2 vehicles. The Evaluation Team prefers the IV-2SLS-based estimates because they account for the potential endogenous siting decisions of public charging (e.g., building public charging

[106] In Stage 1 the Evaluation Team estimated the impact of public EV charging access on EV ownership. Stage 2 built on the Stage 1 analysis and was an attribution analysis for Utility specific investments. A notable benefit of this approach is that it can be applied to evaluations of other programs increasing EV charging access as well, which ensures methodological consistency.

[107] The long differences model estimates indicate the impact of public charging on EV registration over five years. The Evaluation Team divided these estimates by five to annualize them.

infrastructure in locations likely to have low or high rates of EV adoption). These estimates assumed that the 18 activated EV Fast Charge sites operate for a whole year.

Table 106. PG&E EV Fast Charge Program Registrations Attribution

EY2023 Annual Increase of EV Registrations Caused by the Utility Program		PTD Cumulative Increase of EV Registrations Caused by the Utility Program	
OLS	IV-2SLS	OLS	IV-2SLS
2.94	13.67	3.67	16.16
(0.30)	(1.48)	(0.32)	(1.59)

The table shows the EV registrations attributable to the utility investments in public charging infrastructure. The left panel shows the impacts of utility investments since 2020 on registrations in EY2023. The right panel shows the cumulative impacts of utility investments since 2020 on EV registrations in EY2021, EY2022, and EY2023. The Evaluation Team based these estimates on the OLS and IV-2SLS long differences models. The Evaluation Team estimated the OLS long differences model using data for all CBGs in the analysis sample. We estimated the IV-2SLS long differences model for CBGs in the 20 largest California cities. The long differences estimates are five-year estimates, which the Evaluation Team divided by five to annualize. For each affected CBG, the Evaluation Team calculated the increase in annual registrations as the product of the regression-based access coefficient divided by five, multiplied by the change in composite public charging access from utility investments (between baseline 2020 and EY2023), multiplied by the number of CBG households (in thousands). Robust standard errors clustered at the block group level are in parentheses.

Both estimated EY2023 and PTD cumulative impacts of the EV Fast Charge program on EV registrations are small. Across all estimated CBGs, the total annual number of EV registrations is about 3,911 (48 * 81.48), so the EY2023 impact of the EV Fast Charge program, based on the preferred IV-2SLS regression estimate, lifts EV registrations by 0.3%, and PTD impact lifts EV registrations by 0.4%. Compared to EY2022, the magnitude of the impact on EV adoption increased by 50%. The enhanced access to fast charging stations in communities is the primary driver of this increased impact.

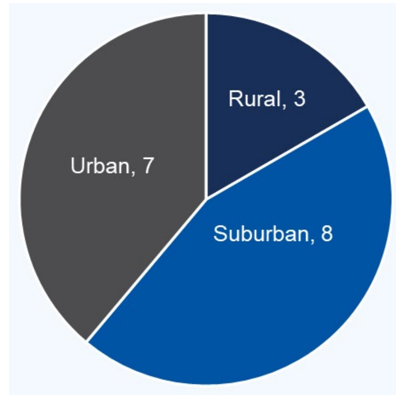
Highlights

- In EY2023, the EV Fast Charge program increased EV adoption by 14 EVs for households neighboring the infrastructure (16 PTD).
- The driver of a 50% increase in EV adoption impact in EY2023 was enhanced access to fast charging stations in communities.
- While the EV Fast Charge program increased neighboring EV adoption, both EY2023 and PTD cumulative effects were small relative to baseline registrations.

Site Visit Findings

The Evaluation Team visited all nine EV Fast Charge sites completed in 2023. These nine sites have a total of 45 DCFC ports and an installed capacity of 2,670 kW. The 2023 sites are located around the San Francisco Bay with one in Fresno, unlike previous years' sites, many of which were mostly along highway corridors in rural areas. Most sites are at gas stations; one is at a public park/aquatics center; and another is a public parking lot serving nearby restaurants, stores, and a public library. Table 107 provides a summary of these sites, and Figure 166 breaks the sites down according to their NCES Locale classifications.

Figure 166. PG&E EV Fast Charge Program Count of Site Urbanization



While on site the Evaluation Team documented construction layouts, connector types, parking elements, and the physical chargers including any available pricing information. Sites this year appear to have ADA parking spaces much closer to the main group of chargers than in previous years. Charging speeds (capacity in kilowatts) range from 50 kW to 180 kW per port. Some of these installations made use of hardware that could share demand in pairs. For example, if only one vehicle is charging (and is capable of higher-speed charging), one charger model can increase its charging speed from 62.5 kW to 125 kW while another can go from 90 kW to 180 kW. This reflects a general increase in charging capacity identified in previous years from 50 kW to 60 kW. Site visits revealed two new NSPs representing more market diversity.

Table 107. PG&E EV Fast Charge Program Site Summary

Site	DCFC Ports	Connections per Charger	ADA Accessible	Adjacent to or Near the Destination Building	Charger Power (kW)	Total Installed Capacity (kW)
1	8	1 CHAdeMO, 1 CCS	2, 1 designated EV and ADA, 1 ADA with access to chargers	Adjacent	50	400
2	4	1 CHAdeMO, 1 CCS	no designated ADA, 2 could be	Near	62.5 (paired)	250
3	4	1 CHAdeMO, 1 CCS	2, 1 designated EV and ADA, 1 ADA with access to chargers	Adjacent	62.5 (paired)	250
4	5	1 CHAdeMO, 1 CCS	no designated ADA, 2 could be	Adjacent	50	250
5	6	1 CHAdeMO, 1 CCS	2, 1 designated EV and ADA, 1 could be and is next to the ADA/EV spot	Near	50	300
6	6	1 CHAdeMO, 1 CCS	2, 1 designated EV and ADA, 1 could be and is next to the ADA/EV spot	Near	50	300
7	4	1x (1x CHAdeMO, 1x CCS), 1x(2xCCS)	no designated ADA, 2 could be	Near	90 (paired)	360
8	4	1 CHAdeMO, 1 CCS	no designated ADA, 2 could be	Near	90 (paired)	360
9	4	1 CHAdeMO, 1 CCS	no designated ADA, 2 could be	Near	50	200
Total	**45**	**9 CHAdeMO, 11 CCS**	**8 designated ADA, 12 could be**	**Both**		**2,670**

Table 108 shows a summary of the EY2023 site visits compared with site visits completed in previous evaluation years.

Table 108. PG&E EV Fast Charge Summary of Ports and Capacity Observed during Site Visits

Site Visit	Ports	Installed Capacity (kW)	Number of Sites
2023 Site Visits	45	2,670	9
Prior Years	39	2,550	9

Figure 167 shows an example of a typical EV Fast charge site layout with the DCFCs installed in a single row of parking, one at each of the adjacent parking spaces. The closest parking space is sized for van parking and ADA accessible (sign included but parking space is not painted blue like ADA parking spaces traditionally are which may contribute to higher competition for the parking space).

Figure 167. Example of DCFC Charging Layout

Pricing

Of the 18 sites (9 were activated in EY2023 and 9 during previous evaluation years), the Evaluation Team confirmed pricing at 17 sites and that 1 site had not yet announced pricing. Four sites (of the 17 with verified pricing) provide TOU pricing to EV drivers while 13 do not, leaving little opportunity to develop VGI-oriented behavior. Of the 13 sites providing flat rates (as opposed to TOU pricing) to EV drivers, 7 use idle fees to encourage turnover of chargers and parking spaces.

This means most sites do not communicate a TOU signal to EV drivers and would in that case have no influence on what time of day they charge. This inherently limits the opportunity of overall VGI, to maximize the value of EV charging and mitigate any issues. Though VGI is not a goal of this program, the application of TOU billing to the customers of record is one indication of the connection between VGI and the program but is not always passed on to the customers in terms of charging prices that would vary based on time of day.

Sites with TOU pricing to EV drivers ranged from $0.07 to $0.36 per kilowatt-hour, with one site charging an additional flat fee per session. For sites without TOU pricing passed on to EV drivers, flat prices ranged from $0.35 to $0.58 per kilowatt-hour.

Seven sites had idle fees while ten did not. Generally, DCFCs are installed at locations expected to have short customer dwell times and high turnover. The idle fees may encourage EV drivers to relocate their vehicles after sufficient charging so that others can make use of the assets. Idle fees at the visited sites ranged from $5 to $120 per hour, and grace periods lasted up to an hour.

Highlights

- All 9 EY2023 activated sites were visited and 45 DCFC ports and 2,670 kW of installed capacity were observed. All 18 PTD activated sites have been visited, and 84 DCFC ports and 5,220 kW of installed charging capacity have been observed.
- Only 4 sites out of 17 (with set pricing) provide TOU rates to EV drivers in support of VGI in terms of encouraging consumption when electrical grid congestion and electricity generation emissions are low such as early afternoon per PG&E tariffs.
- Seven sites out of 17 with set pricing use idle fees to encourage turnover and thereby improve access to charging ports.

Site Costs

The EY2023 report does not include a site cost analysis for these programs because of insufficient data (11 sites were included in the fully closed out site cost data).

Grid Impacts

This section describes grid impacts for the PG&E EV Fast Charge program based on an analysis of energy consumed and customer bills by operational charging stations installed through the program in EY2023.

Data Sources

The primary data source used in this section is the energy usage data, provided in regular 15-minute intervals from the AMI. Other data sources include customer bills, LCFS credit information, and data provided by NSPs. There are several important differences between AMI and NSP data. Whereas the AMI data is only energy usage, NSP data includes energy usage, session start and stop time, duration a vehicle is connected to a charging port, duration a vehicle actively pulls power, and the specific port used for a session. Additionally, NSPs typically do not have the ability to track standing loads (such as those used by the EVSE for communications, cooling, active power converters, solenoids, and screens), which an AMI meter does capture. In the event AMI data is missing from the dataset, the Evaluation Team filled in gaps using NSP data.

Summary of Grid Impacts

Table 109 presents a summary of the estimated EV Fast Charge program grid impacts.

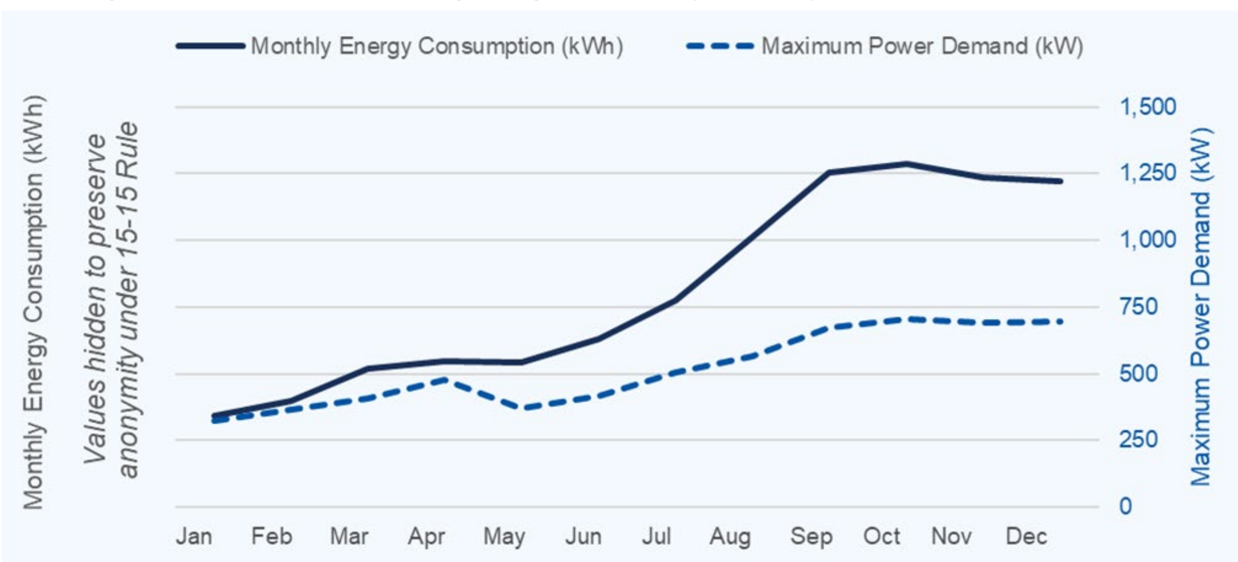
Table 109. PG&E EV Fast Charge Program Grid Impacts

Impact Parameter	2023 Actual	PTD Actual	10-Year Projection
Operational Sites	9	18	18
Installed Charging Capacity, kW	2,670	5,220	5,220
Electric Energy Consumption, MWh	977	1,222	13,170
On-Peak (4 p.m. to 9 p.m.) MWh (percentage of total)	306 (31.3%)	386 (31.6%)	N/A
Maximum Demand, kW (date and time)	703 (10/1/23: 7:30 p.m.)	703 (10/1/23: 7:30 p.m.)	N/A
Maximum On-Peak Demand, kW (date and time)	703 (10/1/23: 7:30 p.m.)	703 (10/1/23: 7:30 p.m.)	N/A

Consumption and Maximum Demand

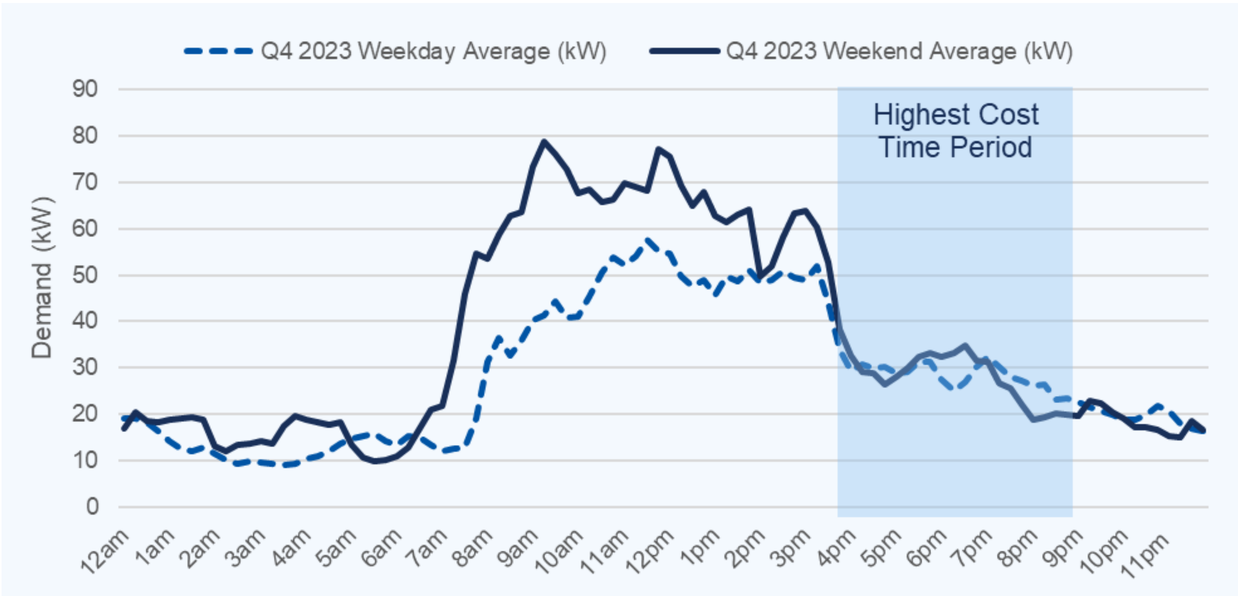
Sites in the EV Fast Charge program reached a total consumption of nearly 1,000 MWh in 2023. Nine sites were activated in EY2023 bringing the PTD total to 18 sites. Figure 168 plots daily energy consumption and maximum demand values for the program. From the start to the end of 2023, consumption across all activated sites PTD increased by approximately 400% stabilizing around 100 - 200 MWh monthly. Demand peaked at 703 kW in aggregate across all sites at 7:30 p.m. on October 1, 2023, compared to 5,220 kW of installed capacity. The Evaluation Team attributes this gap between installed capacity and demand to the adoption rate of these charging stations by EV drivers, as discussed later in this section.

Figure 168. PG&E EV Fast Charge Program Monthly Consumption and Maximum Demand



As shown in Figure 169, the average load shape of sites in the EV Fast Charge program is representative of typical daily vehicle use, with charging demand occurring in conjunction with daylight hours, though charging occurs at all times of day. Demand begins to ramp up at approximately 6 a.m. and continues to increase until 10:30 a.m., at which point demand becomes relatively flat until approximately 8 p.m. The highest day of consumption (6.13 MWh) took place late in the year near the Thanksgiving holiday with only a handful of other days exceeding 5 MWh.

Figure 169. PG&E EV Fast Charge Program Average Weekday and Weekend Q4 2023 Load Curves



Weekend days continue to show slightly higher average demand than weekdays as compared to EY2022. As discussed in the *Site Visits* section, a small group (4 of 17 currently) of these sites provide TOU rates to EV drivers, while PG&E bills all of these sites on their TOU-oriented BEV rates which include demand-oriented fees. This means that PG&E TOU rates have little influence on consumption. This is apparent in Figure 169 and Figure 170, with significant demand occurring from 4 p.m. to 9 p.m. Figure 170 reflects the daily load shape associated with the highest demand day and the highest consumption day.

Figure 170. PG&E EV Fast Charge Program Comparing Days of Highest Demand to Highest Consumption

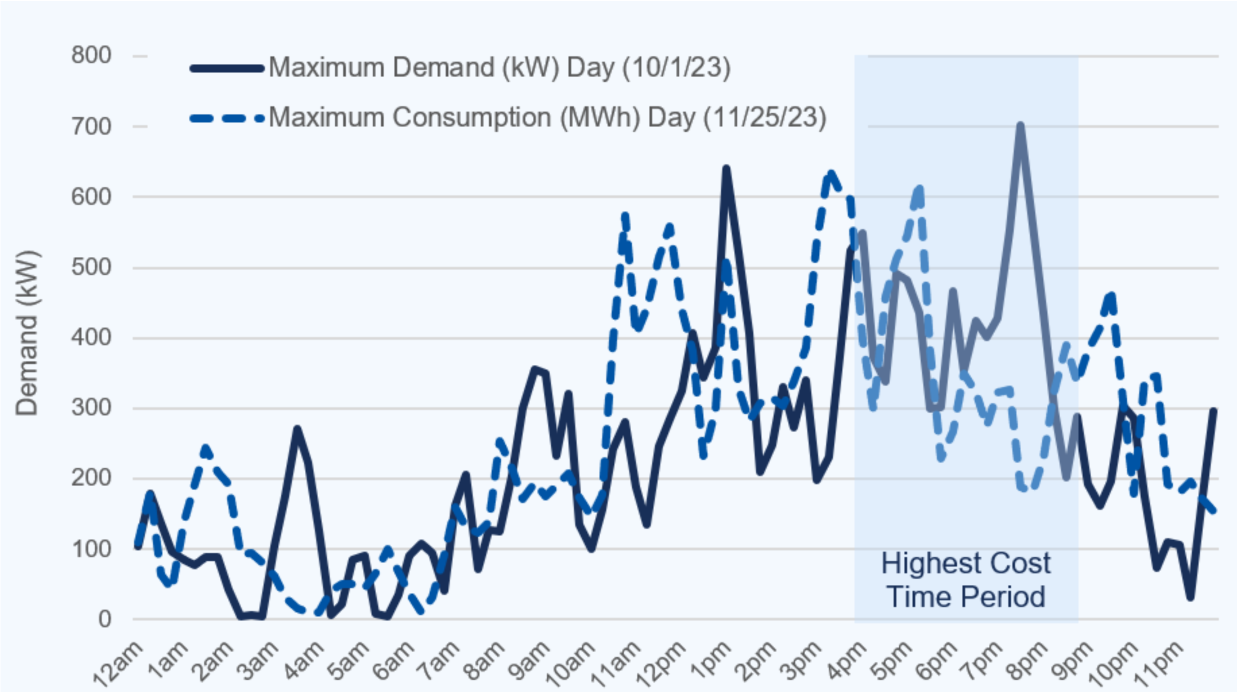


Figure 171 presents the total number of charging sessions in the EV Fast Charge program. Nearly 50,000 charging sessions have occurred in the program to date, over 80% of which occurred in 2023. EV Fast Charge sites show significant fluctuations ranging from 100 to 250 daily charging sessions in Q4 of 2023, which is two to four times the observed amount in the first half of the year.

Figure 171. PG&E EV Fast Charge Program Daily Charging Sessions

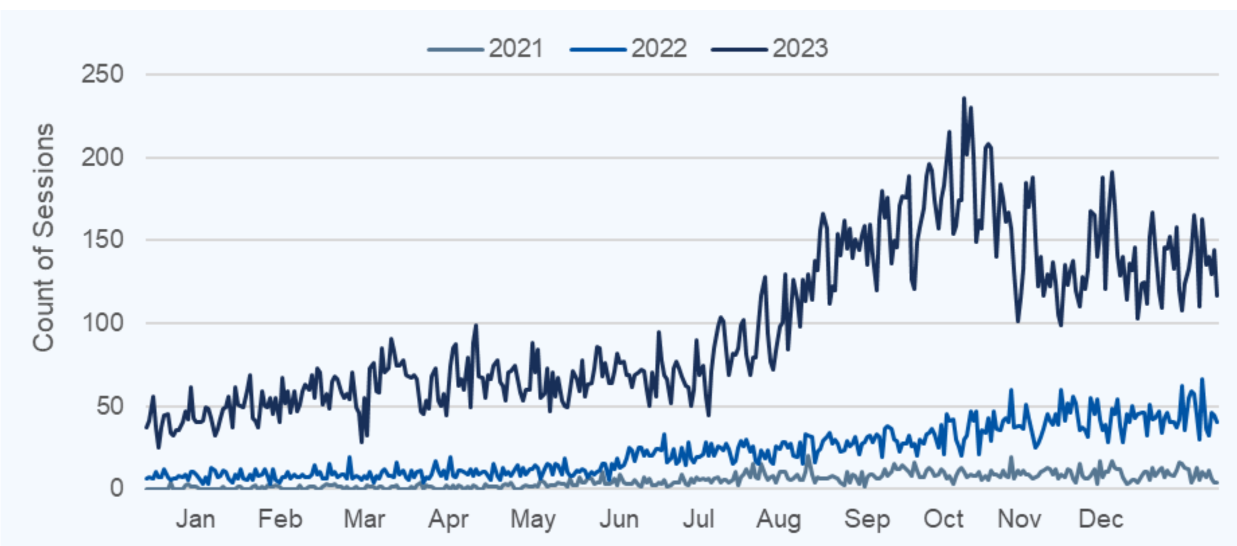


Figure 172 presents the distribution of charging sessions by size (kilowatt-hours consumed) for all sites in the EV Fast Charge program to date. Note that erratic charging sessions (below 1 kWh or less than 0.1 hours) were not included.

Figure 173 shows the monthly load factor of each site based on number of months from activation. Load factor compares a site's actual monthly energy consumption to what its consumption might be if the maximum-demand were consistent throughout the entire month. A constant demand (if max-demand interval was the average), for example, would result in 100% load factor (which is highly unlikely in practice). Load factor for a large portion of sites currently ranges from 6% to 12% with a few sites reaching as high as 15% to 30% for a few months. Such data may help site and Utility program staff better understand the level of demand on a public charging site and how long it takes site to reach full operation and utility. This understanding can also facilitate planning of future sites in terms of charging-parking layout and capacity.

Figure 172. PG&E EV Fast Charge Program Count of Charging Sessions by Size

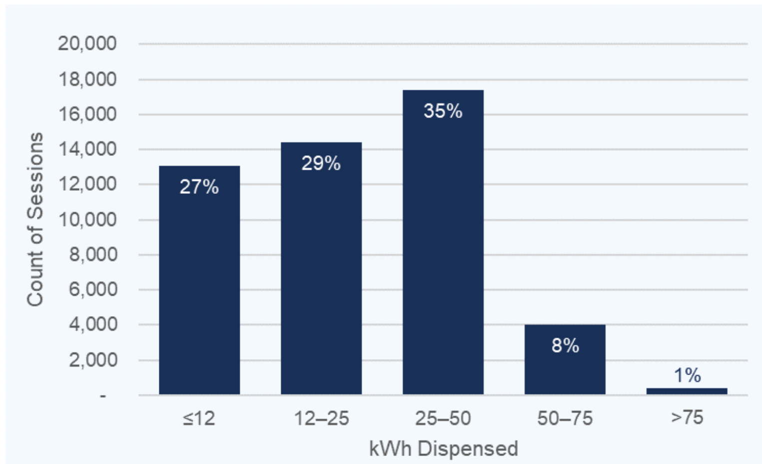
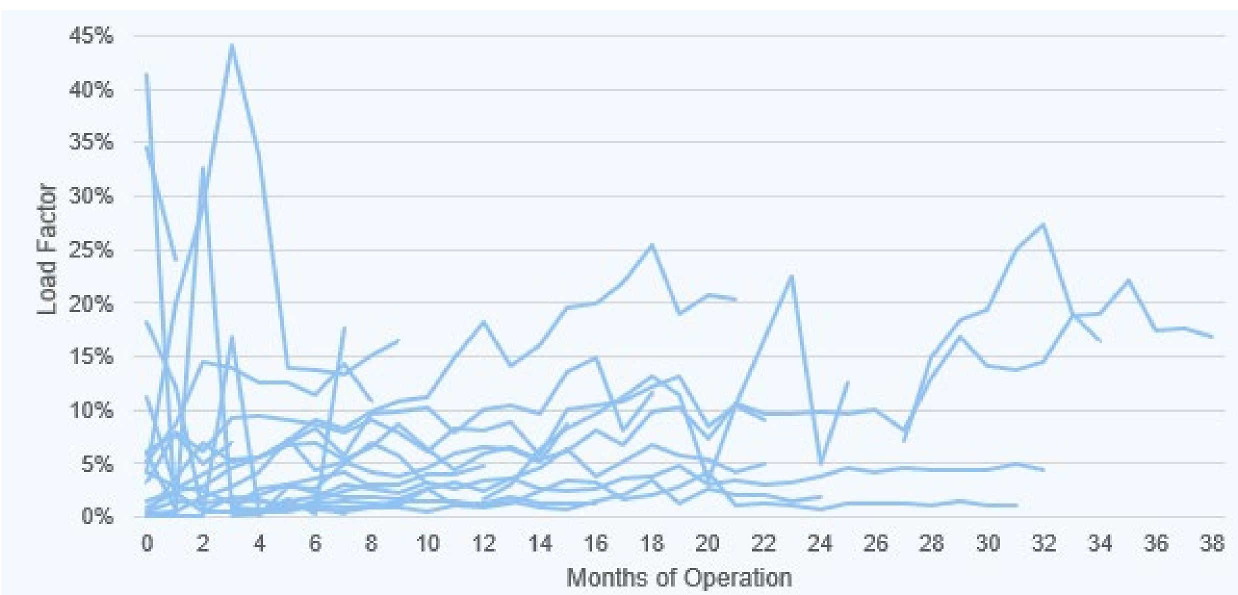


Figure 173. PG&E EV Fast Charge Program Monthly Load Factor by Site



Highlights

- The number of daily charging sessions has continually increased as new sites are activated. Across the program, the rate of daily charging surpassed 100 in the summer of 2023 and peaked in October 2023 with nearly 250 sessions in a day.
- Daily consumption ramped up through the early part of 2023 and peaked at 125 MWh in November.
- While weekday and weekend day charging have similar hourly trends, chargers had higher usage on weekends. Most demand occurred from mid-afternoon into the evening, coinciding with the highest cost time period of the day.
- Most sites do not pass TOU rates onto drivers, limiting the influence of TOU rates on VGI which may limit the benefits this program provides.
- Overall, utilization is still rather low based on the load factor (a comparison of maximum demand to average demand and consistency) and based on utilization rates (such as daily charging sessions and consumption) that appear to be increasing on a daily basis.

Petroleum Displacement

The Evaluation Team estimated program-induced petroleum displacement related to the 18 operational sites using three key pieces of information: electricity used for EV charging, resulting EV annual miles traveled, and equivalent annual counterfactual vehicle petroleum fuel consumption. From this information, the Team estimated the reduction in equivalent gallons of petroleum attributable to the PG&E EV Fast Charge program. Table 110 presents petroleum displacement impacts for the EV Fast Charge program sites through 2023, including estimated actual impacts for 2023, actual impacts for all sites PTD, and a 10-year forecast for PTD sites.

Table 110. PG&E EV Fast Charge Program Petroleum Displacement Summary

DAC	Usage				Petroleum Displacement (GGE)		
	2023 Actual[a] (kWh)	PTD Actual[b] (kWh)	2023 Actual Use (miles)	PTD Actual Use (miles)	2023 Actual	PTD Actual	10-Year Projection
Inside DAC					23,446	33,896	365,801
Outside DAC					57,285	68,080	704,551
Total	**976,565**	**1,222,486**	**2,909,805**	**3,639,561**	**80,731**	**101,976**	**1,070,352**

[a] "2023 Actual" represents the data from all activated sites from program inception for the calendar year 2023.
[b] "PTD Actual" represents the data from all activated sites from program inception for all program years.

Highlights

- All operational sites in 2023 collectively achieved a PTD impact of more than 100,000 gallons of petroleum, with one-third within DACs.
- Over a 10-year period, the sites will displace more than one million gallons of petroleum.

Greenhouse Gas and Criteria Pollutant Impacts

The Evaluation Team calculated reduced emissions from displaced fossil fuel use from ICE vehicles that were not in service because of the EV Fast Charge program. The Team first developed an ICE counterfactual baseline and then calculated the emissions associated with this vehicle under conditions that otherwise matched the EVs to provide a baseline. Although EVs have no tailpipe emissions, the fossil-fuel power plants that supply electricity to the vehicle chargers still release some GHGs and criteria pollutants.

Table 111 presents the GHG reductions resulting from the Program in 2023, along with the program-to-date and 10-year totals, by impact location. Overall, the Program resulted in a 78% reduction of GHGs emissions (745 MT total) relative to the counterfactual to date (955 MT, not shown in table) with 32% of the impact within DACs.

Table 111. PG&E EV Fast Charge Program GHG Reductions Summary

DAC	Usage (n=18)				GHG Reduction (MT)		
	2023 Actual[a] (kWh)	PTD Actual[b] (kWh)	2023 Actual Use (miles)	PTD Actual Use (miles)	2023 Actual	PTD Actual	10-Year Projection
Inside DAC					169	242	2,853
Outside DAC					426	503	5,568
Total	**976,565**	**1,222,486**	**2,909,805**	**3,639,561**	**594**	**745**	**8,421**

[a] "2023 Actual" represents the data from all activated sites from program inception for the calendar year 2023.
[b] "PTD Actual" represents the data from all activated sites from program inception for all program years.

Overall, of the local emissions, the program had the highest impact in reducing CO, resulting in an estimated annualized reduction of 783 kg (Table 112).

Table 112. PG&E EV Fast Charge Program Local Emissions Reductions

Emissions	EY2023 Net Reduction (n=9)			PTD Net Reduction (n=18)	
	Inside DAC	Outside DAC	Total[a]	Actual	10-Year Projected Impact
PM_{10} (kg)	0.49	1.07	1.56	3.93	42.96
$PM_{2.5}$ (kg)	0.45	0.98	1.44	3.61	39.25
ROG (kg)	7.01	15.2	22.2	65.9	880.4
CO (kg)	247	536	783	2196	29,053

[a] Columns may not sum to total due to rounding.

Figure 174 shows the current mix of electricity generation sources from the CAISO grid used to support the PG&E EV Fast Charge program sites.[108] Based on the real-time grid conditions when the EV charging occurred, the overall energy mix contained about 52% zero-emission or renewable sources of electricity (including solar, wind, hydro, geothermal, biomass, and nuclear) and 38% natural gas. With the CAISO grid adding more renewables to meet the Renewable Portfolio Standard, the GHG and criteria pollutant emissions will continue to decrease, though the mix supporting this charging already exceeds RPS goals.

108 The power associated with imports comes from a mixture of hydro, nuclear, coal, and natural gas power plants located outside the CAISO grid.

Figure 175 shows how program GHG reductions have increased to date and are expected to grow over time for all activated sites. The analysis period ranges from the date that the first site in the program was activated through the end of 2023. The analysis incorporates the net reduction (counterfactual emissions minus utility emissions) for each site within the PG&E EV Fast Charge. PTD emissions reductions appear in dark navy while anticipated benefits based on annualization appear in royal blue. As each site has its own starting date of operation, the 10-year sunset for each site is observed as a gradual tapering off of program benefits between 2031 and 2033. While each year's operations appear similar, there are several key factors driving the variations, such as seasonality of utility generation sources (high utility emissions will appear as a dip on the curves), holidays occurring on weekends versus weekdays, and sites that became operational late in 2023 having predicted operations year-round in future years.

Figure 174. PG&E EV Fast Charge Program Net Electricity Mix, Program to Date

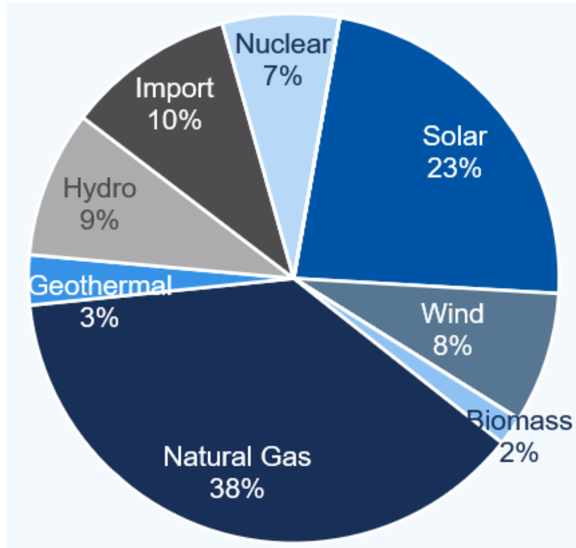
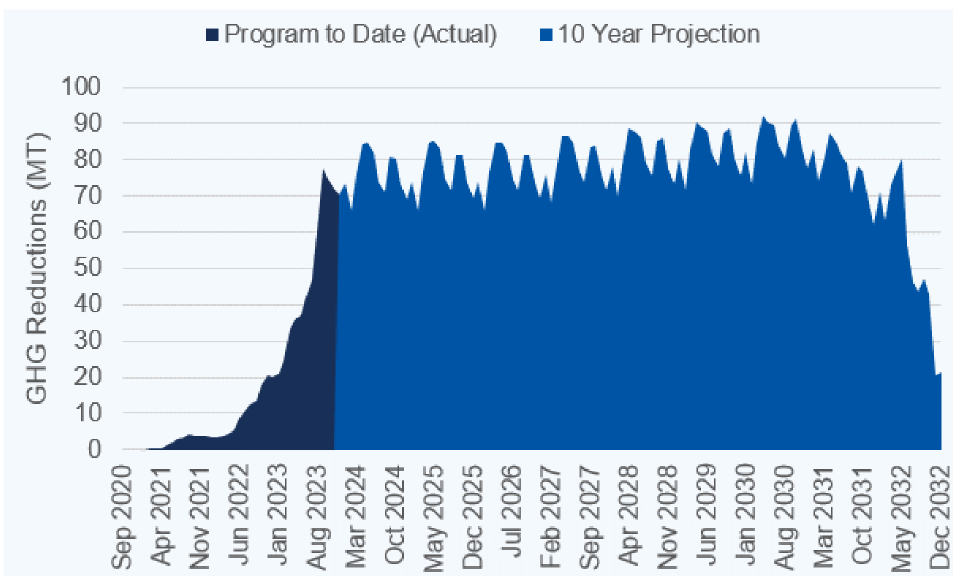


Figure 175. PG&E EV Fast Charge Program Historical and Forecasted GHG Reductions, PTD Sites



Highlights

- The EV Fast Charge program has resulted in a 78% reduction of GHG to date with 32% of the impact occurring within DACs.
- The greatest reduction in local emissions was CO with a PTD reduction of 783 kg in 2023 and a projected 10-year period reduction of more than 29,000 kg.
- Based on the real-time grid conditions when the EV charging occurred, the overall energy mix contained about 52% zero-emission or renewable sources of electricity (including solar, wind, hydro, geothermal, biomass, and nuclear) and 38% natural gas.

Health Impacts

The Evaluation Team calculated public health impacts (as benefits and costs) of reductions in criteria pollutants from vehicle electrification. The pollutants we included in the analysis are primary $PM_{2.5}$ and precursors of secondary $PM_{2.5}$, including NO_x, SO_2, NH_3, and VOCs. The analysis considers only tailpipe emissions reductions rather than full lifecycle emissions (such as power plant emissions). The Team used the EPA's COBRA to evaluate the health benefits associated with the emissions reductions. COBRA estimates the county-level benefits for the county in which emissions are reduced. It also estimates the effect of the transport of emissions on all counties in the United States; however, this analysis includes only the effects of the emissions reductions in California. The Evaluation Team disaggregated the county-level effects to estimate the potential health benefits of sites for DACs and non-DACs.

Economic value depends on the health effects associated with the emissions, that is, whether they are associated with illnesses or death. The monetary value of the morbidity reductions associated with emissions reductions include avoided lost wages, avoided medical costs, and the amount of money people are willing to pay to avoid an illness or condition like respiratory disease. The value of the reduced mortality associated with emissions reduction is measured by the value of a statistical life, which uses value-of-life studies to determine a monetary value of preventing premature mortality. COBRA reports both a low and high impact, representing the uncertainties in the estimates.

The total value of the health benefits associated with emissions reductions is between $2,450 and $5,507. Table 113 shows the cumulative health benefits in California associated with the emissions reductions realized by the electrification of EY2023 PG&E EV Fast Charge sites.

Table 113. PG&E EV Fast Charge Program California Health Benefits for EY2023 Sites

Health Endpoint	Change in Incidence (Annual Cases)		Monetary Value (Annual, 2023 Dollars)	
	Low	High	Low	High
Mortality	0.0002	0.0004	$2,401	$5,433
Avoided Medical Care				
Nonfatal Heart Attacks	< 0.0000	0.0001	$3	$27
Infant Mortality	< 0.0000	< 0.0000	$14	$14
Hospital Admits, All Respiratory	< 0.0000	< 0.0000	$2	$2
Hospital Admits, Cardiovascular	< 0.0000	< 0.0000	$3	$3
Acute Bronchitis	0.0003	0.0003	< $0	< $0

Health Endpoint	Change in Incidence (Annual Cases)		Monetary Value (Annual, 2023 Dollars)	
	Low	High	Low	High
Upper Respiratory Symptoms	0.0058	0.0058	< $0	< $0
Lower Respiratory Symptoms	0.0040	0.0040	< $0	< $0
Emergency Room Visits, Asthma	0.0001	0.0001	< $0	< $0
Asthma Exacerbation	0.7868	0.7868	$1	$1
Lost Productivity				
Minor Restricted Activity Days	0.1783	0.1783	$19	$19
Work Loss Days	0.0303	0.0303	$7	$7
Total Health Effects	–	–	**$2,450**	**$5,507**

As part of this analysis, the Evaluation Team also examined health benefits within DACs, which may be disproportionately burdened by sources of pollution (including air pollution from ICE vehicles). Because COBRA estimates effects only at the county level, the Evaluation Team disaggregated the health benefits by census tract using the relative population of each tract from the most recent American Community Survey. For example, we allocated 10% of the value of the health benefits to a census tract with 10% of the county's population. The evaluation then estimated the total benefits allocated to DACs and non-DACs.[109] This approach assumes that the benefits of emissions reductions are distributed evenly throughout the county. If the sites are located in DACs, and the emissions reductions are greater in the tracts near the sites, this approach understates the potential benefit to DACs. Additional information about emissions dispersion within counties would provide more-precise estimates of the health benefits to DACs and non-DACs.

Most of the health benefits were in Santa Clara County which had 29% of the total benefits, followed by Alameda (20%), San Mateo County (9%), Contra Costa County (8%), and Fresno County (4%). Overall, 15% of the benefits were in DACs.

Highlights

- The monetary health benefits from EY2023 PG&E EV Fast Charge sites range from a low estimate of $2,450 to a high estimate of $5,507.
- Most of the health benefits were in in Santa Clara County which had 29% of the total benefits, followed by Alameda (20%), San Mateo County (9%), Contra Costa County (8%), and Fresno County (4%).
- Overall, 15% of the benefits were in DACs.

[109] DAC Census Tracts are defined as those included in in the SB535 Disadvantaged Communities List (2022), this includes the DAC categories for CalEnviroScreen 4.0 Top 25%, CalEnviroScreen 4.0 High Pollution Burden Score and Low Population Count, and 2017 Disadvantaged Community (CalEnviroScreen 3.0 only).

Utility Staff Insights

In addition to monthly check-in calls with key PG&E staff to discuss the status of the EV Fast Charge program, the Evaluation Team conducted a close-out interview with staff in March 2023 to review overall program challenges and successes in 2023.

Starting in 2021 and through 2023, PG&E staff reported that a continued challenge with the program was that site construction costs were higher than anticipated, compounded by labor constraints, material costs, and supply chain delays. Being several years into implementation and dealing with the reality of increasing costs, PG&E staff have since learned to account for these increased costs when planning; however, they continue to strain program budgets:

- **Construction Labor and Material Costs.** Staff noted that construction labor and site material costs have continued to increase in 2023 and have been more expensive than originally anticipated in 2018 (when the program funding cap was decided).
- **Incorrect Assumptions.** PG&E staff noted in the 2021 evaluation report that during the program design in 2018, they had underestimated assumptions about site needs, such as trench length or proximity to a PG&E power source. Similarly, permitting costs have been higher than expected. These incorrect assumptions have continued to burden the program throughout its implementation.

In 2023, there were two additional challenges that PG&E staff identified as an overall limitation to the program:

- **Site Specifications.** The EV Fast Charge program is focused on enrolling the most cost-effective sites in order to maximize the number of sites and chargers installed across PG&E's territory. However, there are environmental (for example, long trench length), organizational (for example, site host policies), and other considerations (such as supplemental equipment upgrades) that can drive up site costs. Depending on the site and site host, these additional considerations may lead to very specific site specifications or needs that the EV Fast Charge program cannot afford to accommodate.
- **Additional Partnerships.** In 2023, after a previously contracted site owner backed out of the program, program staff received interest from a participating EVSP in a site that would be completed in collaboration with Electrify America. Because the site was viable, PG&E staff agreed to move forward, and all parties entered the contract and site design processes. Initial concerns immediately arose as it became clear that Electrify America has certain physical site requirements, such as utilizing bollards and back-up batteries, while the EV Fast Charge program's focus is on minimizing cost. Though ultimately all parties were able to reach an agreement to contract with the site, the additional back-and-forth that was needed to ensure the site was acceptable prolonged the process. As PG&E staff noted, programs that may have to accommodate a diverse pool of partners and site needs will likely have to plan for additional time, and potentially funds, to work through these considerations.

Despite these challenges, 2023 for the EV Fast Charge program was mostly smooth, with program staff mostly focused on site construction. The successes in 2023 centered on the ability of PG&E staff to remain nimble and focused on refining forecasts to serve as many customers as possible with the available funds:

- **Agile Use of Funding.** In 2023, with a substantial number of projects being fully invoiced, staff were able to more closely analyze the program's budget and learned that the program was forecasted to be underspent. In order to use these funds, staff conducted an additional partial solicitation for the program, targeting customers who had already been engaged with the program and were likely to execute contracts quickly. By December 2023, less than one year after identifying the availability of the funds, the EV Fast Charge team was already coordinating with an existing participant—who not only could execute the contract quickly, but also could contribute funds to ensure that the sites would be completed even if PG&E's extra funding could not cover full costs—to get more sites designed and contracted in 2024.
- **Program Sunsetting.** Though the program is still several years from being fully closed out, due to the complex nature of EV infrastructure programs and lengthy maintenance agreements, PG&E staff are already considering the needs for program sunsetting. Sunsetting efforts are likely to be expanded in 2024 and onward. In 2023 PG&E staff began to anticipate potential pain points in the process and conduct high-level activities like reviews of existing close-out policies for programs with ongoing maintenance requirements.

Highlights

- Similar to previous evaluation years, site costs continue to be a challenge. In particular, securing construction labor as well as the rising labor and materials costs. These challenges were compounded by permitting delays; site specification requirement such as utilizing bollards and back-up batteries; and incorrect program design assumptions from 2018 such as trench length or proximity to a PG&E power source.
- More program data allowed for more accurate site forecasts, which led to the identification of additional funds, allowing PG&E to re-open a partial solicitation in 2023 for adding a few more sites to the program.
- PG&E staff focused on securing final sites and construction as they begin early planning for program sunsetting.

5.3.3. Lessons Learned

The Evaluation Team identified several lessons learned. These lessons, presented below with key supporting findings and recommendations, may be applied to future program years and to other similar efforts.

The EV Fast Charge program sites are helping to displace petroleum, reduce GHG and local emissions, and achieve nominal health impacts overall and within DACs.

The EV Fast Charge sites accounted for a PTD impact of over 101,000 gallons of petroleum, with one-third of the impact within DACs. In addition, the program resulted in a reduction of 745 MT of GHGs, with 32% occurring within DACs to date. These sites all positively contributed to lowering local emissions, with CO reduction being the most prominent, achieving a reduction of over 2,100 kg. Overall, 15% of the health benefits are in DACs with the monetary health benefits in EY2023 PG&E EV Fast Charge sites ranging from $2,450 to $5,507.

Although higher-than-expected site costs and delays continue to challenge implementation, PG&E staff have adapted the Program to mitigate cost impacts.

PG&E began the EV Fast Charge program just as the COVID-19 pandemic started, which had unprecedented economic impacts across nearly every market, driving up costs for materials and labor and disrupting supply chains. These changes were so significant that the estimates PG&E had created for Decision 18-05-040 (which mandated the EV Fast Charge at determined funding levels) did not reflect the actual costs for implementing EV Fast Charge. Similar to previous evaluation years, in 2023 site costs continued to be a challenge. Securing construction labor and absorbing rising labor and materials costs were compounded by permitting delays, site specification requirements such as bollards and back-up batteries, and incorrect program design assumptions from 2018 such as trench length or proximity to a PG&E power source.

In 2022, after discussions with staff in the CPUC Energy Division, PG&E staff shifted the program design to allow partnering site hosts to contribute to site costs if the costs exceeded the program funding limits. Staff also added more phone screening steps to try to mitigate the attrition of site hosts in later stages of the application process. In addition, staff worked to obtain approval to adjust the program goal from 52 to between 30 and 40 sites. In 2023, PG&E staff focused on securing final sites and construction based on more accurate forecasts, which led to the identification of additional funds and allowed PG&E to re-open a partial solicitation for allowing a few more sites into the program before early-stage preparation to sunset the program.

PG&E's EV Fast Charge program has a nominal, but growing, influence neighborhood EV adoption.

In 2023, the EV Fast Charge program increased the number of operational sites by nine to bring the PTD total to 18. This uptick in sites increased EV adoption by 14 EVs for households neighboring the infrastructure (16 PTD). While still limited in overall impact, this represents a substantial increase in EV adoption than previous years, with a 50% rise compared to 2022. This growth, driven by improved access to fast charging stations, highlights the potential for even small enhancements in infrastructure to significantly boost EV adoption rates over time.

TTM and BTM infrastructure costs continue to vary widely between sites. Program participants continue needing Utility infrastructure support.

Across 11 financially closed out sites, Utility spending resulted in an average infrastructure cost of $365,070 per site and $1,357 per kilowatt when including Utility-sponsored TTM and BTM infrastructure but excluding EVSE cost. All-in costs paid by the *customer and PG&E* vary widely between sites, with an average of $565,524 per site. The cost for EVSE was the highest across the sites, followed by BTM and then TTM.

6. San Diego Gas & Electric Transportation Electrification Programs

6.1. Power Your Drive for Fleets

6.1.1. Overview

This overview provides a detailed description of the San Diego Gas & Electric (SDG&E) Power Your Drive for Fleets (PYDFF) program; summaries of the program implementation process, performance metrics, materials, and budget; and a timeline of major milestones. Following the overview, the Evaluation Team presents the EY2023 findings, highlights, and lessons learned.

Program Description

Per Decision 19-08-026, SDG&E's PYDFF program provides infrastructure for fleet electrification at low or no cost to participants. SDG&E launched the program in September 2020 to accelerate the adoption of MDHD EVs by providing infrastructure for fleet electrification and working with fleets from initial planning to design, construction, and ongoing site maintenance phases. PYDFF has an approved budget of $155 million and is designed to enroll and assist a minimum of 300 sites supporting the electrification of 3,000 MDHD on-road and off-road vehicles.

> **PYDFF Program Target**
>
> Achieve a minimum of 300 sites with 3,000 MDHD EVs supported.

Customers participating in the program can choose either Utility ownership or customer ownership of behind-the-meter (BTM) infrastructure. With Utility ownership, SDG&E will pay for, construct, own, and maintain all infrastructure up to the charging station. The customer will then pay for, construct, own, and maintain the charging station. If the customer decides to own the BTM infrastructure, then SDG&E will pay for, construct, own, and maintain all to-the-meter (TTM) infrastructure, and the customer will pay for, construct, own, and maintain all BTM infrastructure and receive an incentive payment for up to 80% of the resulting costs. Additional charger rebates of up to 50% of the cost are available for transit agencies, school districts, and fleets located in DACs that are not operated by Fortune 1000 companies.

> **PYDFF Program Design Goal**
>
> Accelerate the adoption of MDHD EVs by providing infrastructure for electrification while working with fleet operators from the initial planning phases to design, construction, and ongoing site maintenance.

The PYDFF program requires participating customers to purchase, lease, or convert at least two MDHD EVs. MDHD EVs are defined as Class 2 through Class 8 on-road and off-road vehicles, including MDHD trucks and vans, transit buses, commuter buses, school buses, TRUs, airport GSE, port equipment, forklifts, and other equipment. Additionally, fleets must own or lease the property, operate and maintain the infrastructure for 10 years, provide data related to EV usage, use approved vendors for the electric vehicle supply equipment (EVSE), and use qualified/state-licensed labor for all work, among other requirements. Specific terms and conditions listed in Appendix A and section 6.4 of Decision 19-08-026 require that a minimum of 30% of the infrastructure budget for PYDFF shall be allocated to deploy infrastructure in DACs, consistent with the California Environmental Protection Agency's CalEnviroScreen 3.0 tool (used to identify the top quartile of census tracts on a statewide basis). As allowed by the Decision, SDG&E submitted an Advice Letter in September 2023 requesting to expand the DAC definition to the service territory application, which the CPUC denied without prejudice.[110] SDG&E is continuing to perform outreach to DAC customers to meet the 30% requirement. The Decision also states that at least 10% of the infrastructure expenditures must support the deployment of transit buses and school buses, and no more than 10% can support the deployment of electric forklifts.

Implementation

Figure 176 shows the key steps in the PYDFF program implementation process.

Figure 176. SDG&E PYDFF Program Implementation Process

SUBMIT INTEREST

1. Customer submits interest form
2. An SDG&E representative works with fleets to ensure that the site is eligible and to help fleets apply for the program

PRELIMINARY DESIGN AND ENGINEERING

1. SDG&E conducts a physical inspection of the site location
2. Customer returns the executed customer package (participation agreement, 30% design, and easement)
3. SDG&E creates and finalizes the infrastructure design package and obtains permits

CONSTRUCT INFRASTRUCTURE

1. SDG&E constructs a make-ready EV charging infrastructure
2. Fleets have two options to construct and pay for charging infrastructure

ACTIVATE SITE

1. Customer commissions EV charging stations
2. SDG&E inspects and energizes equipment

CLOSE-OUT AND MAINTENANCE

1. SDG&E conducts a post-event job walk
2. SDG&E is responsible for ongoing maintenance of SDG&E-owned infrastructure
3. Customer is responsible for ongoing maintenance of customer-owned infrastructure and equipment

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[110] As of May 2, 2024, SDG&E has submitted a second Advice Letter with updated information on their state DAC outreach efforts: 4436-E.

Program Performance Metrics

The Evaluation Team reviewed the sites participating in the PYDFF program and organized them by program status. Table 114 provides the number of sites in the program by completion status as of December 31, 2023.

Table 114. SDG&E PYDFF Program Complete Site Count by Status

Site Status	EY2023	Program to Date
Utility Construction Complete	10	23
Activated	8	21
Operational	8	21
Closed Out	8	12

In EY2023, SDG&E's PYDFF program received 31 additional applications, signed contracts with 11 sites and activated 8 sites that supported 227 MDHD vehicles across four market sectors. This increased the total number of applications received to date by SDG&E's PYDFF program to 102 and the total number of contracts executed to date to 35. As shown in Table 115, none of the MDHD activated sites in EY2023 or the program to date are located within a DAC.

Table 115. SDG&E PYDFF Program Activated Sites by Market Sector in EY2023 and Program to Date

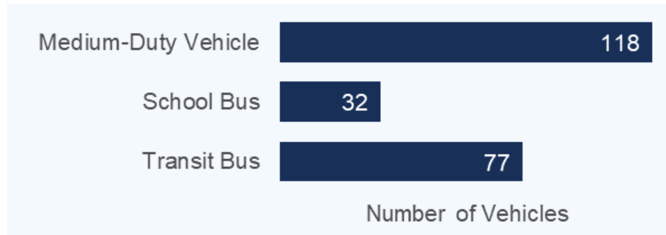
Market Sector	EY2023		Program to Date	
	Number of Sites in DAC	Number of Sites in Non-DAC	Number of Sites in DAC	Number of Sites in Non-DAC
Airport GSE	–	–	–	1
Medium-Duty Vehicle	–	5	–	7
School Bus	–	1	–	10
Transit Bus	–	2	–	2
TSE	–	–	–	1
Total	**0**	**8**	**0**	**21**

In EY2023, the highest participation rate in the SDG&E PYDFF program came from medium-duty vehicle fleets, with 63% of EY2023 activated sites. The transit bus and school bus market sectors are the only other sectors with sites activated in EY2023, with two and one site, respectively.

The majority of activated sites in the SDG&E PYDFF program to date are school bus fleets (10, or 48% of activated sites). Medium-duty vehicle sites represent the second largest market sector (7, or 33%). The transit bus market sector has two activated sites, or 10% of activated sites in the PYDFF program to date, while the airport ground support equipment and truck stop electrification market sectors each have only one site, which is less than 5% of all activated sites.

SDG&E installed infrastructure in EY2023 to support 227 MDHD vehicles across three market segments based on 10-year VAPs submitted by customers at the time of application. This brings the total number of MDHD vehicles electrified in the PYDFF program to date to 472. As shown in Figure 177, the medium-duty vehicle market sector is the largest sector of MDHD vehicles electrified in EY2023 (118, or 52%), followed by transit bus (77, or 34%). School bus is the least common MDHD market sector, with only 32, or 14%, of vehicles electrified in EY2023. SDG&E submitted AL 4349-E requesting to modify the PYDFF program to allow truck stops to participate; CPUC issued Draft Resolution 5335-E on May 31, 2024, approving the Advice Letter. This modification allows vehicle operators besides the site host to meet the vehicle purchase requirement for program participation.

Figure 177. SDG&E PYDFF Program Vehicles Supported by Market Sector, EY2023 Sites



As displayed in Table 116, by the end of 2023, the PYDFF program had activated 21 sites satisfying 7% of the program's *per se reasonableness* goal of 300 sites. These sites support the electrification of 472 MDHD vehicles per customers' VAPs, which achieves 16% of the program's *per se reasonableness* goal of electrifying 3,000 MDHD vehicles. The 35 contracts signed in the PYDFF program to date will support 668 MDHD vehicles. This satisfies 12% of the program's site and 22% of the program's vehicle *per se reasonableness* goals. Altogether, the 102 applications received to date could meet 34% of the program's site goal. While the Decision goals have a ratio of 10 MDHD EVs per site, the PTD ratio is 23 MDHD EVs per site, more than twice the Decision goal. With CPUC approval of Resolution E-5335 on July 11, 2024, truck stop sites may increase.

Table 116. SDG&E PYDFF Program *Per se Reasonableness* Site and Vehicle Goal Progress

Program Goal	*Per se Reasonableness* Goal	Program to Date
Activated Sites	300	21
MDHD EVs	3,000	472

Table 117 displays the median durations per program phase (measured in calendar days) for EY2023 and PTD activated sites. The column labeled EY2023 refers to sites activated in 2023. The "Program to Date" column refers to all 21 sites activated from the initiation of the program through December 31, 2023.

Values in Table 117 provide insight into program phase length trends over time. Sites did not necessarily pass through each phase in the same calendar year. For example, EY2023 activated sites may have passed through Design and Permitting in 2022 while others passed through in 2023.

Table 117. SDG&E PYDFF Program Median Calendar Days per Phase for EY2023 and PTD Sites

CPUC Program Phase	Median Calendar Days	
	EY2023	Program to Date
Application Review	62	31
Site Assessment	100	129
Contract Issuance	162	112
Design and Permitting	196	252
Construction Complete	398	175

CPUC Program Phase	Median Calendar Days	
	EY2023	Program to Date
Activation	12	6

Durations also vary by market sector. For instance, the school bus applications in the Site Assessment phase took a median of 68 calendar days to complete, while it took applicants in the transit bus market sector, which has the next highest median duration, with a median of 306 days to complete the same phase.

Figure 178 expands the analysis of program phase duration by displaying the average number of calendar days per phase (denoted by X), calendar day median (middle line inside box), the first quartile (bottom of box), third quartile (top of box), minimum (bottom tail), maximum (top tail), and outliers (dots). The distributions per program phase provide deeper insight into program phase completion, showing that the Construction Complete, Design and Permitting, and Contract Issuance phases took the most calendar days to complete and had the greatest variation in completion time. Application Reviewal and Activation are the phases in which the customer applications experienced the shortest amount of time. These phases are also the phases with the least variation in completion times in EY2023—a trend first observed among sites activated in 2022.

Figure 178. SDG&E PYDFF Program Calendar Days per Phase for EY2023 Sites

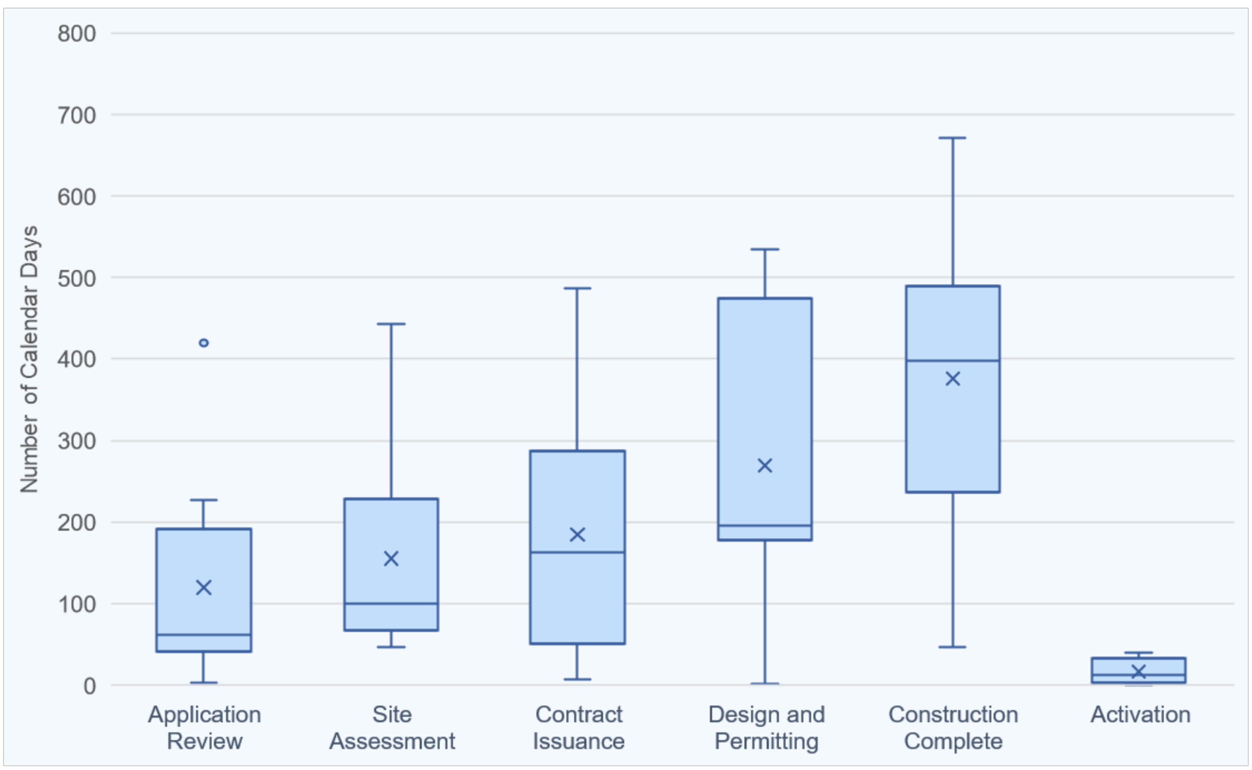


Table 118 displays the median number of calendar days that PYDFF program applicants took from program start to finish (Application Review to Activation) for the 8 activated sites across four market sectors in EY2023, and the 21 activated sites to date. The 8 activated sites in EY2023 had an overall median start-to-activation duration of 1,045 calendar days, up 391 days from the median in EY2022 (654 days). There was some variation between the longest and shortest median start-to-finish durations across market segments, with the shortest median duration (school bus market sector) taking 682 days PTD, or 554 calendar days fewer than the longest median duration (transit bus market sector) of 1,236 days PTD. The 21 PTD activated sites had an overall median start-to-activation duration of 702 calendar days, ranging from 477 calendar days for TSE applications to 1,236 days for transit bus applications.

Table 118. SDG&E PYDFF Program Median Duration for Site Activation by Market Sector, EY2023 and Program to Date Sites

Market Sector	EY2023		Program to Date	
	Median Duration Start-to-Finish (Calendar Days)	Number of Activated Sites	Median Duration Start-to-Finish (Calendar Days)	Number of Activated Sites
Airport GSE	–	–	570	1
Medium-Duty Vehicle	871	5	852	7
School Bus	577	1	682	10
Transit Bus	1,236	2	1,236	2
TSE	–	–	477	1
All Market Sectors	**1,045**	**8**	**702**	**21**

Program Materials Summary

This section highlights findings from the review of program materials and ME&O activities SDG&E conducted in 2023. SDG&E staff coordinated multitouch marketing activities, including activities geared to DAC audiences, created locally focused outreach materials, and hosted hands-on, collaborative events to increase program participation and share program successes:

- **DAC Outreach.** In addition to distributing new materials for DAC marketing (developed in 2022) and the other activities in 2023 (described further below), SDG&E conducted multiple waves of targeted DAC outreach in 2023. For example, in April 2023, SDG&E conducted a sales pitch in Spanish at a larger EV event with over a hundred stakeholders from EPA, CALSTART, and local counties. SDG&E staff also implemented a multi-month marketing campaign to generate awareness for commercial fleets in DACs through mail, email, social media and phone outreach.

- **San Pasqual Event.** SDG&E's San Pasqual event celebrated the first charging station SDG&E installed on tribal lands at a ball field frequently used by community members (Figure 179). The event gained wide coverage in both English and Spanish from KPBS and KOGO radio; KUSI and ABC television; and NBC and the San Diego Union Tribune articles, which reported that the number of EV chargers now exceed the number of gas pumps on the tribe's land. Additionally, NBC's article highlighted the funding opportunities, long-term cost savings for energy expenses, and contribution to statewide sustainability goals as benefits of the program.

Figure 179. Photo from SDG&E San Pasqual Event

- **Strategic Partnerships and Presentations.** SDG&E staff partnered with the Port of San Diego and participated in its public forum presentation. Outside of the public forum, SDG&E conducted presentations to trade organizations, community-based organizations (CBOs), and industry partner networks to share information about their programs with a local and national audience.
- **National Attention on a Joint Webinar.** In 2023, SDG&E staff hosted a webinar with Southern California Edison (SCE) and Pacific Gas & Electric (PG&E) staff to support small businesses trying to understand upcoming ACF regulations. In addition to local and state attendees, utility staff were pleased to see participation from stakeholders in other states looking to learn more about California policies. Because other states will likely enact their own TE legislation in the coming years, out-of-state stakeholders have been planning for their states' eventual adaptation.
- **Direct Outreach.** SDG&E continued to coordinate ad campaigns promoting grants and funding sources. Continuing efforts that began in 2022, staff conducted standard outreach through phone calls, social media, email, and webinars in 2023. SDG&E's direct outreach strategy also targeted decision-makers and leveraged internal connections to potential participants through account managers and field personnel.
- **Local Information Outreach.** SDG&E staff have found that small businesses are often confused about regulatory requirements around TE and look to SDG&E for guidance on next steps and best practices. In addition to helping customers on an as-needed basis, SDG&E staff created a section on its website to promote San Diego–specific information, such as the LCFS program, local grant opportunities, and legislative requirements for TE. SDG&E further

> ***As local businesses and public agencies transition to zero-emission fleets, they need technical support and resources. EV Fleet Day helps them by bringing together key stakeholders regionwide to share best practices for planning, deploying, and maintaining electric vehicles and the infrastructure needed to support them.***
>
> – Miguel Romero, SDG&E Vice President

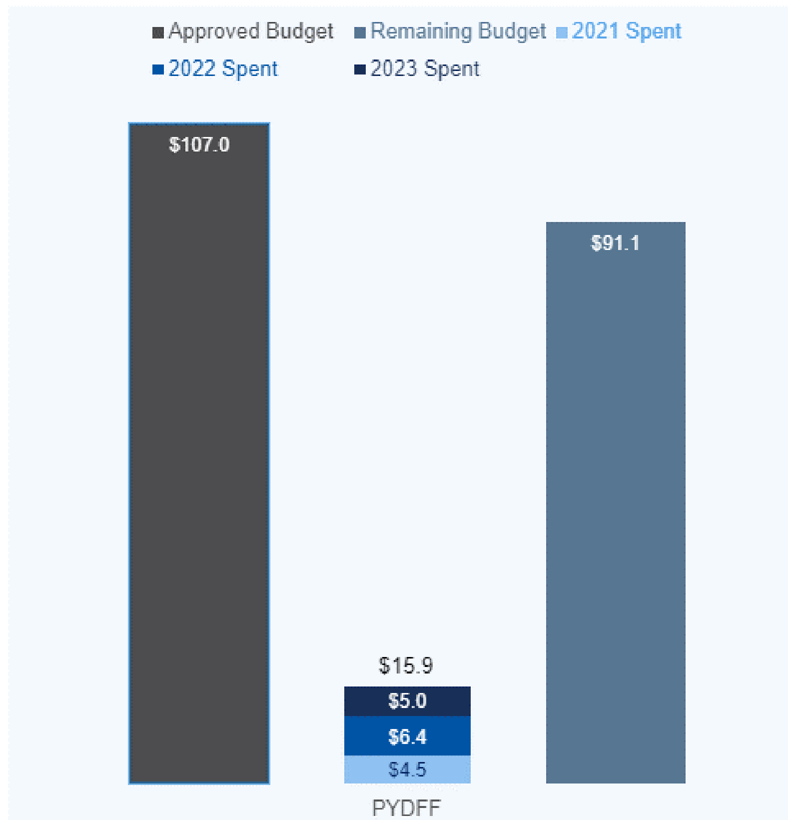
collaborated with funding agencies in an ad campaign to link and promote local, statewide, and federal opportunities such as incentives or rebates to reduce electrification costs.

- **Hands-On Events**. SDG&E hosts an annual "EV Fleet Day," which provides an opportunity to engage a multitude of industry players with booths, displays, and ride & drives with providers. More than 1,000 attendees explored 24 MDHD commercial EVs on display and heard panel discussions on California's clean fleet regulations as part of the day's events.

Budget Summary

As shown in Figure 180, from program inception through December 31, 2023, SDG&E spent $15.9 million of the approved $107 million (constant dollars). In EY2021, program spending was $4.5 million, in EY2022 $6.4 million, and in EY2023 $5 million. Figure 180 does not include spending on sites that were not fully closed out as of December 31, 2023.

Figure 180. SDG&E PYDFF Spend Compared to Program Budget (Million USD) as of Dec. 31, 2023



Timeline

Since the beginning of the program SDG&E has filed two Advice Letters. Though SDG&E did not submit any formal Advice Letters in 2023, SDG&E confirmed with the CPUC that the two-year timeline for the PYDFF program ends two years from the date the last contract was signed. Additionally, SDG&E received a rejection of AL 4086-E, originally filed on September 30, 2022. This Advice Letter requested to expand the definition of DACs to the service territory application, matching the definition approved in AL 2876-E.[111] CPUC rejected AL 4086-E, indicating that SDG&E did not have enough evidence of their outreach to state-defined DACs. Therefore, in 2023, SDG&E continued to prioritize outreach to state-defined DACs and increased the rigor of documentation for this outreach.[112]

Figure 181 shows all major milestones since the beginning of the program.

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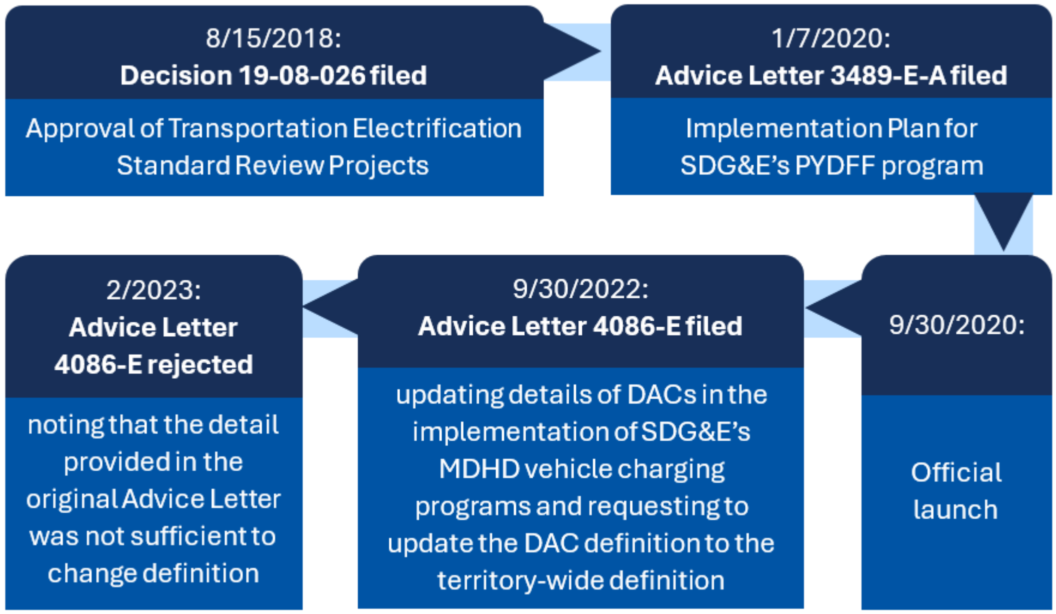
111 SDG&E submitted AL 2876-E to allow SDG&E to define DACs using the CalEnviroScreen service territory definition rather than the CalEnviroScreen state DAC definition.

112 As of May 2, 2024, SDG&E has submitted a second Advice Letter with updated information on their state DAC outreach efforts: 4436-E.

Figure 181. SDG&E PYDFF Program Key Milestones



6.1.2. Findings

The following sections provide findings from the Utility staff interviews, as well as from surveys, site visits, and deep dive sites. The Evaluation Team also provides insights from the co-benefits and co-cost analysis, site costs, as well as the grid impacts, petroleum displacement, GHG and criteria pollutant reductions, health, and net impacts.

Table 119 summarizes key impact parameters for EY2023 as well as for the program to date. Annual estimates of impacts are provided for goals calculated as part of the impact evaluation. Additionally, the table provides estimates of impacts across all sites included in the program population through the end of 2023.

Table 119. SDG&E PYDFF Program Impacts Summary

Impact Parameter	EY2021 Sites[a]	EY2022 Sites[a]	EY2023 Sites[a]	EY2023 Sites Percentage in DAC	PTD Sites Actual	PTD Sites Actual Percentage in DAC
Population of Activated Sites (#)	1	12	8	0%	21	0%
Sites Included in Analysis (#)	1	12	8	0%	21	0%
Ports Installed in Analyzed Sites (#)	2	181	78	0%	260[d]	0%
EVs Supported (#) [b]	2	246	227	0%	472	0%
Electric Energy Consumption (MWh)	N/A			0%	2,120	0%
Petroleum Displacement (DGE)	N/A	109,285	113,530	0%	222,425	0%
GHG Emission Reduction (MT GHG) [c]	N/A	947	790	0%	1,907	0%
NO_x Reduction (kg)	N/A	1,274	None	0%	1,848	0%
PM_{10} Reduction (kg)	N/A	8.0	0.32	0%	859	0%

Impact Parameter	EY2021 Sites[a]	EY2022 Sites[a]	EY2023 Sites[a]	EY2023 Sites Percentage in DAC	PTD Sites Actual	PTD Sites Actual Percentage in DAC
$PM_{2.5}$ Reduction (kg)	N/A	7.4	0.30	0%	85.7	0%
ROG Reduction (kg)	N/A	71.9	30.85	0%	111.5	0%
CO Reduction (kg)	N/A	2101	23,782	0%	9,921	0%

[a] Energy consumption, petroleum displacement, and emissions reductions are based on annualized data. Program to date results in the table are based on actual data (see *Appendix A* for more details).

[b] The Team derived the EVs supported value from applicants' VAPs. This value represents the maximum number of vehicles expected to be supported by the charging infrastructure.

[c] GHGs include CO_2, CH_4, and N_2O multiplied by their respective GWP as defined by IPCC AR5 (see *Appendix A* for more details).

[d] EY2022 evaluation report had 183 ports installed in analyzed sites for PTD Sites Actual. EY2023 sites added 76 ports but the Utility attributed one port that was counted as part of EY2022 site previously to EY2023 site in this report.

Utility Staff Insights

In addition to monthly check-in calls with key SDG&E staff to discuss the status of the PYDFF program, the Evaluation Team also conducted a close-out interview with staff in March 2024 to review overall Pilot challenges and successes in 2023. Program staff identified several program challenges:

- **Permitting Delays.** Program staff reported that staffing shortages at local and state government agencies have increased program permitting delays for sites within the City of San Diego. To address this concern, SDG&E worked on a new permit route with the City of San Diego in 2023 to fast-track sites starting in 2024, particularly for large-scale customers. Staff are hopeful that this program adjustment will help address permitting delays and ease large business participation in the program, ultimately making the program easier to run and more attractive to prospective participants.
- **Supply Chain and Materials Costs.** Staff indicated a continued long-term impact from COVID-19 supply chain interruptions, which increased material costs and slowed site development. As noted in 2022, staff reported that equipment and material lead times increased to 52 weeks or more for switchgears and to six months for EV chargers, and these problems have continued into 2023. In addition, equipment and construction costs grew significantly during 2023 for everything from labor to switchgear and its components and conduit to concrete.
- **EV and Infrastructure Uncertainty.** Staff reflected uncertainty surrounding availability and regulation of EV technology creates discomfort for customers who lack information they need to fully electrify:
  - *Dynamic Technology and Directives:* Staff expressed that customers are hesitant about fleet electrification because of barriers in understanding the fast-paced, ever-changing technology and regulatory landscape in California. These customers are apprehensive about committing to equipment that is not readily available, may not be compliant with certain standards as regulations shift during the time it takes to procure equipment, or is not known very well because it is new. To address this uncertainty during the program enrollment process, SDG&E staff prioritizes learning more about each customer's business models and specific electrification needs to provide advisory services given SDG&E's expertise and close involvement with the dynamic landscape of TE.

- *Charging Needs Outside of Territory:* Staff reported that customers with long haul needs are apprehensive about participating in the program because the infrastructure needed to support EV charging beyond their base may not be readily available (if at all).

- **Small Business Barriers.** Because 83% of commercial customers in SDG&E's territory are classified as small businesses[113] (based on SDG&E's analysis of their energy demand), when implementing this program SDG&E staff emphasized that they must consider the specific needs and challenges of small business fleet electrification. As the program has progressed, SDG&E staff have noted that small businesses have more challenges with program awareness, infrastructure capacity, and limits with program design requirements than medium- and large-size businesses:
  - *Awareness:* Staff reflected that because small businesses often have limited resources, they are typically not as aware of optional rebate opportunities like this program and have fewer ways to increase their awareness. SDG&E has found that the most effective way to engage these customers in a meaningful way is to answer specific questions on electrification possibilities during one-on-one conversations. This takes significant time and effort from SDG&E outreach staff but is a priority for reaching small business customers. Staff typically use marketing tools such as fact sheets, guidebooks, and vehicle guides to facilitate conversations.
  - *Disinterest in Owning Charging:* Program staff reported that small businesses customers sometimes would prefer to leverage public charging or similar communal charging opportunities rather than own and maintain their own EVSE, even with the support of organizations like SDG&E.
  - *Cannot Commit to Owning Infrastructure:* SDG&E staff noted that smaller businesses tend to lease or rent rather than own their properties, and some have very limited lease terms. These lease terms may prevent interested business owners from participating in the program because the leases do not permit them to install infrastructure. Even if installing infrastructure were an option, these customers may not be able to commit to the length of time needed for participation in the program because they cannot be certain they will stay in the same location. After running into an issue with one program participant who had to unexpectedly leave their leased property, SDG&E staff now ask participants at the start of the enrollment process for their lease terms (if applicable) to ensure that the program is compatible with the customer's lease and future plans.
  - *Design Requirement Limitations:* Staff indicated that the program requirement of a two-vehicle minimum has continued to be challenging for small fleets in 2023, because these fleets may not be able to afford more than one vehicle or own a dedicated parking space (or

[113] Residential and Small Commercial shall mean all residential customers and any commercial customer with a maximum peak demand of less than 20 kilowatts per P.U.Code § 331(h). Demand of less than 20 kilowatts shall be determined as having been met if SDG&E has a demand meter in place and the customer's maximum demand has been below 20 kW for at least nine out of the preceding 12 months, or if SDG&E does not have a demand meter in place and the customer's maximum monthly consumption has been below 12,000 kWh for at least nine out of the preceding 12 months. In addition, it shall mean any customer served on Schedule A or Schedule A-TC.

two). SDG&E staff noted that they have had interest in the program from customers wanting to purchase a single EV but are not ready to commit to the cost of two.

- **Legal Agreement Constraints.** As the PYDFF program is an optional rebate program with robust long-term commitments and legal liabilities, SDG&E staff cannot accept modifications to the participation agreement, as it would be unrealistic to manage hundreds of custom contracts on a long-term basis with the provided funding. Though this generally reduces time spent in contracting across the program, some customers' legal teams find it very challenging to accept contracts where no redlines are allowed. Staff reported that this is a deal breaker for some customers, who do not enroll; legal teams for other customers that stick with the program are very cautious through the process, which results in nine months to a year of questions to resolve before an agreement is signed.
- **DAC Requirement.** SDG&E program staff are concerned about meeting existing DAC requirements (which are defined by CalEnviroScreen 3.0, per the Decision) given the limited number of state-defined DACs in SDG&E's service area. In 2022, SDG&E submitted AL 4086-E requesting an update to the definition of DACs to SDG&E's more expansive service area definition, but the CPUC denied this request in Q1 2023, saying that SDG&E had not provided sufficient evidence of outreach. Therefore, in 2023, SDG&E continued to prioritize DAC outreach (such as through targeted events in specific locations and with presentations given in Spanish) and increased its documentation of these efforts. Unfortunately, SDG&E did not gain significant traction with DAC participants in 2023 and on May 2, 2024, resubmitted the proposed adjustments to the DAC definition in AL 4436-E, which is currently pending disposition in 2024.

As noted above, PYDFF program staff focused on crafting tailored solutions to specific programmatic challenges throughout 2023. In addition to these solutions, SDG&E noted other successes in 2023:

- **Earned Media and Expanded Outreach.** As the program has matured, SDG&E staff have showcased finished and successful sites through multiple workshops and clients, as detailed in the *Program Materials Summary* section. Through these efforts, SDG&E staff have earned attention from media outlets promoting the PYDFF sites.
- **Positive Customer Relationship Building.** SDG&E staff's transparency with program successes and implementation challenges such as lead times, along with demonstrations of how SDG&E worked through these issues, have been received positively by active and prospective participants.

Highlights

- Similar to previous evaluation years, site costs continue to be a challenge. In particular, material costs which have been compounded by supply chain delays.
- In addition to costs, long lead times for permitting were a challenge; however, staff developed a new permit route in 2023 to fast-track sites starting in 2024.
- The uncertainties of legislative enforcement impacts utility planning, program participation, and customer choices in the EV market.
- Small fleets, which represent a large percentage of the SG&E customer base, have more challenges than medium- and large-size businesses with program awareness, infrastructure capacity, and limits with program design requirements.
- Legal agreement constraints may impact participation as staff cannot accept modifications to the participation agreement given it would be unrealistic to manage hundreds of custom contracts on a long-term basis with the provided funding.
- Although SDG&E continued to prioritize DAC outreach, they did not gain significant traction with DAC participants and plan to re-submit proposed adjustments to the DAC definition in 2024 as they remain concerned about meeting existing DAC requirements given the limited number of state-defined DACs in SDG&E's service area.
- Earned media, expanded outreach, and continued staff transparency with program successes and implementation challenges help foster positive customer relationships.

Survey Results

The Evaluation Team surveyed fleet managers who participated in SDG&E's PYDFF program about their motivations for and barriers to electrification, satisfaction with and awareness of the program, experience with EVs and charging infrastructure, view of the impact of the program on fleet electrification, and perspective on the industry. Table 120 shows the distribution of fleet managers who responded to the survey by sector. In addition, the sections below provide insights from one fleet manager who withdrew from the program (known as withdrawn fleet managers).

Table 120. SDG&E PYDFF Fleet Manager Survey Sample in EY2023

Survey Type	Sector	Number of Surveys Sent	Number of Partial Surveys	Number of Completed Surveys
Participants	School bus	1	–	–
	Transit bus	2	–	1
	Medium-duty vehicle	1	–	–
	Heavy-duty vehicle	1	–	1
Total Participants	**–**	**5**	**0**	**2**
Withdrawn Fleet Managers	–	10[a]	-	1

In some cases, the number of responses to a question is greater or less than two (the number of completed surveys). This is due to the inclusion of partial participants (those who answered some questions but did not complete the survey) and cases in which not all respondents answered a question.

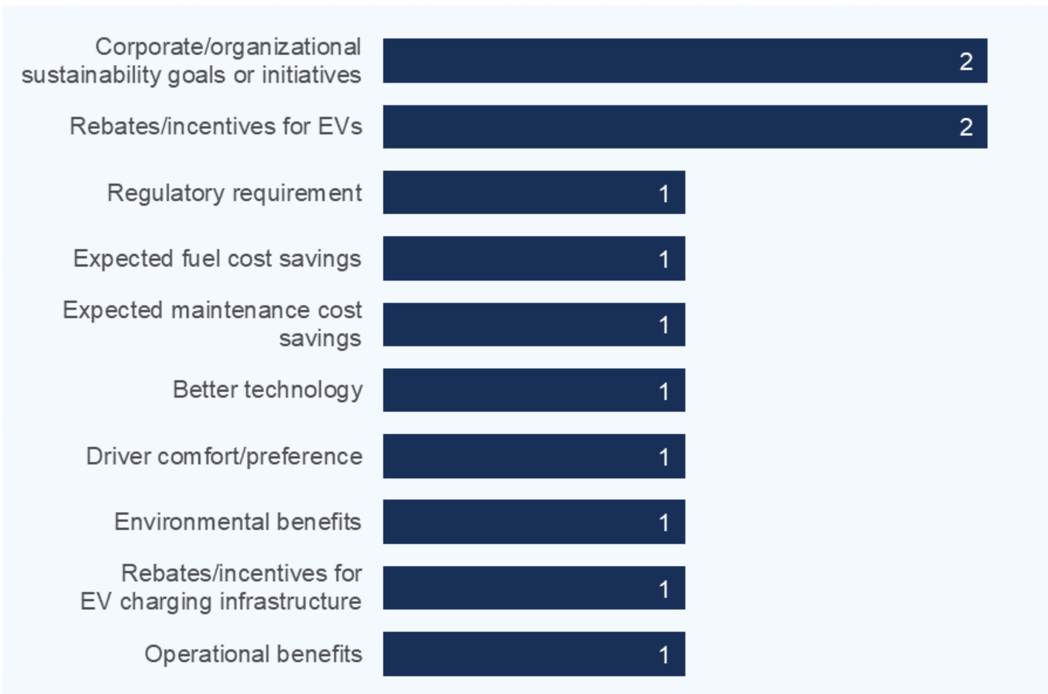
[a] One email was returned as undeliverable from the original sample (11).

Despite the Evaluation Team's efforts to improve the response rate through multiple rounds of outreach and the available survey incentives, the fleet manager survey did not reach the target response number, which limits the insights that can be gleaned from a smaller sample size.

Electrification Motivators and Barriers

The Evaluation Team asked fleet managers about their motivations for transitioning to EVs. As shown in Figure 182, the top motivators were corporate/organizational sustainability goals or initiatives (two respondents) and rebates/incentives for EV charging infrastructure (two respondents).

Figure 182. SDG&E PYDFF Program Participant Motivators for Transitioning to EVs in EY2023



Source: Fleet Manager Survey Question C1. "Why did your fleet decide to transition to EVs? Select all that apply." (n=2; multiple responses allowed)

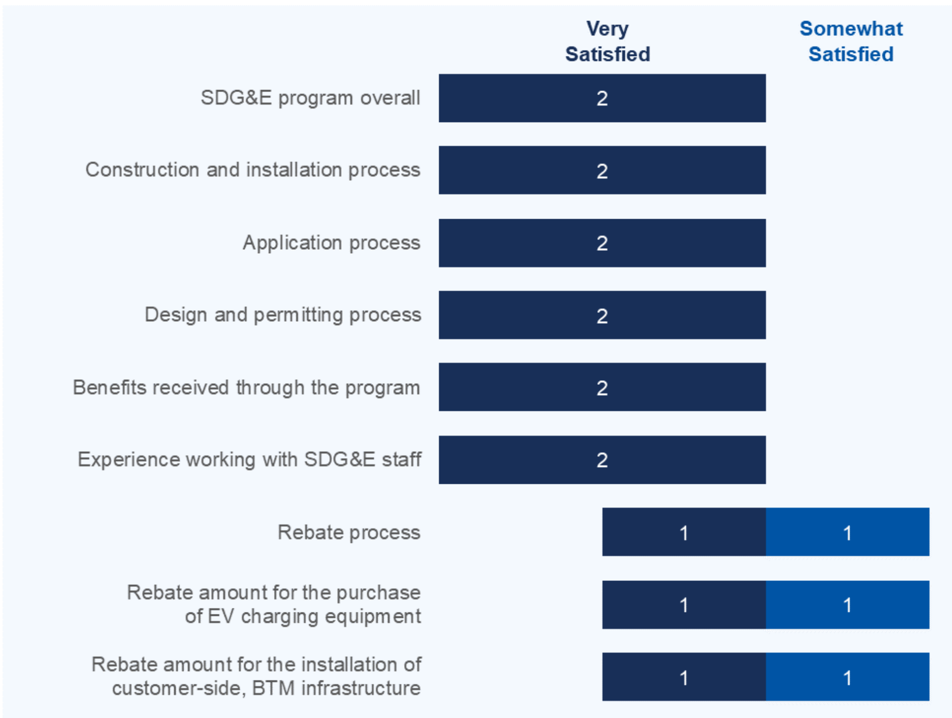
The Evaluation Team asked fleet managers which barriers to electrification their fleets faced before program participation and which barriers remained after participation. One fleet manager said a barrier prior to electrification was the **cost of EVs** and another said they had **site constraints**. After participating in the PYDFF program, this fleet manager still reported site constraints as the remaining barrier to electrification.

Program Satisfaction

When asked to rank the likelihood of recommending the PYDFF program on a scale of 0 to 10, with 10 being already recommended, one of two fleet managers had already recommended the program, while one fleet manager rated their likelihood as a 9. Together, these ratings led to a Net Promoter Score (NPS) of +100.[114]

Two of two managers rated their satisfaction with their overall program experience as *very satisfied*. For comparison, five of six fleet managers in EY2022 also rated their overall program experience as *very satisfied* or *somewhat satisfied*. As shown in Figure 183, both responding fleet managers rated themselves as *very satisfied* or *somewhat satisfied* with benefits received through the program. One fleet manager was particularly satisfied with the SDG&E support teams, stating they were *very satisfied* with the "ease and speed of the entire process" and the "staff was great to work with."

Figure 183. SDG&E PYDFF Program Satisfaction with Program Elements in EY2023



Source: Fleet Manager Survey Question B1. "Thinking about your experience with the Power Your Drive for Fleets program, how satisfied are you with the following?" (n=2).

As shown in Figure 183, one fleet manager was *somewhat satisfied* with the rebate process and rebate amount for EV charging equipment and installation of customer side, BTM infrastructure. One transit bus fleet manager provided a comment about their dissatisfaction with the program, stating that "**communication** at times was difficult. The turnaround time for minor changes or RFI took longer than it should have."

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114 The NPS is calculated by subtracting program detractors (those who rated their likelihood to recommend the program to others as a 0 through 6) from the program promoters (those who rated their likelihood to recommend the program as a 9 or 10). Those who gave a rating of 7 or 8 were labeled as passives and their scores did not negatively or positively impact the score.

One fleet manager shared what they would have done differently if they were going through the program again, stating they would "do more research on EV equipment and requirements. Verify lead times on equipment and not break ground until all equipment has been confirmed for delivery. Ensure an open line of **communication** between all stakeholders."

Program Awareness

The Evaluation Team asked fleet managers how they learned about the PYDFF program. One of two fleet managers learned about the program directly from SDG&E and one learned about the program from a contractor/engineer. Prior to joining the program, both fleet managers said they knew they needed to upgrade the electrical infrastructure from the Utility grid to their meter to charge EVs at their site.

Experience with EVs and Charging Infrastructure

When asked about the reliability and ease of using the EV charging equipment in their fleet, both fleet managers rated the equipment as *somewhat reliable*. When asked about reliability of the EVs, only one fleet manager responded and rated EVs as *not too reliable.*

Additionally, two of two fleet managers rated the ease of using EV charging equipment as *very easy to use* and *somewhat easy to use.*

Impact of Program on Fleet Electrification

The Evaluation Team asked fleet managers if they plan to accelerate their procurement of EVs and EV-related equipment because of their program experience. Two of two fleet managers said they will not make any change. However, when asked about the number of EVs they plan to acquire in the next 10 years, one fleet manager planned to procure two electric transit buses in the next 5 years and six in the next 10 years, and the other planned to procure seven medium-duty vehicles in the next 5 years and ten medium-duty vehicles in the next 10 years.

The team asked fleet managers if they changed the number of EVs they acquired or plan to acquire based on program participation. One of two fleet managers said their program participation caused them to increase the number of EVs they acquired by two (heavy-duty vehicle sector).

Industry Perspective

Fleet managers were asked how well their industry or sector is positioned for electrification. As shown in Table 121, the two fleet managers in transit and heavy-duty vehicle sectors who answered this question responded *neutral* and *not too well-positioned* and provided the following feedback:

- The transit bus fleet manager who rated the sector as *neutral* said, "technology is changing fairly quick, and we are still collecting data from pilot programs."
- The heavy-duty vehicle fleet manager who rated the industry as *not too well-positioned* said the "trucking industry is not ready."

Table 121. SDG&E PYDFF Program Industry Positioning for Electrification among Program Participants in EY2023

Market Sector	Extremely Well-Positioned	Somewhat Well-Positioned	Neutral	Not Too Well-Positioned	Not at All Well-Positioned
Heavy-Duty Vehicle (n=1)	–	–	–	1	–
Transit Bus (n=1)	–	–	1	–	–

Source: Fleet Manager Survey Question F1. "How well-positioned do you think your industry/sector is for electrification?" (n=2)
Note: No fleet managers provided a rating of *extremely well-positioned, somewhat well-positioned,* or *not at all well-positioned.*

When asked about the limitations of current EV options in their sector, one of one responding fleet managers in the heavy-duty vehicle sector stated range and load capabilities.

The Evaluation Team asked fleet managers whether, given what they know or believe about requirements for fleets to purchase zero-emission MDHD trucks, electric or diesel trucks seem like a riskier purchase in the next three years and in the next 10 years. Two of two fleet managers said that electric trucks are a riskier purchase in the next three years. One of two fleet managers stated that diesel trucks are a riskier purchase in the next 10 years, while the other said electric trucks seem like a riskier purchase.

Withdrawn Fleet Managers

In addition to the fleet managers who participated in the program, the Evaluation Team received a response from a fleet manager who withdrew from the program (known as a withdrawn fleet manager). This fleet manager was originally drawn to the program for a variety of reasons, including regulatory requirements, corporate goals, expected fuel/maintenance cost savings, available incentives, and environmental benefits.

When asked why they withdrew from the program, this fleet manager said the vehicle costs were too high, there was a lack of available EV types to meet their needs, and they were concerned about reliability. They said that allowing some flexibility for vehicle types would have allowed them to continue participating in the program.

In terms of additional support, they would have liked the withdrawn fleet manager reported improved make-ready infrastructure support on both the utility and customer sides. When asked what items the program should rebate, the fleet manager noted that construction costs and vehicle costs should be eligible for rebates.

The Evaluation Team asked the withdrawn fleet manager about their level of satisfaction with various program aspects. This fleet manager was *not too satisfied* with the program overall because "the capped requirements did not allow us to flexibility to choose what we need." However, they were *very satisfied* with the level of support from SDG&E and working with SDG&E staff and was *somewhat satisfied* with other program aspects. After withdrawing from the program, this respondent put the project on hold pending further funding.

Highlights

- Both fleet managers were motivated to participate primarily because of corporate/organizational sustainability goals or initiatives and rebates/incentives for EVs. However, the surveyed fleet managers also mentioned the cost of EVs (one mention) and site constraints as barriers to electrification (one mention).
- Both responding fleet managers rated themselves as *very satisfied* with their experience participating in the PYDFF program.
- One of two responding fleet managers learned about the program directly from SDG&E.
- One of two fleet managers had already recommended the program and the other rated their likelihood to recommend as a 9 out of 10.
- Both fleet managers rated the reliability of EV charging equipment as *somewhat reliable,* but agreed EV charging equipment is *somewhat* to *very easy* to use.
- One heavy-duty vehicle fleet manager said their industry is *not too well-positioned* for electrification.
- Both fleet managers reported no plans to accelerate procurement of EVs and EV-related equipment, however one fleet manager plans to procure eight electric transit buses in the next 10 years and the other plans to procure seventeen medium-duty vehicles in the next 10 years.
- The withdrawn fleet manager was frustrated with the lack of availability of EV types that could be eligible for the program.

Site Visit Findings

In EY2023, the Evaluation Team completed eight site visits (n=8) in the SDG&E territory across several market sectors: medium-duty, school bus, and transit bus. During the site visits, the Team collected qualitative and quantitative information that provided the Team with an understanding of fleet composition and operations. The team used site visits to verify aspects about sites such as the number of installed chargers, electric vehicle service providers (EVSPs) the fleet uses, types of EVs in use or scheduled for delivery, and physical influences on construction designs.

Table 122 provides a summary of charging site characteristics by market sector, including number of site locations visited, number of L2 and DCFC ports, and total charging capacity. In total, the SDG&E PYDFF program added 30 L2 ports, and 48 DCFC ports with nearly 4 megawatts (MW) of EV charging capacity in EY2023.

Figure 184 presents charging port and charging capacity of PYDFF program site visit locations by market sector for EY2023 and for the program to date.

Table 122. SDG&E PYDFF Program Quantity of Ports by Type and Installed Capacity, by Market Sector, EY2023 Sites

Market Sector	Number of Sites	L2 Ports	DCFC Ports	Total Installed Capacity (kW)
Medium-Duty Vehicle	5	12	14	1,003
School Bus	1	18	2	305
Transit Bus	2	-	32	2,765
Total	**8**	**30**	**48**	**4,073**

Figure 184. SDG&E PYDFF Program EY2023 and PTD Ports and Capacity

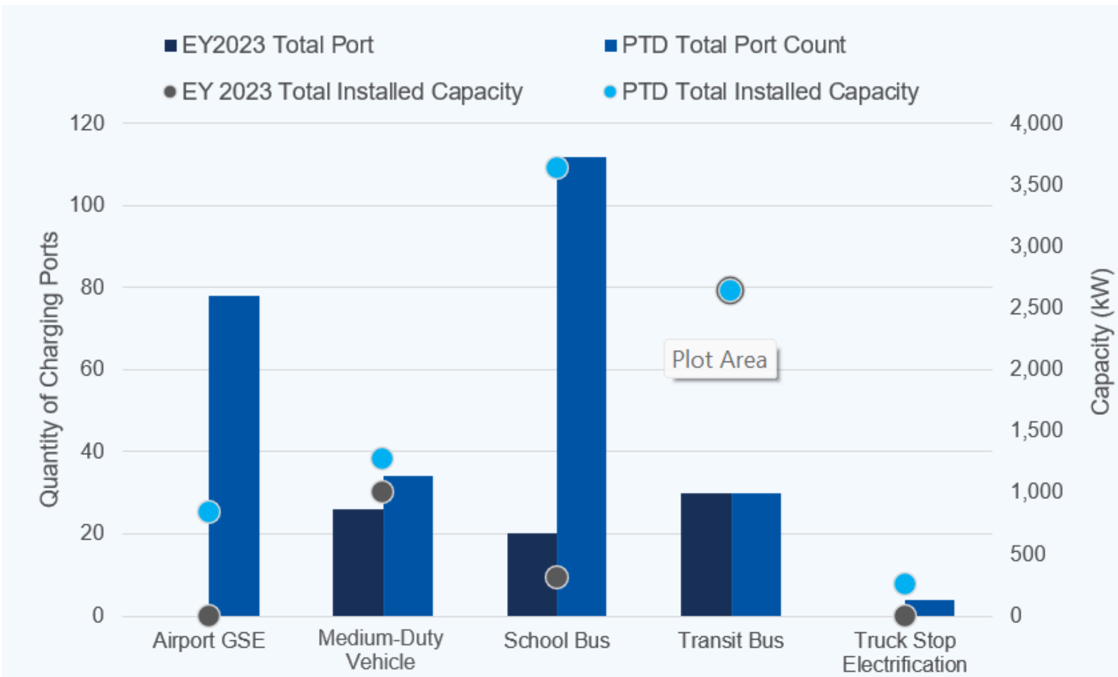
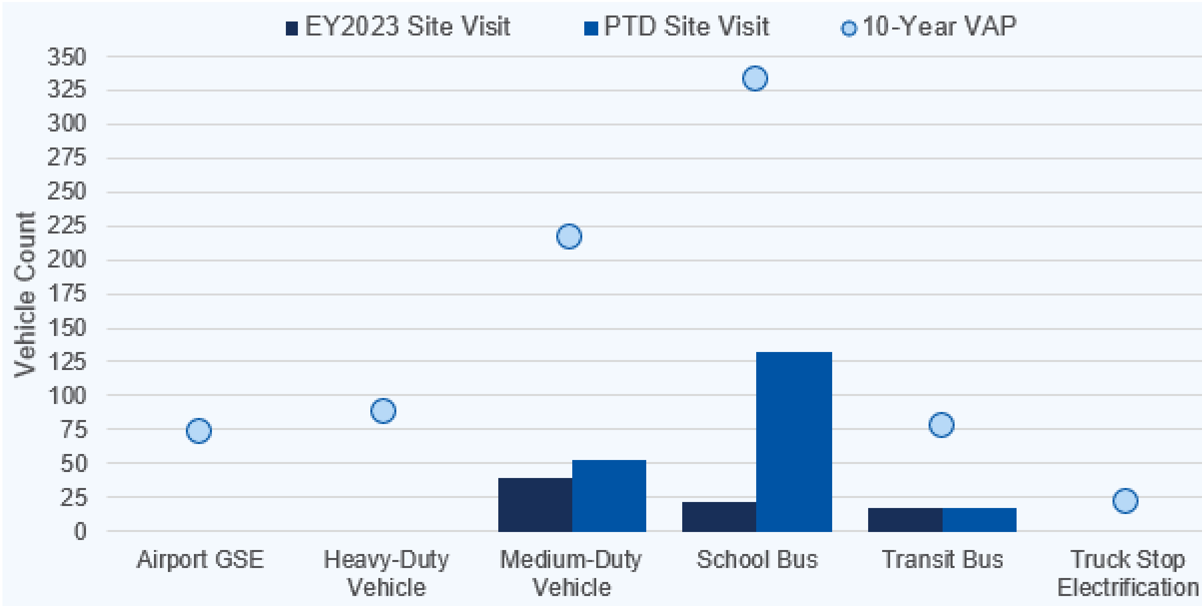


Figure 185 shows the counts of vehicles noted through site visits compared with 10-year VAPs. Although not shown in the figure, a comparison was also made to the VAP for vehicles anticipated through the end of 2023. Sites are not included that have not been completed even if their VAP lists prior years. The figure and analysis suggest that vehicle deliveries are not running on schedule and therefore most of the fleets have not yet acquired the vehicles per their agreement with SDG&E. Market sectors closest to plan include medium-duty vehicles and school buses. The transit bus market sector appears to have the largest gap between vehicles on site versus anticipated followed by airport GSE and truck stop electrification.

Figure 185. SDG&E PYDFF Program Comparison of Verified Vehicles to Long-Term VAP



During site visits, the Evaluation Team reviewed charge management capabilities and electrical infrastructure, discussed future vehicle/equipment replacement plans (including future vehicle adoption) and public funding sources and investigated whether fleets had an interest in on-site solar and/or battery storage. Site visits allowed the Team to obtain direct feedback from the individuals involved with operations and to identify EVSP points of contact to obtain charging session data.

The Team noted some challenges this year across market sectors. Some sites experienced significant delays or errors with installing switchgear and other critical infrastructure, attributed to communication gaps between site and program staff, leading to stakeholders (planning, construction, operators) falling out of alignment on site progress, process, and next steps. One of these sites discovered a mismatch between chargers they already had on site and the infrastructure that SDG&E ultimately installed. Another site experienced issues with Utility trenching blocking one of the facility entrances for approximately two months and with site inspection delays, while a third site required the modification and rework of newly poured transformer and switchgear pads.

Across SDG&E fleets, site staff reported maintenance, service, and reliability issues with both nascent and established vehicle and charging equipment manufacturers. Multiple fleets expressed feelings of uncertainty around the reliability of their vehicles, citing unexpected maintenance-related costs, recurring mechanical and electrical issues, and the inability to schedule load management in a sustainable and effective manner.

Despite these challenges, multiple sites explicitly noted that their communication with SDG&E program staff was excellent, and they felt they had been equipped with the tools and context needed to understand their site's progress through the PYDFF program. Similarly, vehicles were consistently well-regarded for their low noise and high performance when operating correctly. Most sites were also continuously refining their on-network charging management, with broad movement toward NSPs, which are able to intelligently and reliably manage demand and provide real-time status and feedback on any errors.

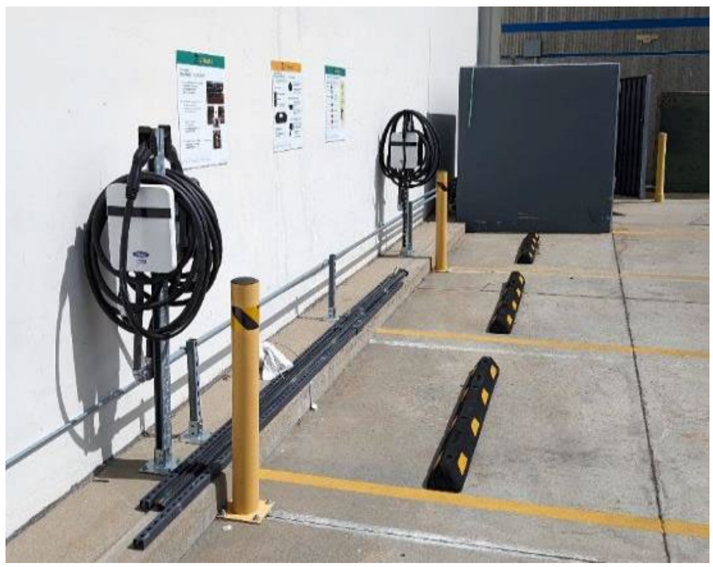
Vehicle-charger interoperability is not currently tested for charger/vehicle inclusion on the Qualified Products List offered by the Utility programs nor is validating an NSP's load management ability. A suggested improvement from several fleets across utilities would be to highlight known-good EVSE/NSP/vehicle pairings to minimize the risk of disruptions to basic service goals.

The following sections provide a summary of key observations and data collected during site visits, organized by market sector.

Medium-Duty Vehicles

In EY2023, the Evaluation Team conducted site visits to five medium-duty vehicle sites, encompassing 12 L2 and 14 DCFC ports and 1,003 kW of installed capacity. These sites operate a diverse variety of vehicles: EY2023 sites include shuttle vans, Class 2 pickup trucks, and cargo vans.

Figure 186. SDG&E PYDFF Program Vacated Medium Duty Fleet Site



Having monitored site charging behavior and energy consumption, the Evaluation Team noted that one medium-duty site showed little activity after February 2024. This site, which was activated in 2023, was vacated by the program participant as of the site visit in early 2024; however, the charging infrastructure remained installed and appeared to be powered (shown in Figure 186). This site served four medium-duty cargo vans with four 10 kW L2 chargers for less than six months. SDG&E is aware of this vacancy and is working with the site host and landlord to determine the appropriate pathway forward, giving the site one year to either find a replacement tenant who will make use of the EVSE or repay SDG&E for the cost of the installation. This is the second case of temporarily stranded assets for the SDG&E PYDFF program.

One additional site has encountered difficulties deploying charging stations it had already procured—a miscommunication between the site and their utility resulted in the installation of infrastructure that did not match the site's chargers. This required the site to acquire new chargers, which have not yet been installed. Additionally, delays in infrastructure installation led to the site placing chargers into storage for more than a year, during which time a dispenser for a bus charger was misplaced and ultimately lost. Due to significant delays in installation because the charging infrastructure was part of a major parking lot redevelopment effort, the site host reported that the chargers that came with the EVs were three years old by the time they were installed. While this site has significant TTM capacity installed (more than 5 MW) that is sized to support charging for nearly 60 bus parking spaces; currently only 10 EVSE are installed and activated with 13 additional disconnect switches, and electric conduit in all parking spaces to support EVSE installations planned for future expansion phases. When the Utility manages TTM installation but is not involved in the BTM installation, increased communication and coordination between the Utility and site are vital to avoiding these types of issues, especially in complex sites.

A third site experienced issues with the switchgear delivered not matching the specifications of the switchgear the Utility ordered; however, at the time of delivery, the switchgear pad had already been poured to match the dimensions of the switchgear the site was expecting. This required portions of the existing pad to be modified and repoured, delaying the site's implementation.

Despite this, the two remaining sites have expressed positive sentiment toward their EVs, with one noting that their drivers are thrilled with the vehicles and the other highlighting that the buses are used in high-constant operation with little downtime.

School Bus

In EY2023, the Evaluation Team conducted site visits of a single school bus site, totaling 18 L2 ports and 2 DCFC ports for a combined 305 kW of installed capacity. The size and scale of these deployments tend to be large, due to the size of the fleets and the common presence of dedicated vehicle storage and maintenance yards. This was the second charging infrastructure deployment for this site (Phase two); eight L2 chargers were installed in Phase one in EY2022. This is an example of a staged or phased site rollout, with site applying lessons learned from an initial rollout to make changes in subsequent phases.

Phased rollouts have proven to be beneficial in multiple cases, such as with one EY2022 activated school bus site that experienced significant technical hurdles with its NSP and plans to switch to an entirely new provider starting in the second phase. However, the repetitive nature of this approach can also lead to unexpected delays and complications, and a need to adjust approaches. The EY2023 site experienced an internal misalignment around the quantity of EVSE to purchase and install, leading to multiple infrastructure stub-outs provided in a previous phase that may be used in the future.

Transit Bus

In EY2023, the Evaluation Team conducted site visits of two transit bus sites, totaling 34 DCFC ports for a combined 2,765 kW of installed capacity.

Figure 187. Pantograph Charging System Installed to Serve a Transit Bus Site

At the time of the site visits, the two sites supported a combined 17 vehicles, representing nearly 10 MW of vehicle battery storage, with plans for additional vehicle procurement. Both sites have expressed plans for significant expansion in the coming years, with one site citing a procurement plan for 13 additional 60-foot electric buses by 2025. Both sites use approaches to high-powered charging that are relatively unique within the context of the PYDFF activated sites. One site uses an established manufacturer's new modular structure for DCFC, which allows for a higher throughput power than previous offerings. The other site uses a top-down pantograph system with integrated bus RFID authentication, seen in Figure 187. This site's pantographs are fed by a modular DCFC, a single EVSE power cabinet which can provide 180 kW of power to one connector, or 60 kW to each of the three, if all three are used at the same time.

Vehicles at both sites are still in the early stages of deployment—one fleet estimates that its vehicles will be able to cover roughly half of the ICE bus routes (EVs were rated at 175 miles of range on a single charge, with routes ranging from 50 to 320 miles), while the other fleet has deployed EVs on bus rapid transit routes in DACs. The novel deployments at both sites have improved the automated connection and authentication of the bus charging process, and the site's ability to dispense a flexible, reliable charge to its vehicles.

These routes were new services designed specifically for EVs to meet the conditions of a state grant aimed at improving both air quality and transit options within communities of concern. As vehicle operations mature and stabilize, the Evaluation Team will continue to monitor both fleets to understand how well the vehicles and charging infrastructure serve their respective duty cycles.

Highlights

- The Evaluation Team visited all eight sites across three market sectors that were activated in EY2023. These sites account for 30 L2 and 48DCFC ports.
- Medium duty vehicle sites accounted for five of eight EY2023 activated sites. The two transit bus sites energized 30 DCFC and accounted for two-thirds of the 4 MW of newly installed charging capacity.
- At the time of the site visits, both transit bus sites were still in the process of commissioning electric buses, with full deployment anticipated by mid-2024.
- MDHD sites experienced a number of issues with utility communication during construction, with two sites reporting delays with their installation processes (one on infrastructure rework and one on incompatible infrastructure) resulting primarily from supply chain issues.
- Consideration of stranded assets arose at two sites: one was activated and then vacated by the tenant after approximately six months of operation and the other had extremely low usage through 2023 and might not experience a significant increase until the end of 2024 or even later.

Deep Dives

The Evaluation Team conducted deep dives in EY2023 for three sites in the PYDFF program. The team selected deep dives from sites completed in 2022 that had significant demand, energy consumption, or installed charging capacity. The team was also interested in sites with a demonstrated ability to expand charging infrastructure, the presence of load management, unique vehicles or charging equipment, a large fleet size, and/or a fleet manager who was willing to participate.

The three sites selected were a regional air transportation hub operating electric GSE and shuttle vans, a school district operating Type D electric school buses, and a parking operator operating electric shuttle vans. The Evaluation Team conducted in-depth fleet manager interviews and analyzed advanced metering infrastructure (AMI) and EVSP data as part of the deep dives. During fleet manager interviews, the team requested permission to conduct fleet driver surveys but did not receive responses from the participating fleets.

Findings presented in this section are based on the fleet manager interviews and data analysis. The *Deep Dive* section presents more detailed case studies on each of these fleets.

Ground Support Equipment and Shuttle Sites

The Evaluation Team selected an operator that maintains two discrete sites due to the deployment of unique vehicles and varied duty cycles. One of the operator's sites operates electric aircraft GSE and the other operates shuttle vans.

As of the time of writing, the operator had 105 electric ground support vehicles, a mix of previously operated and recently acquired vehicles, skewed towards the former. The operator charges their GSE on 40 kW DCFCs, with charging primarily taking place between 10 p.m. and 4 a.m. and shorter charging opportunities during the airport's normal operating hours of 6 a.m. to 9 p.m. The operational patterns lend well to avoiding energy consumption during the 4 p.m. and 9 p.m. peak period, with only approximately 15% of monthly energy consumption during the period.

The shuttle van chargers were not yet networked at the time of the fleet manager interview, and Utility AMI data was unavailable for public reporting. However, NSP data is available from a temporary, non–AB 1082/1083 DCFC charging location on the site's property, which is currently serving as the primary charging site for the fleet. At the temporary location, the shuttle vehicles follow a parabolic trend in terms of charging sessions started each hour, which peaks around 12 p.m. and reaches its minimum at midnight. Over the site's NSP data record (April 2023 to September 2023), total monthly energy dispensed and the county of monthly sessions on the temporary chargers have steadily decreased. This decreased demand may be due to several factors, but based on anecdotal conversations with site personnel, the EVs and chargers have likely been removed from service for maintenance or repairs.

The fleet manager noted that site planning and coordination and charger reliability are areas for improvement. At the shuttle lot, the fleet encountered a communication issue during planning and installing its charging equipment. The power requirements for the charging stations were not properly communicated to project designers, resulting in TTM and BTM that does not supply the correct power levels for the charging stations that were already on-hand. The fleet manager was also dissatisfied with the pace of coordination and execution of the shuttle lot site. At the time of writing, only one out of six of the chargers were installed with no timeline for the installation of the remainder. The fleet manager noted that these chargers are already out of date and of questionable reliability given their experience with an identical charger model at the temporary charging location.

However, the operator noted that many of the airlines are enthusiastic and ambitious about moving forward with their EV procurements. Procurement for GSE vehicles has tended to occur in advance of infrastructure installation.

Medium-Duty Site

The Evaluation Team selected a medium-duty site operating Class 4 shuttle vans for a deep dive due to its deployment of retrofitted EVs, its unique, long-duration operating schedule, and a high proportion of EVs in its fleet. The site charges its vehicles using a combination of 50 kW DCFCs and 25 kW DCFCs. The EVs operate between 5 a.m. and 12 a.m. seven days per week.

A major issue for the site is ongoing, recurring mechanical EV failures. The site indicated that the EVs have had repeated driveline component failures, including rear differential gears and driveshafts. The site's mechanics and service technicians believe these failures are related to the stock components being used, which are built for ICE loads and less intense torque from acceleration and engine braking. Additionally, a key partner for the site's EV manufacturer has ceased business operations and is no longer offering manufacturer support.

The medium-duty site implemented load management by instituting a 150-kW system load cap across its chargers starting around October 2023. The site explored additional demand management strategies but ultimately did not pursue them because of EV reliability issues. The considered demand management strategy would have required rotating EVs in and out of service over the course of a normal shift, and the fleet did not have enough spare vehicles to make this viable.

The fleet manager believes they electrified their fleet too quickly and has found it necessary to lease ICE vehicles to have the operational flexibility required to fulfill their duty cycles. The bankruptcy and dissolution of a key vehicle stakeholder added complexity and uncertainty to operations, and the site is exploring their options for alternative vehicle manufacturers and models to understand how best to move forward. The site does plan to continue operating ZEVs because of cost savings and the ability to claim LCFS credits and is interested in understanding how best to capture value from charging operations.

School Bus Site

The Evaluation Team selected a school bus site for a deep dive site due to its interesting mix of vehicles and charging setups, with two vehicle manufacturers and two types of DC charging infrastructure – four 3-dispenser, sequential DC fast charging setups and 3 conventional standalone DCFCs. The site charges its EVs in three shifts, five days per week: a moderate-power period from 12 a.m. to 5 a.m.; a higher-power, opportunity-charging period from 8:30 a.m. to 2 p.m., and a charge-managed period from 3 p.m. to 9 p.m.

The site has encountered significant issues with sequential charging, leading to elevated dissatisfaction among drivers. The site's NSP set the transition point for rotation to 100%—meaning that vehicles need to reach 100% battery state-of-charge before the setup will begin charging the next vehicle in line. The nature of EV battery chemistry means that the vehicles' DC Fast charging curve—the rate at which energy is added to the battery—is nonlinear, with the last 15% to 20% charging at significantly diminished rates compared to the initial 75% to 80%. By forcing vehicles to charge to 100%, the NSP is spending more time ensuring that a single vehicle is fully charged rather than ensuring that all connected vehicles receive a minimum viable level of charge. Coupled with ongoing communication issues with their NSP and third-party contractor, this has resulted in consistent issues with vehicles not having enough charge to fulfill their duty cycles.

In addition to the charging issues, the site has experienced problems with their bus reliability. Initially, their buses experienced issues with phantom drains on their 12V batteries when the vehicles were sitting for extended periods of time. A subset of their vehicles – all from a single manufacturer – then began experiencing issues with their onboard electronics, requiring a return and repair under their manufacturer's warranty.

The combination of these factors has led to a widespread loss of confidence in the EV buses among the fleet's drivers. However, a second phase of buses and chargers is being delivered and installed, using lessons learned from their initial deployment, and the fleet is optimistic about their pathway forward. The site is additionally examining the option of selling their LCFS credits on third-party markets as an additional source of revenue.

Highlights

- All three fleets have encountered significant issues with their vehicles, including driveline hardware failures and electronics issues, and a variety of electrical issues, which have resulted in significant downtime for their fleets. One fleet that chose to electrify almost the entirety of its vehicles was forced to lease a conventional vehicle to be able to continue reliable service.
- One fleet found that its NSP has contributed to significant issues with site operations. Communication breakdowns between the site and the third-party charging manager and subcontracted NSP have led to dissatisfaction among both drivers and fleet managers.
- One fleet experienced issues in the site planning phase, which led to additional delays and expenses as the chargers bundled with the vehicles were not compatible with the infrastructure installed at the site. Breakdowns in communication during the site design process resulted in the installation of electrical service that was incompatible with the chargers already on site.
- One site has been significantly underutilized due to issues with the EVs and problems with procuring and installing chargers. Due to the delays the site experienced with site installation and commissioning, its planned transit bus chargers are older models designed for 60 kW of output, but its recently acquired vehicles are capable of receiving significantly higher power. The older models paired with the newer vehicles decrease the site's overall charging adequacy

Co-Benefits and Co-Costs

Through fleet manager surveys, deep dive fleet manager interviews, and site visits, the Evaluation Team identified several co-benefits and co-costs associated with the PYDFF program's vehicle electrification sites.

Fleet Manager Surveys

The fleet manager surveys used both aided (asking fleet managers if they have noticed a specific co-benefit or co-cost) and unaided (open-ended) questions to assess co-benefits and co-costs.

Table 123 shows that fleet manager respondents expected to realize some significant benefits for their community or fleet because of electrifying. The responding two fleet managers had the highest expectations about reduced noise pollution and improved driver comfort/convenience. Additionally, one fleet manager said "more data on buses, equipment and operators will be available to help increase efficiency in operations. Use of operator data will help in future training efforts, bus/equipment data can help adjust services blocks."

Table 123. SDG&E PYDFF Program Benefits Fleet Managers Reported from Electrification in EY2023

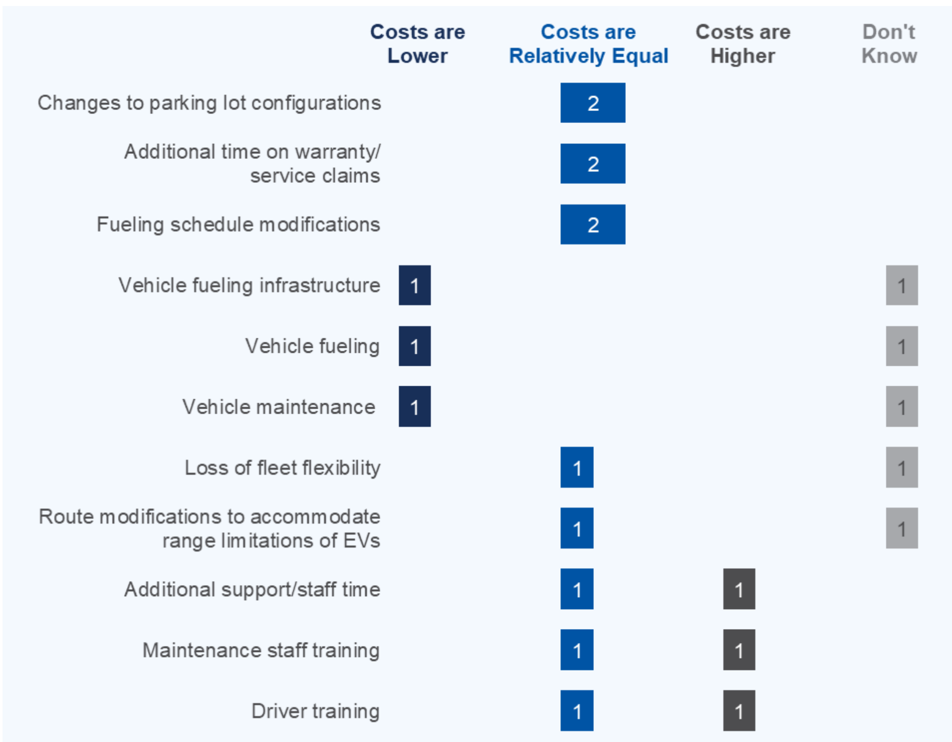
Benefit	Significant Benefits	Some Benefits	No Benefits	Not Sure
Reduction in noise pollution	2	–	–	–
Improved air quality/health	–	1	–	1
Improved driver comfort/convenience	–	2	–	–
Encourages other individuals/fleets to convert to EVs	1	1	–	2
Increased fleet flexibility	–	–	2	–

Benefit	Significant Benefits	Some Benefits	No Benefits	Not Sure

Source: Fleet Manager Survey Question D1. "What ancillary benefits do you think will be realized for your community/fleet as a result of electrifying?" (n=2)

Figure 188 shows the surveyed managers' responses to questions on the observed cost changes associated with operating and maintaining EV fleets. One of the two fleet managers reported that *costs are lower* for vehicle fueling and vehicle fueling infrastructure and vehicle maintenance. Both fleet managers reported that for changes to parking lot configurations, additional time for warranty/service claims, and fueling schedule modification, *costs are relatively equal* to the costs for these activities before electrification. One fleet manager said *costs are higher* for additional support/staff time, maintenance staff training, and driver training.

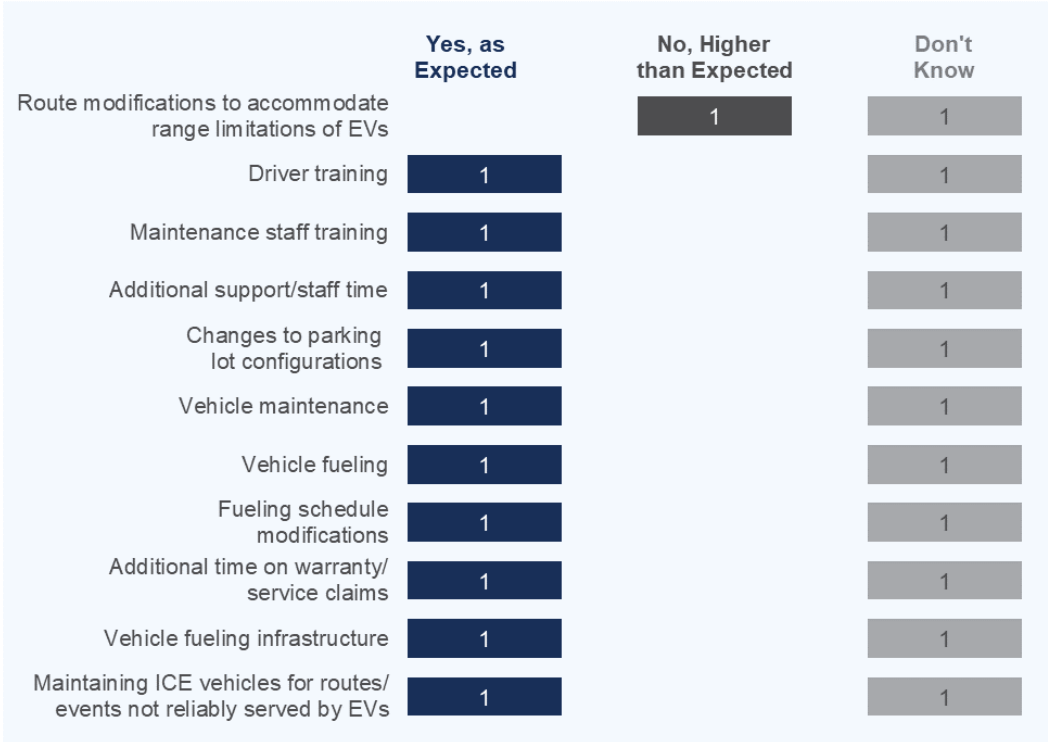
Figure 188. SDG&E PYDFF Program Observed Cost Changes since Electrification in EY2023



Source: Fleet Manager Survey Question E1. "Please think about all the costs associated with operating and maintaining your fleet. For each cost type shown below, please estimate how much the cost has changed since transitioning your fleet to EVs." (n=2)

The Evaluation Team also asked fleet managers to what extent operational and maintenance cost changes aligned with their expectations prior to electrifying their fleet. As shown in Figure 189, one fleet manager said costs were *as expected* for all categories except route modifications to accommodate range limitations, which were *higher than expected.* One fleet manager responded *don't know* for all categories when asked if costs after electrification were as expected.

Figure 189. SDG&E PYDFF Program Differences between Electrification Expectations and Costs in EY2023



Source: Fleet Manager Survey Question E2. "Have these operational and maintenance costs been what you expected?" (n=2)

Deep Dive Fleet Manager Interviews

The Evaluation Team conducted deep dive interviews with two SDG&E fleet managers to assess the co-costs and co-benefits of TE for fleets and fleet drivers. During the interviews, fleet managers noted two primary costs:

- **Communication and installation issues.** One fleet manager noted that plans for their initial charger deployment had been disrupted by the installation of infrastructure that was incompatible with the chargers bundled with their buses based on a miscommunication of equipment requirements. Utility delays around installing Utility-TTM infrastructure forced the site to place their chargers into storage for upwards of three years, during which time a dispenser associated with a 100-kW power cabinet was lost. The fleet manager also reported that the chargers being installed as of 2023 are already outdated (from their perspective as faster charging has become available within the industry, not necessarily in review of data), with the chargers dispensing 50-60kW while their vehicles are capable of receiving substantially higher power, significantly increasing charging times.
- **EV reliability.** Both surveyed fleet managers have encountered problems keeping most of their current fleet of EVs operational. This is due to a combination of software, electrical, and hardware issues, though hardware issues were specifically identified by a fleet operating EV-

retrofitted ICE vehicles. This fleet manager shared that fleet vehicles frequently experienced mechanical failure of critical driveline components, including differentials, driveshafts, and axles, inferred to be the result of utilizing components not specifically designed for the torque loads associated with heavy-duty EV operation. The other fleet manager said most problems were with ancillary systems, including HVAC, brakes, and air compressors, which frequently removed vehicles from operation for extended periods of time.

Both fleet managers characterized their experience with their vehicles as positive overall when the EVs were operating correctly, with one respondent specifically noting the proactive and responsive nature of their EVSP and the other highlighting good collaboration and active load management with their EVSP. One fleet manager noted that some of their operational difficulties were remedied when a third-party entity started managing their buses.

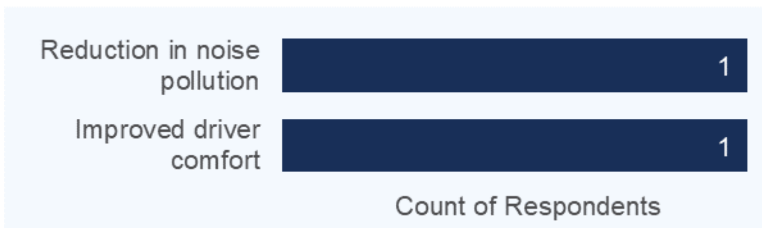
Fleet Driver Surveys

The Evaluation Team reached out to the single active participating deep dive site to attempt to field surveys with their drivers – however, the team did not receive a response and was thus unable to derive any insights around driver perceptions of the vehicle and charging deployment.

Additional Insights from Site Visits

To inform co-costs and co-benefits findings, the Evaluation Team examined qualitative insights from site visits to all eight EY2023 activated sites in the PYDFF program. Many of these sites were activated in the second half of 2023 and unable to determine co-costs and co-benefits at the time of visit due to limited experience with EV and charging infrastructure operation. As shown in Figure 190, reductions in noise pollution and improved driver comfort constituted the only reported co-benefits of fleet electrification (1 site each).

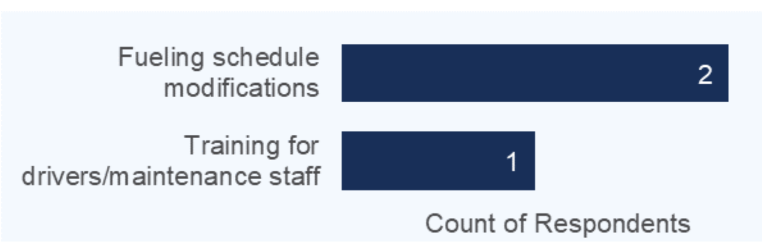
Figure 190. SDG&E PYDFF Program Co-Benefits Identified during Site Visits



Source: Site Visit Prompt. "What ancillary benefits have been realized for your fleet/community as a result of electrifying?" (n=2)

Figure 191 displays the frequency with which co-costs were reported during site visits. The most commonly reported co-cost associated with fleet electrification was fueling schedule modifications (two sites). Additionally, one site contact reported that their drivers and/or maintenance staff required additional training.

Figure 191. SDG&E PYDFF Program Co-Costs Identified during Site Visits



Source: Site Visit Prompt. "What challenges, if any, has your fleet/community experienced as a result of electrifying?" (n=3)

Highlights

- The responding fleet managers expected to realize some significant benefits for their community or fleet because of electrifying. The two fleet managers had the highest expectations about reduced noise pollution and improved driver comfort/convenience.
- One of two fleet managers reported costs are lower for vehicle fueling infrastructure and vehicle maintenance. For one fleet manager, costs were higher for additional support/staff time, maintenance staff training, and driver training.
- One fleet manager said costs were as expected for all categories except route modifications to accommodate range limitations, which were higher than expected.
- Of eight activated sites in EY2023 most were activated in the later part of the year and therefore had limited experience with EVs and charging operation. During site visits two operators acknowledged reduction in noise pollution as a co-benefit and fueling schedule modifications as a co-cost of fleet electrification.

Site Costs

The Evaluation Team conducted a cost analysis of 12 sites with fully closed out finances as of December 31, 2023, including EY2021, EY2022, and EY2023 sites. The set of fully closed out sites is smaller than the set of activated sites because of the time lag involved in collecting receipts, paying invoices, administrative approvals, etc. The 12 sites included 8 school bus sites, 3 medium-duty vehicle sites, and 1 airport GSE site. Sites included a mix of L2 and DCFC ports and averaged 14.5 ports and 367 kW of installed capacity per site.

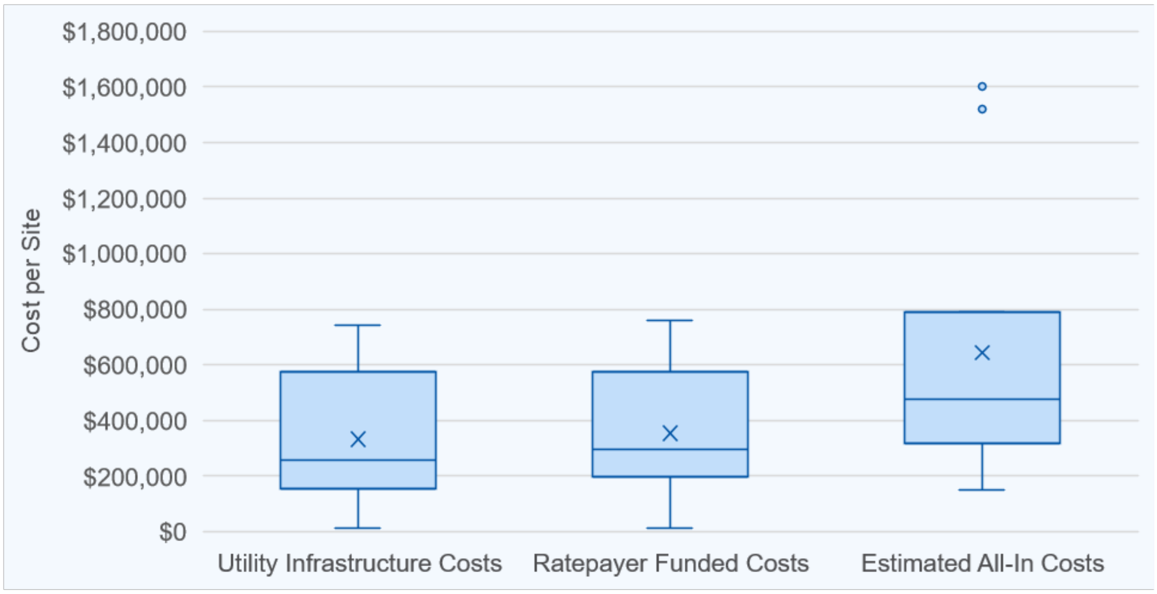
Figure 192 shows the distribution of site-level costs of the 12 sites. The horizontal lines of the boxes show the 25th, 50th, and 75th percentile of sites; the "x" represents the mean site cost; and the three panels are defined as follows:

- **Utility Infrastructure Costs**. Site costs borne by the Utility for TTM and BTM rebates.[115]
- **Ratepayer-Funded Costs**. All site costs paid for by the Utility, including TTM, BTM (or BTM incentive if infrastructure is customer owned), and EVSE rebate.

[115] Values are the same as the Ratepayer-Funded Costs, without the inclusion of the EVSE estimates.

- **Estimated All-in Costs.** The estimated total cost of installing the site, including capital and labor costs for the Utility and the customer. The value includes the actual TTM costs[116], the actual or estimated BTM costs,[117] and the estimated EVSE costs.[118]

Figure 192. SDG&E PYDFF Program Per Site Costs Organized by Three Perspectives, Across Closed-out Sites



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[116] The Utility pays 100% of the TTM costs therefore reports actual TTM costs to the Evaluation Team.

[117] The Evaluation Team receives actual BTM costs for sites with Utility-owned BTM. In total, nine of the 12 sites have utility-owned BTM. For the two customer-sponsored BTM sites, the BTM cost is estimated using an equation developed using actual BTM costs: for DCFC ports, the BTM cost per kilowatt is $\$11{,}6133 * Installed\ kW^{-0.541}$. For L2 ports, the cost per kilowatt is $\$42{,}975 * Installed\ kW^{-0.705}$.

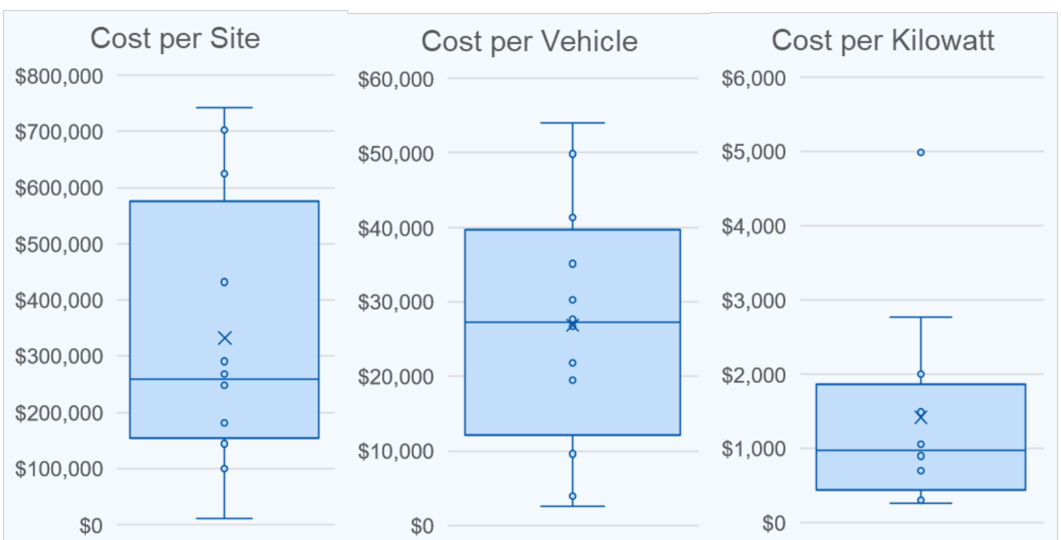
[118] Since actual EVSE costs are not known by the Utility, The Evaluation Team estimates EVSE equipment costs using an assumption of $3,000 per port for L2 ports.

Figure 193 shows average all-in costs for the 12 sites. EVSE is the largest cost across the sites, followed by BTM, then TTM. Together, the average estimated all-in TTM, BTM, and EVSE cost is $644,103.[119]

Figure 194 shows the distribution of utility infrastructure costs (corresponding to the far-left panel in Figure 192) presented per site, per vehicle, and per kilowatt. The average Utility infrastructure cost of TTM and BTM borne by SDG&E across sites was $354,599 per site,[120] $26,868 per vehicle, and $1,418 per kilowatt.[121]

Figure 193. SDG&E PYDFF Program Average All-In Costs Across 12 Sites

Figure 194. SDG&E PYDFF Program, Utility Infrastructure Cost per Site, per Vehicle, and per Kilowatt for 12 Sites across EY2021, EY2022, and EY2023



119 Calculated by summing all TTM, BTM, and EVSE costs borne by SDG&E and the customer, then dividing by the number of sites.

120 Calculated by summing all TTM and SDG&E-sponsored BTM costs and dividing by the number of sites. Number reflects maximum infrastructure rebate offered for sites that have not yet applied for rebates, which may vary significantly from actual infrastructure rebate amount paid.

121 Calculated by summing all TTM and SDG&E-sponsored BTM costs and dividing by the sum of installed capacity.

Highlights

- All-in costs paid by the customer and SDG&E vary widely between sites, with an average of $644,103 per site. EVSE was the largest cost across the sites accounting for nearly half of the total, followed by BTM, then TTM.
- The average cost of SDG&E-sponsored TTM and BTM across sites was $354,599 per site, $26,868 per vehicle, and $1,418 per kilowatt.

Grid Impacts

This section describes grid impacts for the PYDFF program based on an analysis of energy consumed and customer bills by operational charging stations installed through the program in EY2023.

Data Sources

The primary data source used for the analyses detailed in this section is the energy usage-related data provided in regular 15-minute intervals from the AMI. Other data sources include customer bills, LCFS program information, and charging session-specific data provided by NSPs. There are several important differences between AMI and NSP data. While AMI data only provides energy usage, NSP data also includes session start and stop time, the duration of a vehicle's connection to a charging port, the duration of a vehicle actively pulling power, and the specific port used for a session. AMI meters track standing loads (such as those the EVSE uses for communications, cooling, active power converters, solenoids, and screens), which NSPs typically cannot do. In instances where AMI data is missing from the dataset, the Evaluation Team uses NSP data to fill the gaps.

Summary of Grid Impacts

Table 124 presents the estimated PYDFF program grid impacts.

Table 124. SDG&E PYDFF Program Grid Impacts

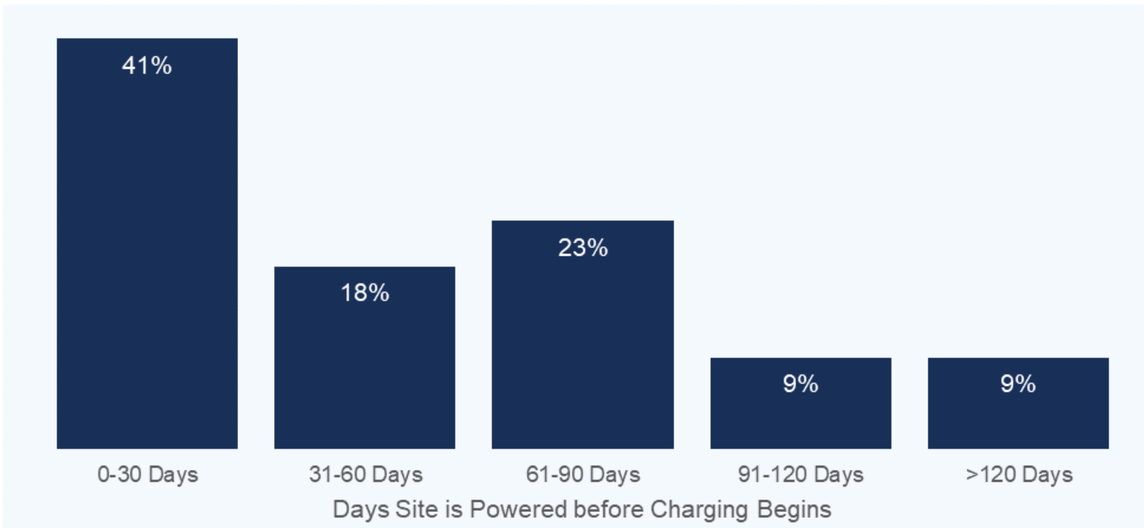
Impact Parameter	2023 Actual	PTD Actual	10-Year Projection
Operational Sites	21	21	21
Installed Charging Capacity, kW	3,948	8,502	8,502
Electric Energy Consumption, MWh	1,622	2,120	26,388
On-Peak (4 p.m. to 9 p.m.) MWh (percentage of total)	401 (24.7%)	552 (26.0%)	N/A
Maximum Demand, kW (date and time)	1,633 (9/18/23: 9:15 a.m.)	1,633 (9/18/23: 9:15 a.m.)	N/A
Maximum On-Peak Demand, kW (date and time)	1,052 (11/29/23: 5:30 p.m.)	1,052 (11/29/23: 5:30 p.m.)	N/A

Energy Trends

Site Startup

The Evaluation Team examined the duration between PYDFF site activation and operational status to illustrate the timing relationship between readiness of charging infrastructure and actual vehicle charging. AMI data demonstrates that 82% of sites had significant operations within 90 days of activation, as illustrated in Figure 195. However, as shown in the final column, nearly 20% of sites are not in use at least three months after activation. At least one site may take a full year before any vehicles are delivered and available to charge.

Figure 195. SDG&E PYDFF Program Percentage of Sites by Days between Activation and Operation for PTD Sites



Consumption and Maximum Demand

Figure 196 depicts the growth of SDG&E's monthly energy consumption and maximum demand for all operational sites in the PYDFF program to date. In EY2023 both consumption and maximum demand increased as new sites became operational.

The PYDFF program sites collectively reached 1.6 MW of demand at the end of 2023, with installed capacity of 8.5 MW, nearly doubling 4.6 MW installed in the previous years. As detailed in the *Site Visit Findings* section, this gap is likely due in part to operators still gaining expertise and working out EV reliability and operations issues. In addition, all fleet sites activated in 2023 had vehicles that had not yet been delivered or deployed, and some did not yet have an estimated delivery date. Comparing the early 2023 demand of approximately 500 kW to the peak demand of more than 1.6 MW in late 2023 shows that demand for PYDFF program sites more than tripled in 2023. Energy consumption has similarly increased significantly for the PYDFF program sites in recent months. Figure 196 shows the final two months of 2023 each doubling the monthly consumption observed in the first half of 2023.

Figure 196. SDG&E PYDFF Program Monthly Energy Consumption and Maximum Demand for PTD Sites

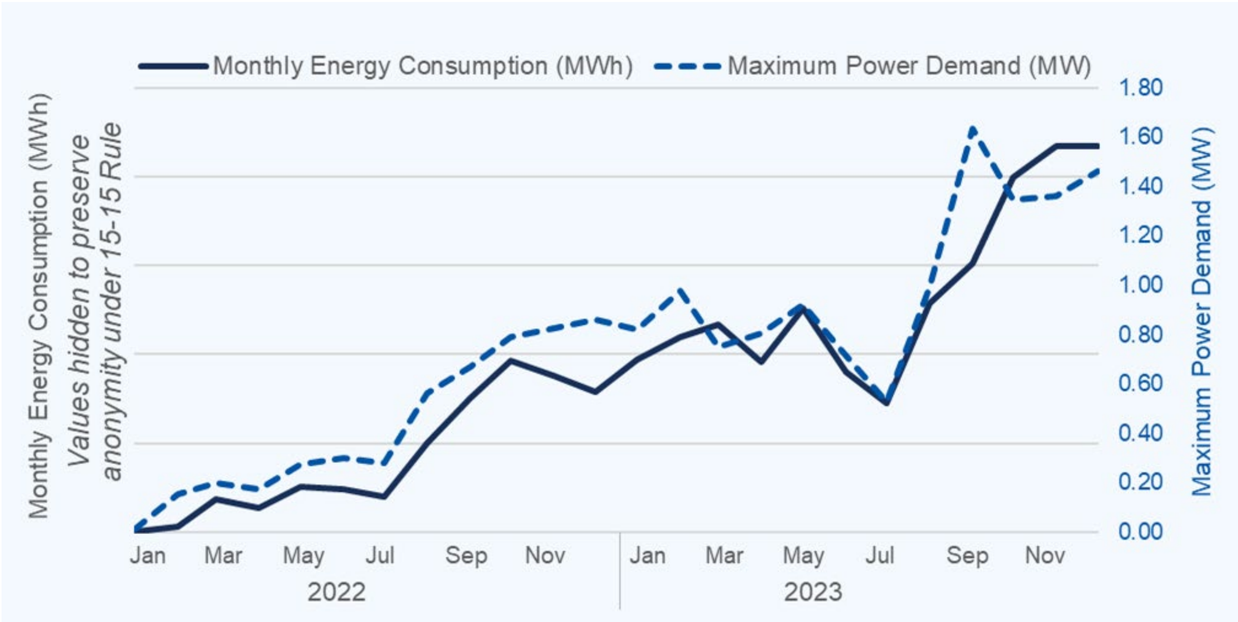
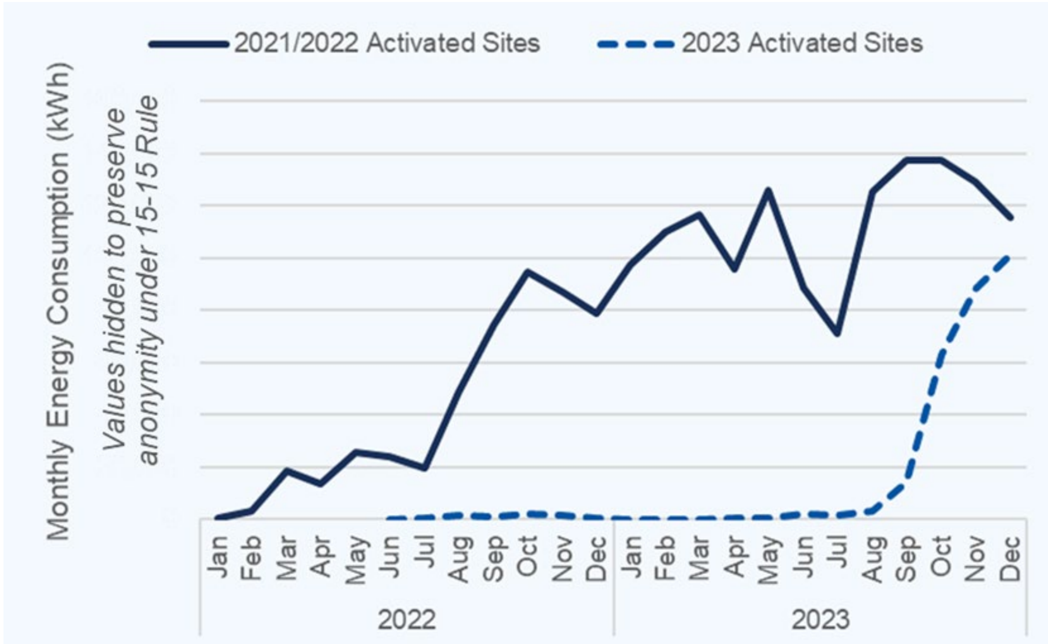


Figure 197 provides insight into monthly energy consumption trends of activated sites by program reporting year. Monthly energy usage of sites activated prior to 2023 continues to increase throughout 2023 but seems to level off as sites approached the middle of 2023. A noticeable dip is evident during the summer due to significantly reduced school bus operations when the schools are not in session. The monthly energy consumption of the sites activated in 2023 shows significant growth in the fourth quarter of 2023 and nearly matches the monthly energy use of sites activated in 2021 and 2022. Based on the historical trends of activated sites not reaching maturity for up to 12 months, monthly energy use of sites activated in 2023 is likely to continue increasing before leveling off in 2024.

Figure 197. SDG&E PYDFF Program Monthly Energy Consumption of Sites Grouped by Initial Reporting Year



Daily energy consumption and demand across all sites continue to increase. However, there are wide variations in daily energy consumed, as well as consumption between weekdays and weekends as shown in Figure 198. In the final months of 2023, sites reached a new maximum power demand of 1,633 kW, nearly doubling the 2022 maximum of 860 kW. The maximum demand represents 19% of 8.5 MW installed capacity. While maximum daily power demand values trend upward with time as seen in Figure 199, they are inconsistent. As noted in *Site Visit Findings*, one new site does not expect any usage until late 2024 because it is awaiting EV delivery, and another site's fleet vacated when its property lease expired. Both sites represent built-out charging capacity that is currently not utilized and therefore not contributing to the maximum power demand.

Figure 198. SDG&E PYDFF Program Daily Energy Consumption for PTD Sites

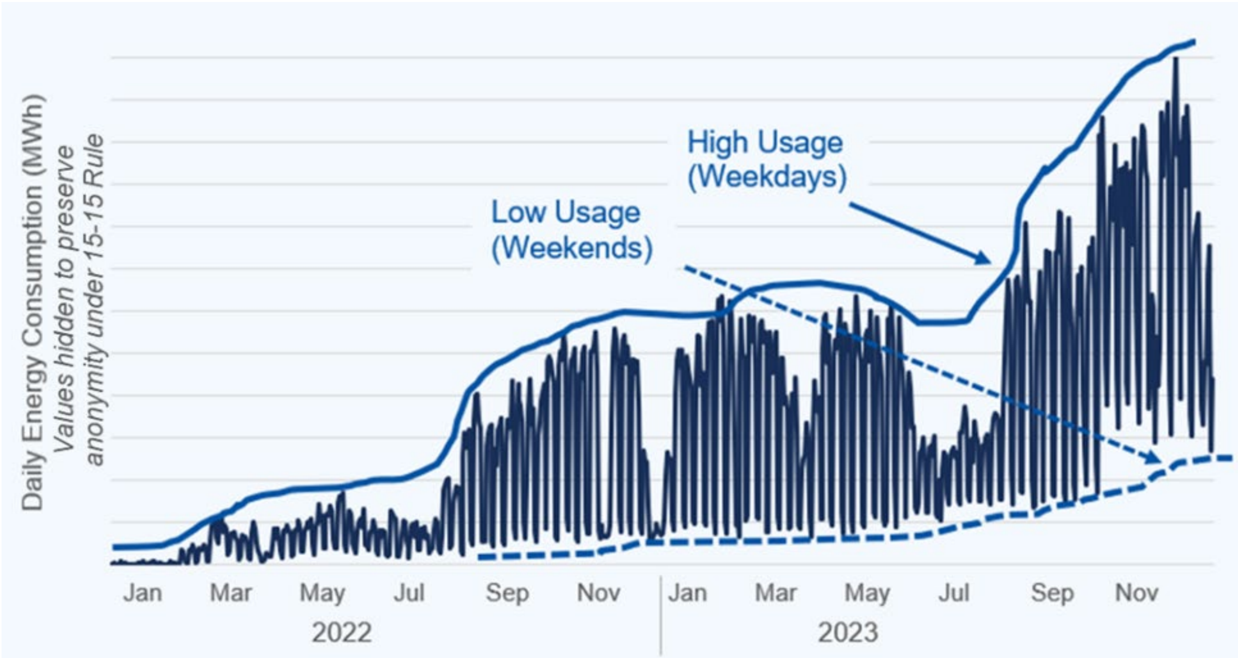
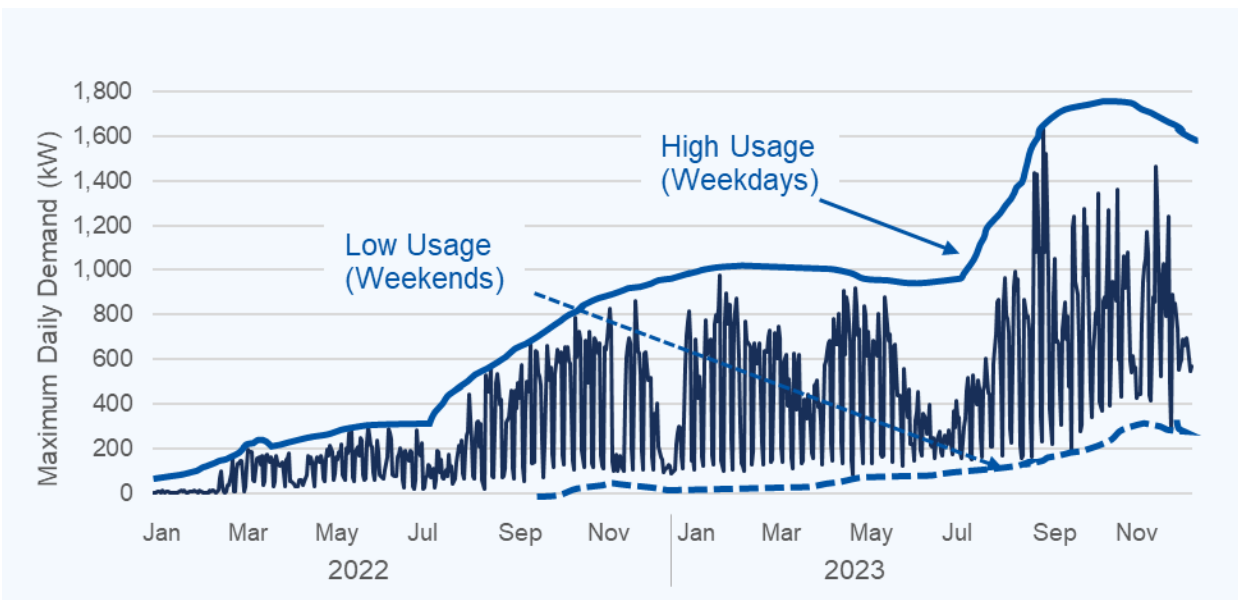
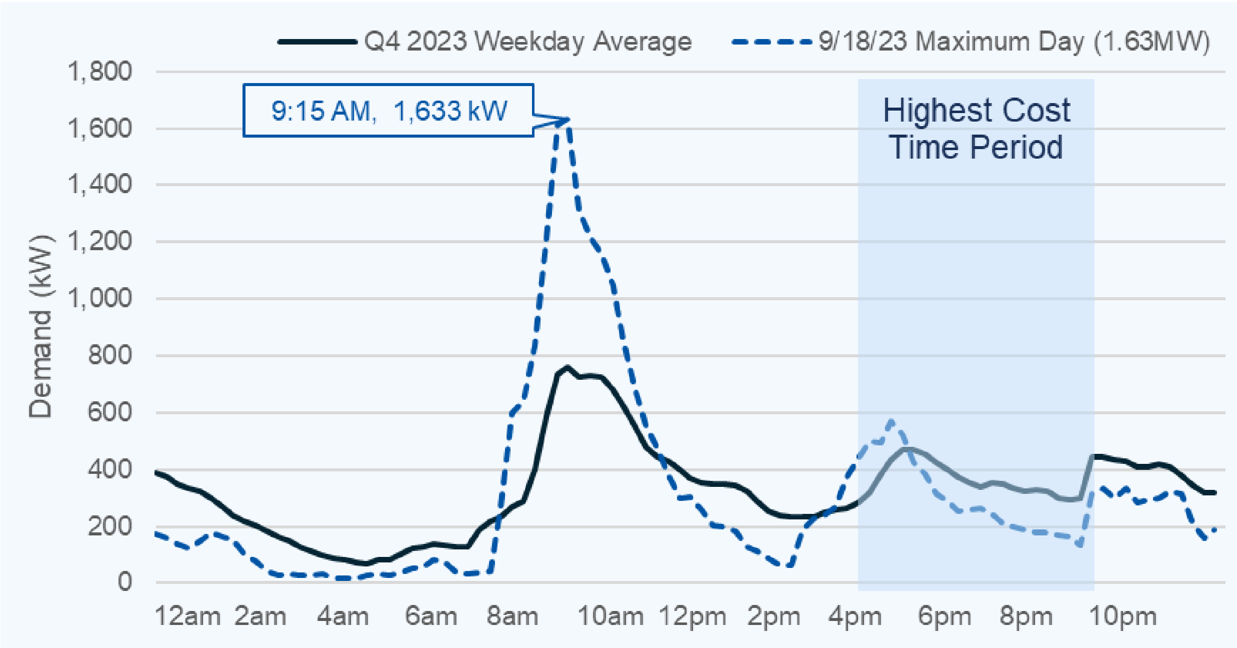


Figure 199. SDG&E PYDFF Program Daily Maximum Demand for PTD Sites



The final quarter of 2023 exhibited the most consistent consumption (and demand) of the year at over 200 MWh monthly within Figure 197. Figure 200 uses that time period to compare the day of highest demand to the average weekday during that quarter. Monday, September 18 had the highest demand of 2023, with maximum demand occurring just after 9 a.m. A plot of the weekday average demand in the final months of 2023 (September 1 to December 31) shows peaks occurring at similar times. Both curves also show increases at around 5 p.m. (when many fleets return to base) and at 9 p.m. (when fleets that are using load management start to charge). The prominence of the 9 p.m. peak typically varies throughout the Monday-through-Friday workweek. Notably the demand at 9 p.m. on the day with the maximum demand is double that of an average day after 9 p.m. and shows curtailment from 4 p.m. to 9 p.m., with over 200 kW of demand shifting to after 9 p.m. This indicates that significant load has shifted from periods of peak demand and high energy prices (4 p.m. to 9 p.m.) to off-peak periods, likely through the implementation of load management practices on days with the highest overall demand.

Figure 200. SDG&E PYDFF Program Highest Demand Day (9/18/23) and Q4 2023 Weekday Average Demand



Load Management and Charging Flexibility Analysis

This section describes analyses around load management and load flexibility. Load-managed sites are those that adopt techniques to avoid charging vehicles during periods of peak energy prices. The analyses consider sites to be load managed if they exhibited consistent load management regardless of when load management was implemented during the year; otherwise they are labeled as non-load-managed.

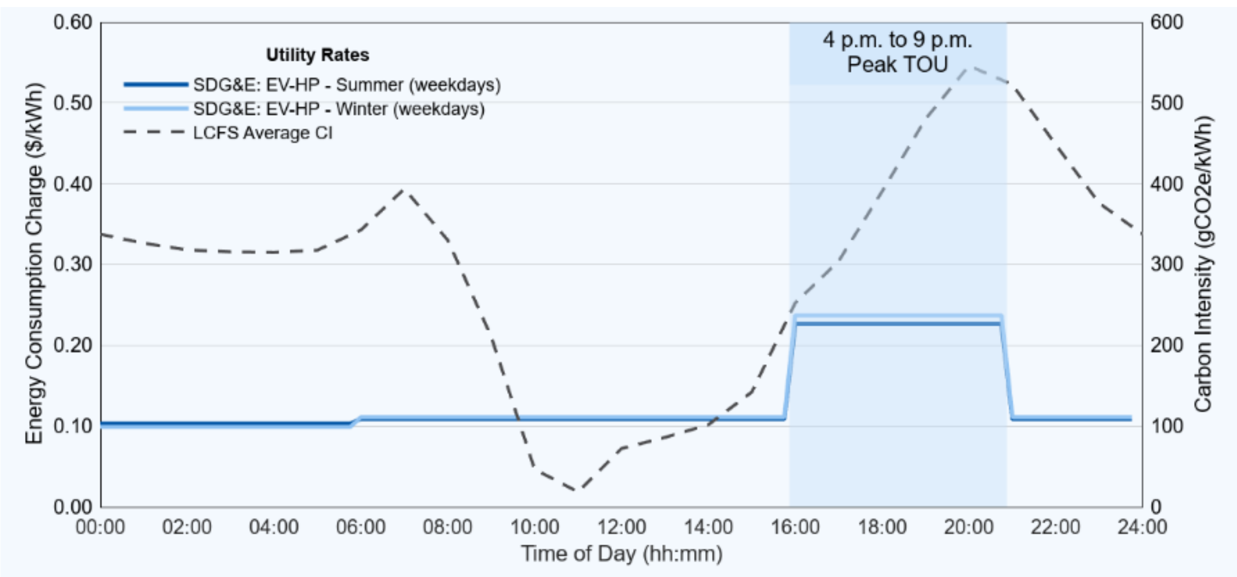
SDG&E's on-peak TOU period occurs each day from 4 p.m. to 9 p.m. During those peak hours, for sites under the EV-HP rate structure (>20 kW demand) in SDG&E's PYDFF program, energy costs in 2023 were $0.226 to $0.237 per kilowatt-hour depending on the time of year, while off-peak and super off-peak TOU rates ranged from $0.099 to $0.111 per kilowatt-hour. Figure 201 displays these TOU rates for summer and winter weekdays. In many cases, lower-cost TOU periods correlate with relatively lower carbon intensity of the grid, as indicated by the dashed line, which shows the 2023 annual average carbon intensity (expressed as an hourly average across Q1–Q4 values) for generating credits using the LCFS Smart Charging mechanism with grid electricity in California.

What is Load Management?

Load Management is an effort to control vehicle charging for several purposes:

- Mitigation of electricity costs
- Participation in special programs (Demand Response or California Low Carbon Fuel Standard)
- Compensation for limited electrical capacity

Figure 201. SDG&E PYDFF Program Hourly TOU Electricity Rates and Average Carbon Intensity Used for Generating LCFS Credits in 2023



The Evaluation Team periodically reviews data on a site-by-site basis throughout the year to identify load-managed sites. Visiting sites in person and speaking to fleet managers also provides context around load management intent. When accounting for demand-related costs, charging flexibility can aid in estimating how much more slowly a vehicle can be charged to mitigate and minimize demand.

Of the 21 operational sites, two sites appeared to be using load management at the start of 2023, though one of these sites changed locations and left at least part of its charging equipment behind. Though this is a concern in terms of stranded assets, it also reflects an influence on grid impacts (consumption and demand) for part of the year. Five additional sites appear to have initiated or attempted load management by the end of 2023. This was evident in two ways:

- Load spiked quickly around 9 p.m.

- The proportion of total monthly energy consumption that was used between 4 p.m. and 9 p.m. was often below 10%

The Evaluation Team assessed consumption trends for sites that had implemented load management and those that had not. Load-managed sites are sites that adopt techniques to avoid charging vehicles during periods of peak energy prices (4 p.m. to 9 p.m.). Figure 202 shows an intermittent trend of load-managed sites decreasing their 4 p.m. to 9 p.m. consumption percentage throughout 2023. The lines representing non-load-managed sites and all sites also show a downward trend, though at a much slower pace.

Figure 202. SDG&E PYDFF Program Percentage of Monthly Consumption between 4 p.m. and 9 p.m. for PTD Sites

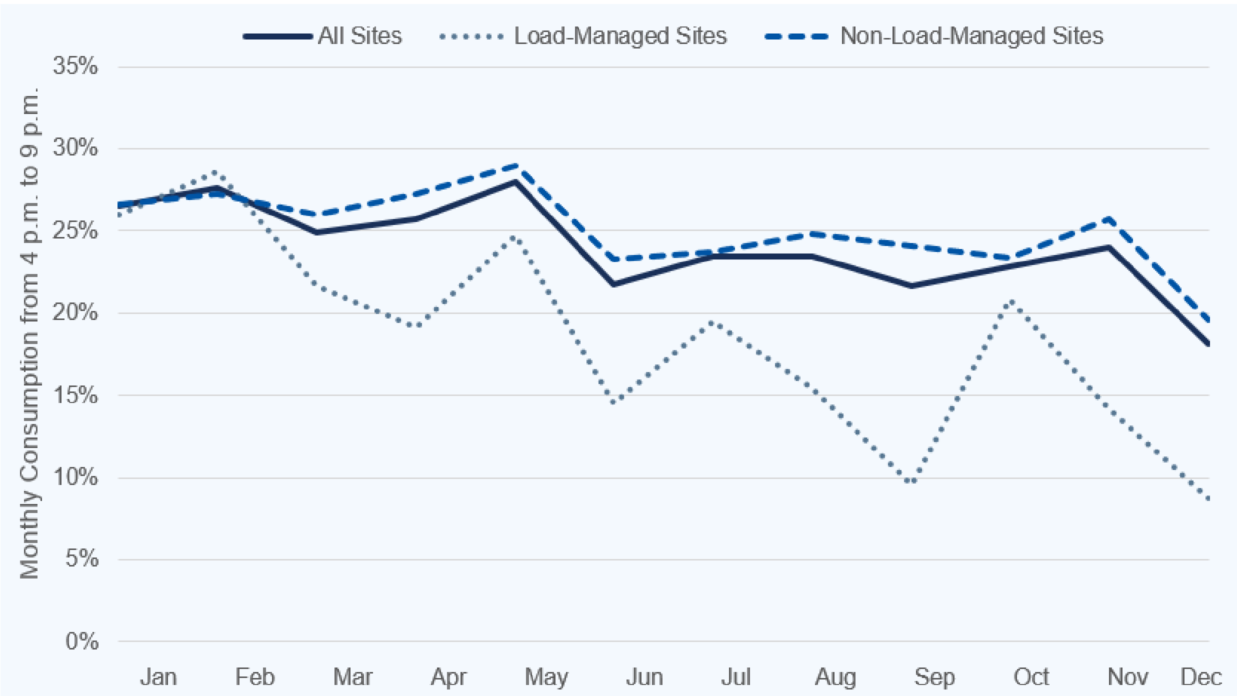


Figure 203 illustrates the differences in peak demand between load-managed and non-load-managed sites (determined using consumption data). Because few sites are currently using load management, the chart compares shapes rather than amplitudes. The months of October through December best highlight differences between trends of load-managed and non-load-managed sites. While the curve for the load-managed sites shows slightly increased demand during 4 p.m. to 9 p.m., it also clearly shows a peak after 9 p.m., indicating demand was avoided during the earlier period.

Conversely, non-load-managed sites show a significant spike in demand that peaks at 5 p.m. during the period when electricity prices are highest, coincident with many fleet vehicles returning to base. Although the load-managed average does show consumption from 4 p.m. to 9 p.m., this is likely due to the data representing a time period when operators have not yet fully adopted consistent load management practices. For example, the single-day load-managed curve in Figure 203 shows a maximum demand between 4 p.m. and 9 p.m. that is exceptionally low compared to the morning and after 9 p.m. This particular example is important to show here as it communicates that some operators are able to achieve near perfect load management to minimize energy costs and maximize VGI, as opposed to the watered-down “LM Site Average” for the quarter. Sites identified as using load management based on consumption trends are included in the EY2023 analysis as load-managed sites regardless of when their load management practice began. For example, if a site transitioned to load management in November, non-managed load for this site in September would be included in the LM Site Average series below.

Figure 203. SDG&E PYDFF Program 2023 Q4 Average Demand of Load-Managed and Non-Load-Managed Sites along with Single-Day Load-Managed Example, PTD Sites

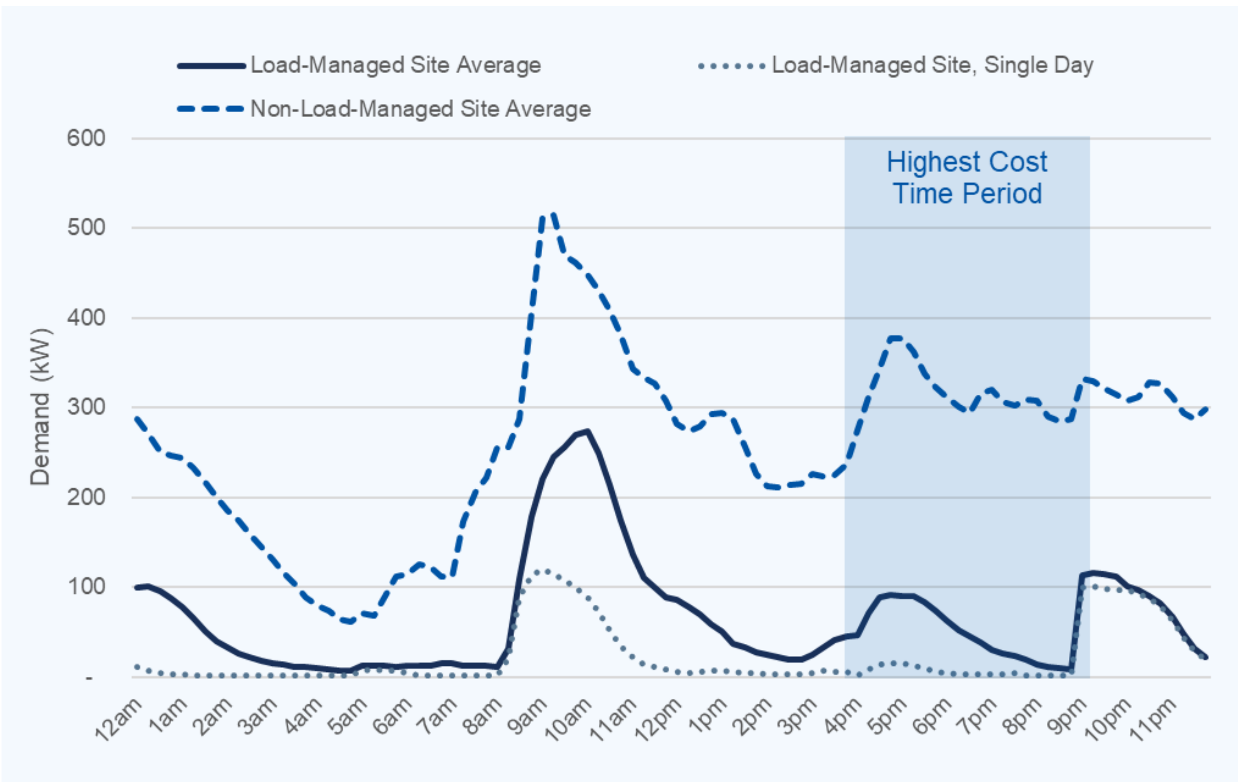


Figure 204 shows the average weekday and weekend daily load across all sites in the PYDFF program for the months of September through November, which have the highest demand. Most fleets exhibit higher consumption and demand on weekdays than on weekends because most fleets such as school buses and delivery trucks have little to no activity during weekends. However, some fleets such as the transit buses may also operate on weekends, creating more consistent demand. For both weekday and weekend operations, energy prices are highest during the period from 4 p.m. to 9 p.m.

Figure 204. SDG&E PYDFF Program Weekday and Weekend Daily Average Loads for PTD Sites from September 2023 through November 2023

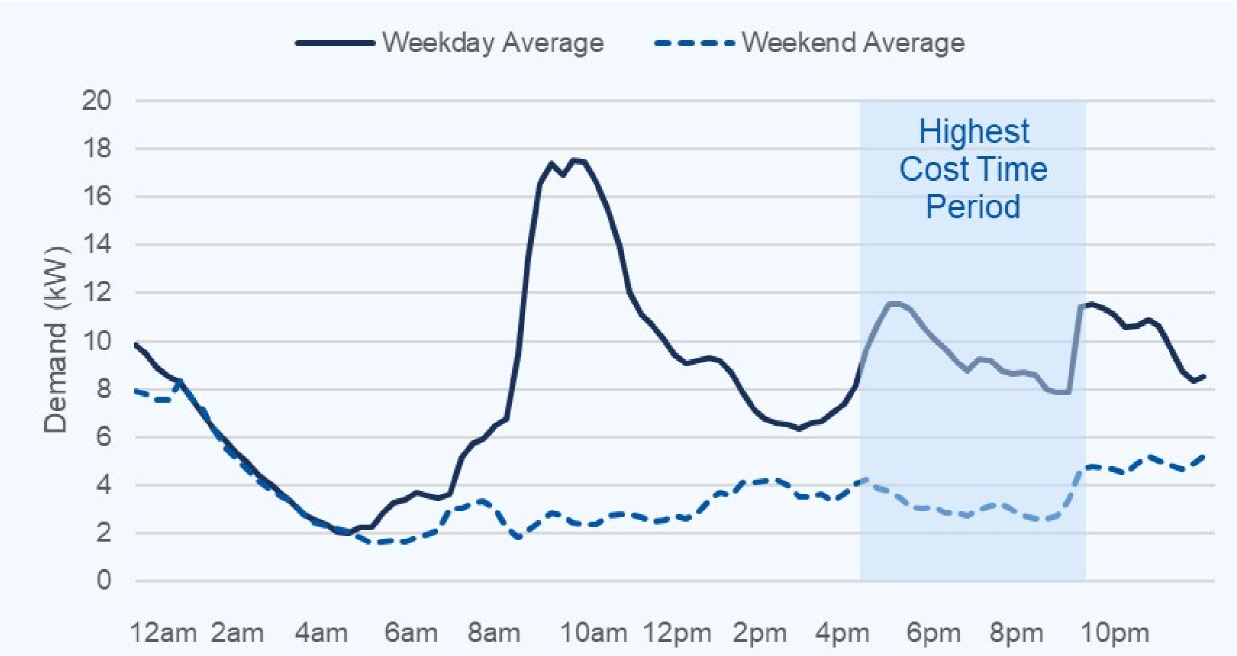


Figure 204 clearly shows a significant increase in demand starting at 9 p.m. for weekday operations, after the highest-cost and highest-demand time period has passed, indicating a portion of program sites are employing load management. At the same time, the lack of a demand peak after 9 p.m. on weekends suggests that most weekend operators are not currently using load management.

Charging Flexibility

The Evaluation Team used site charging data to determine the amount of time vehicles are connected to a charging port but not actively consuming energy. This allowed the Team to assess charging flexibility, or the ability for a vehicle to shift charging from periods of high-cost electricity to low-cost electricity without impacting vehicle operations. In addition, site visits allowed the Evaluation Team to confirm vehicles' make, model, and battery size, all of which affect charging flexibility. For instance, many school bus charging sessions use less than half of the vehicle's battery capacity. Providing feedback to operators about historical usage trends like charging session size in relation to battery size and available time to charge may help inform charging plans.

Figure 205 shows the relative charging flexibility for school bus fleets which represents the number of hours that fleet vehicles are connected to a charging port but not consuming electricity. Figure 205 displays only charging sessions that took place partially or entirely during periods of highest cost electricity (54% of all school bus charging sessions) and omits charging sessions that did not overlap with the period between 4 p.m. and 9 p.m.

Figure 205. SDG&E PYDFF Program Flexible Charging Availability for PTD Sites in Sessions Overlapping the Time Period Between 4 p.m. and 9 p.m. (54% of all sessions)

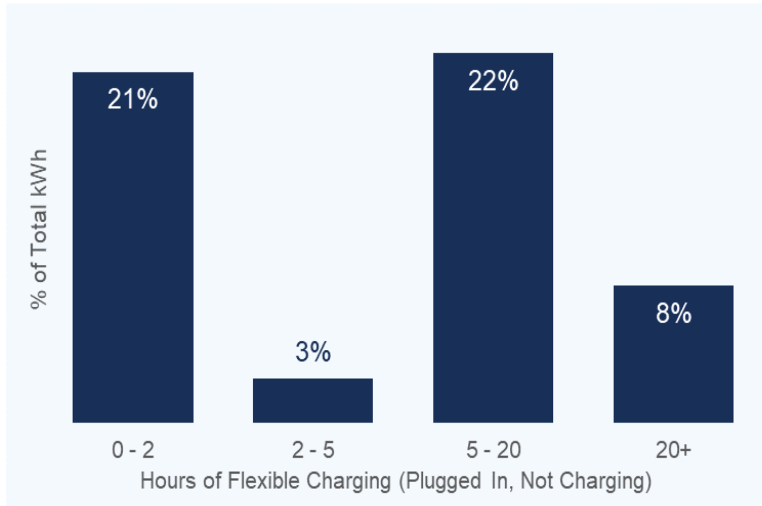


Figure 205 also shows that 30% of charging sessions have enough flexibility (i.e., five hours or more) to completely avoid consumption during that time period. As the period of highest-cost electricity lasts for five hours (4 p.m. to 9 p.m.), a charging session up to five hours of charging flexibility to fully shift consumption from on-peak to off-peak periods. However, vehicles with less than five hours of charging flexibility (almost 25% of all sessions) will still benefit from adopting load management by shifting a portion of consumption to periods of lower-cost electricity.

Another form of this type of flexibility analysis could look at daily consumption relative to vehicle-fleet on-board energy storage capacity. For example, if a fleet has 100 kWh batteries but uses 65 kWh daily, there may be charging flexibility options that a site can leverage for load management. Larger batteries, more charging opportunities, and higher charging power lead to greater flexibility overall. SDG&E school sites more frequently use DC charging than other Utilities' program school sites throughout the state. This higher-power charging in turn provides even greater opportunity for school buses, which already are better suited than most fleets to take advantage of lower-cost energy.

Costs and Billing

Previous sections have focused on energy trends and on charging flexibility that hints at how those trends could change in the future. The following sections discuss billing cost trends and to what extent those may improve based on charging flexibility. The Evaluation Team's review of billing data focuses on the average unit cost of a kilowatt-hour for a given site-billing month compared to the TOU-based tariff cost of energy.

A unique component of the PYDFF program is that there are three sites with V2G capability and one with solar generation. Those V2G sites (all school bus sites) can send energy back to the grid from the EV batteries. This allows SDG&E customers to participate in the Emergency Load Reduction Program (ELRP) to earn revenue for discharging energy from the EVs to the grid, similar to the standalone V2G project also conducted by SDG&E and reported in the *Vehicle-to-Grid Pilot* section.

There are several methods of participating in the ELRP but the focus so far for fleets is to return as much energy to the grid as possible. This method of ELRP incentivizes participation at $2 per kilowatt-hour. Each of these sites has a utility meter set up to monitor energy flow separately to and from the grid, similar to Net Metering (solar) customers. At this time very little V2G energy (under 1,000 kWh) has been sent to the grid. As fleets gain confidence in their EV environments (vehicles, EVSE and NSPs) V2G is expected to take on a bigger role. Energy consumption during high-cost times (e.g. 4 p.m. to 9 p.m.) may increase due to EV batteries undergoing a deeper state of charge cycles (between discharging for routes and V2G). The site with solar generation is not included in cost reporting below and tracking V2G incentives will be a consideration in future evaluation reports.

One factor impacting this section is that SDG&E filed a General Rate Case with the CPUC on 1/17/23[122], which included a request for CPUC approval to change TOU time periods. Compared to current rates, SDG&E would add a super off-peak period from 10 a.m. to 2 p.m. on weekdays year-round. Currently, this only applies in March and April. If CPUC approved this request, EV operators would have more access to low-cost energy as well as an incentive to charge midday, which typically coincides with carbon intensity of electricity generation. This measure could potentially change energy trends in the future.

NSPs' load management capabilities and fleets' adoption rate of load management impact costs and energy trends. Nearly every NSP involved in the PYDFF program provided reliable data; however, not all of these NSPs offered load management as a service on their platform as of the end of 2023. When provided, load management may be a base offering or tiered-cost package. Interoperability between hardware, software, and vehicles presents challenges that can make load management impractical or difficult to achieve.

Many fleet operators remain unaware of their energy use and charging costs even though most EVSPs make this data available. Often a site host's finance office will receive utility bills but will not share information with fleet operators that would enable them to compare energy costs with other fuel types in their fleets. The Evaluation Team uses energy trends as discussion points during site visits if operations have started. Many fleet operators said they had not seen these data trends prior to the evaluation site visits.

Figure 206 illustrates the relationship between percentage of on-peak energy consumption and the average monthly customer bills for medium-sized consumers with monthly consumption from 5 MWh to 15 MWh (each dot represents a month). Figure 206 shows a slight trend of the average unit pricing being inversely related to energy consumption. Higher monthly consumption seems to result in lower average cost. This is possibly due to fixed costs being spread over greater volume, or increased consumption at lower-cost time periods (that is, other than 4 p.m. to 9 p.m.)

[122] Microsoft Word - 2024 GRC Phase 2 - Chapter 3 (Rate Design) (sdge.com)

Figure 206. SDG&E PYDFF Program Monthly Billing Energy Consumed vs. Average Energy Price for Medium Consumption Billing Months (5 MWh to 15 MWh) for PTD Sites

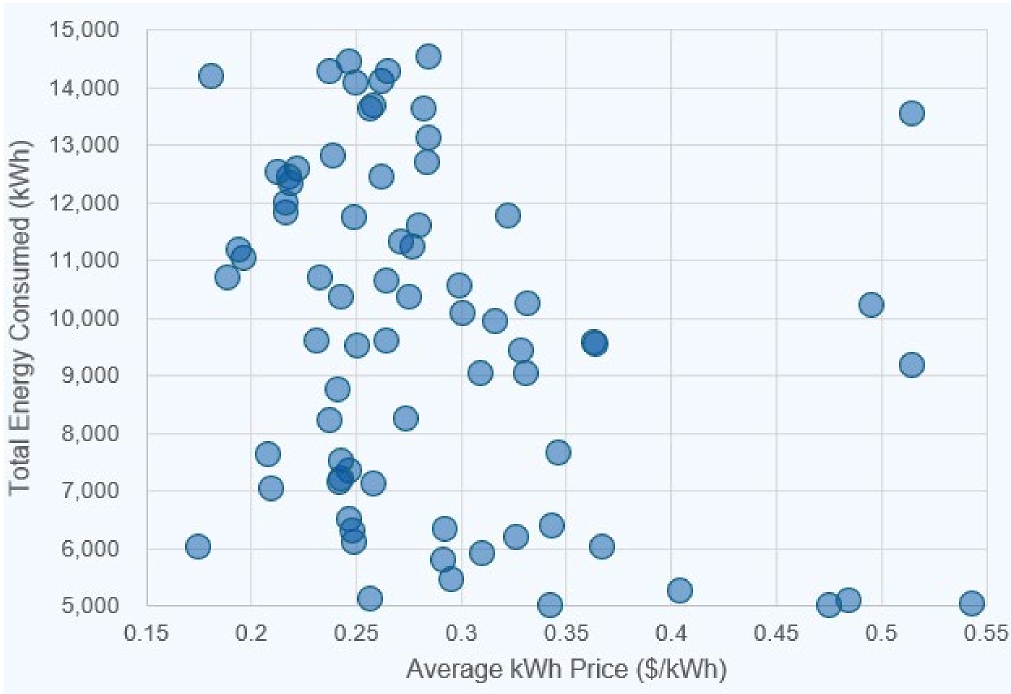


Figure 207 provides a comparison of the average energy price for sites with the largest billing months (greater than 20 MWh) and the proportion of energy consumed during the peak period of 4 p.m. to 9 p.m. Large billing months (>15 MWh) seem to show higher average unit costs given a higher proportion of consumption from 4 p.m. to 9 p.m. Note that these billing month energy ranges are specific to SDG&E's data (i.e., large billing months for other utilities are frequently even larger). Plotting the same data by monthly consumption (Figure 208) appears to indicate that larger billing months receive some of the lowest average unit costs, ranging around $0.22 to $0.32 per kilowatt.

It should be noted that some of the data points in Figure 208 do not appear in Figure 209 because of limiting the y-axis to 30,000 kWh.

Figure 207. SDG&E PYDFF Program Percentage of Monthly Energy Consumed from 4 p.m. to 9 p.m. vs. Average Energy Price for High Consumption Billing Months (>15 MWh) for PTD Sites

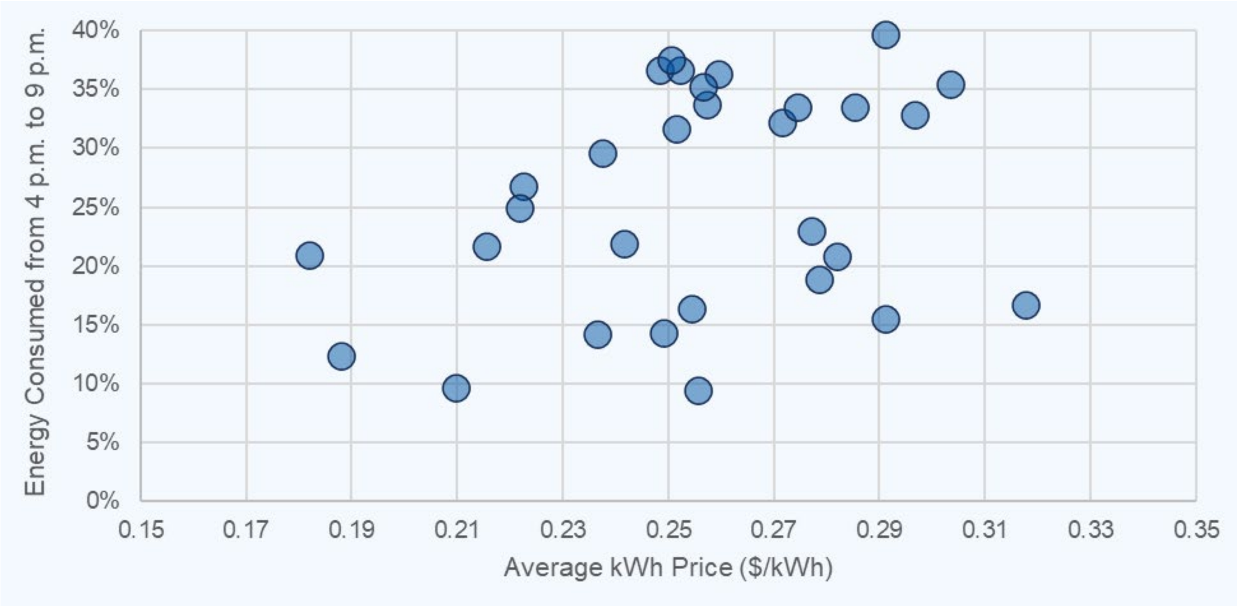


Figure 208. SDG&E PYDFF Program Monthly Energy Consumed vs. Average Energy Cost for High Consumption Billing Months (>15 MWh) for PTD Sites

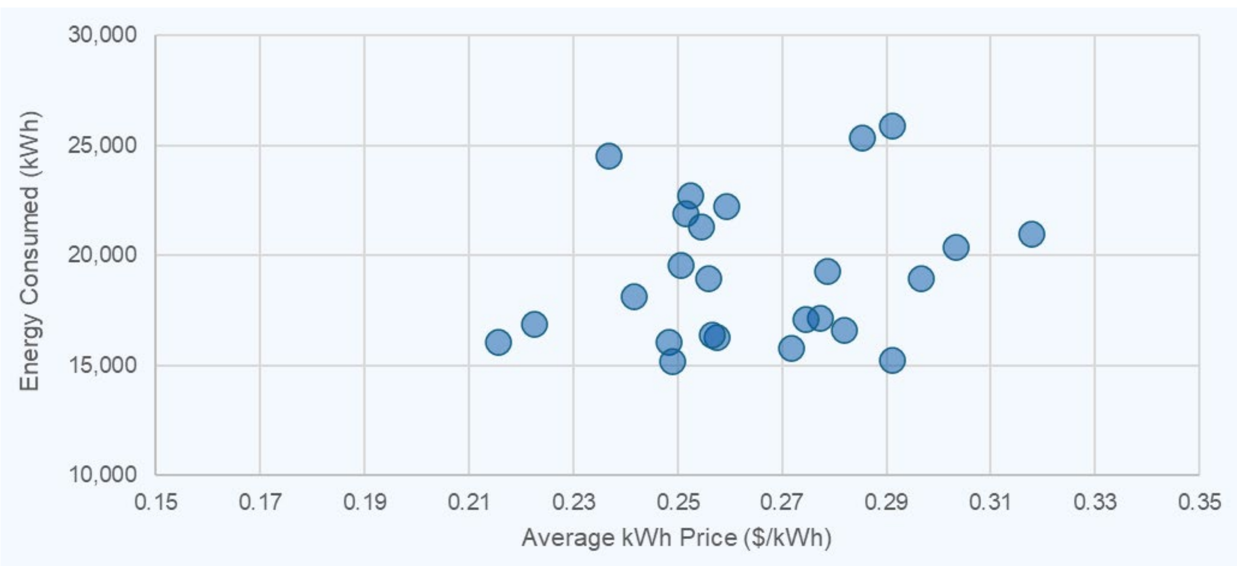
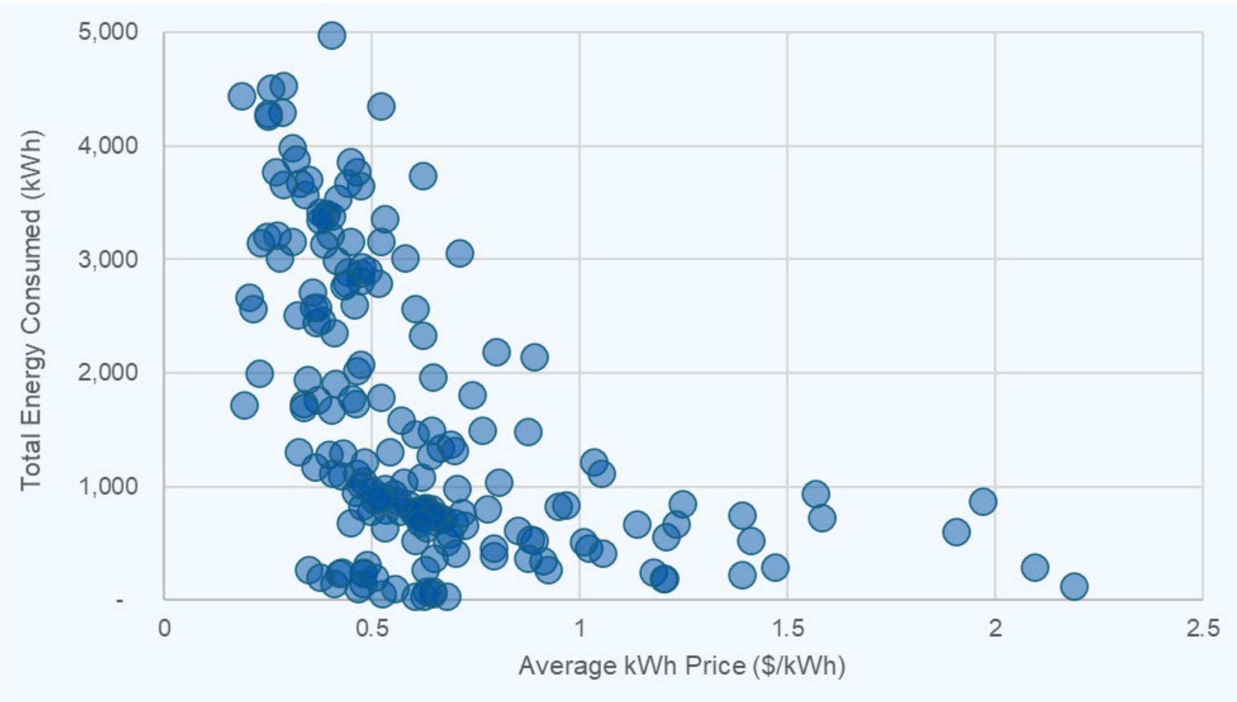


Figure 209 shows that smaller billing months (<5 MWh) demonstrate an inverse relationship between consumption and average billing prices. Sites with the lowest monthly energy consumption often have the highest electricity costs per kilowatt-hour. This is due to fixed fees, which are spread across the total kWh consumed and therefore have a greater impact on sites with lower total consumption. Months with the lowest billing often represent early months in a site's timeline, typically consisting of charger commissioning activity and/or charger standby load before regular vehicle charging begins. SDG&E uses capacity subscriptions, meaning that instead of billing demand at a per-kilowatt fee, SDG&E uses increments of either 10 kW or 25 kW allotments plus overage fees. However, so far instead of billing its overage fees, SDG&E has increased customer subscription tiers to accommodate their demand, which has helped to mitigate the overall average unit cost of energy.[123]

Figure 209. SDG&E PYDFF Program Monthly Energy Consumption vs. Average Energy Price for Low Consumption Billing Months (<5 MWh), PTD Sites



Electricity Cost and Emissions Optimization Analysis

This section builds upon the grid impact findings above to include an analysis of hypothetical customer bills and emissions under an optimal load management scenario, assuming perfect load management across all sites. While real-world constraints—such as technology, operations, and education—currently prevent ideal load management, the findings shed light on the long-term potential of load management. To quantify the potential benefits of using load management, the Evaluation Team analyzed observed outcomes of sites with and without existing load management practices and conducted a load-shifting optimization exercise to estimate the total potential cost savings and emissions reductions. This analysis primarily uses NSP data to assess charging flexibility. Future efforts will extend this analysis to fleets without NSPs. *Appendix A* provides additional methodological notes.

Load Management Outcomes Observed in EY2023

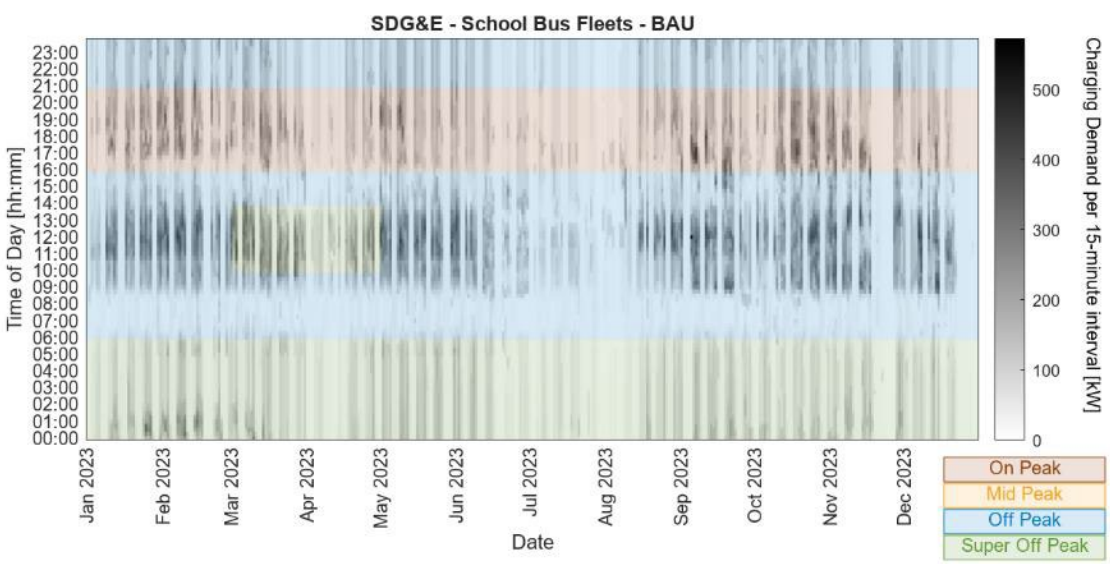
The Evaluation Team assessed a subset of all PTD sites that had the necessary AMI and NSP data—a total of 13 SDG&E PYDFF program sites. This analysis does not use data from all 21 operational sites in

123 Note that a single site incorporates solar generation on its EV account, and those data points were not included here.

the PYDFF program to date, but only from those sites with AMI and NSP data that met analysis requirements. Of these 13 sites, 9 were school bus sites and 4 were sites in other market sectors, including the medium-duty vehicle and TSE sectors.

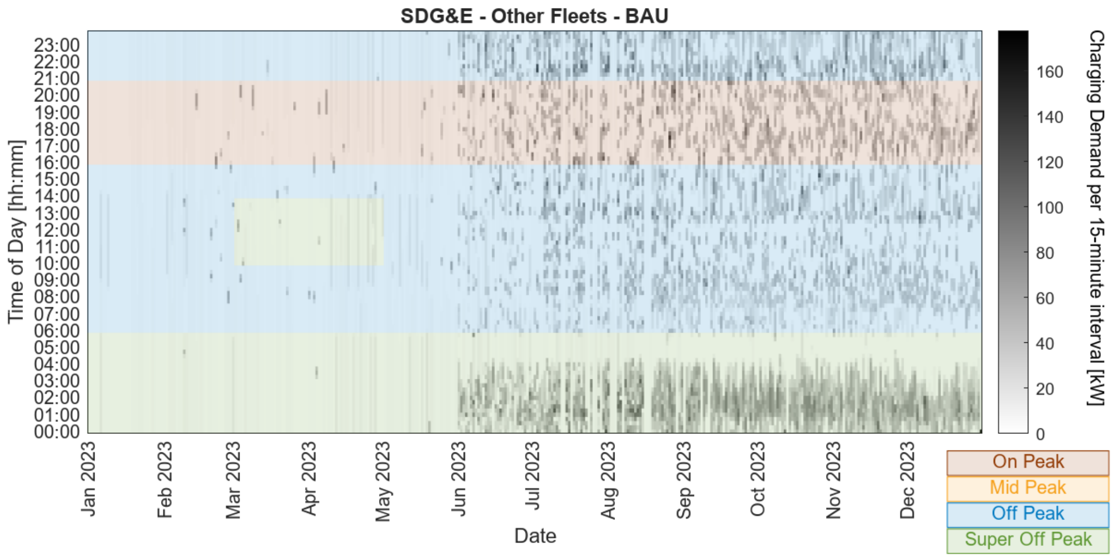
Figure 210 and Figure 211 depict the BAU historical energy consumption of school bus and non-school bus fleets in aggregate during 2023. BAU is the current charging behavior of the 13 sites represented in this analysis. In these figures, the areas with darker shading area indicate those times of day (y-axis) and days throughout the year (x-axis) when charging demand is highest. Areas with no shading represent no energy demand. School bus fleets show a relatively consistent trend of charging twice per day: first during the school day, then again once school is out for the day and buses complete afternoon runs. This spread generally coincides with higher TOU rates. As Figure 210 shows, demand is visibly lower during the winter holiday, spring break, and summer vacation periods, when many schools are not in session. For comparison, Figure 211 presents the BAU charging demand for all other SDG&E fleets.

Figure 210. SDG&E PYDFF Program Heatmap of the Collective BAU Charging Demand for All SDG&E School Bus Fleets in 2023



Dark shading intensity indicates average charging demand (in kilowatts) per 15-minute interval.
Colored regions indicate TOU periods.

Figure 211. SDG&E PYDFF Program Heatmap of the Collective BAU Charging Demand for All Other SDG&E Fleets in 2023

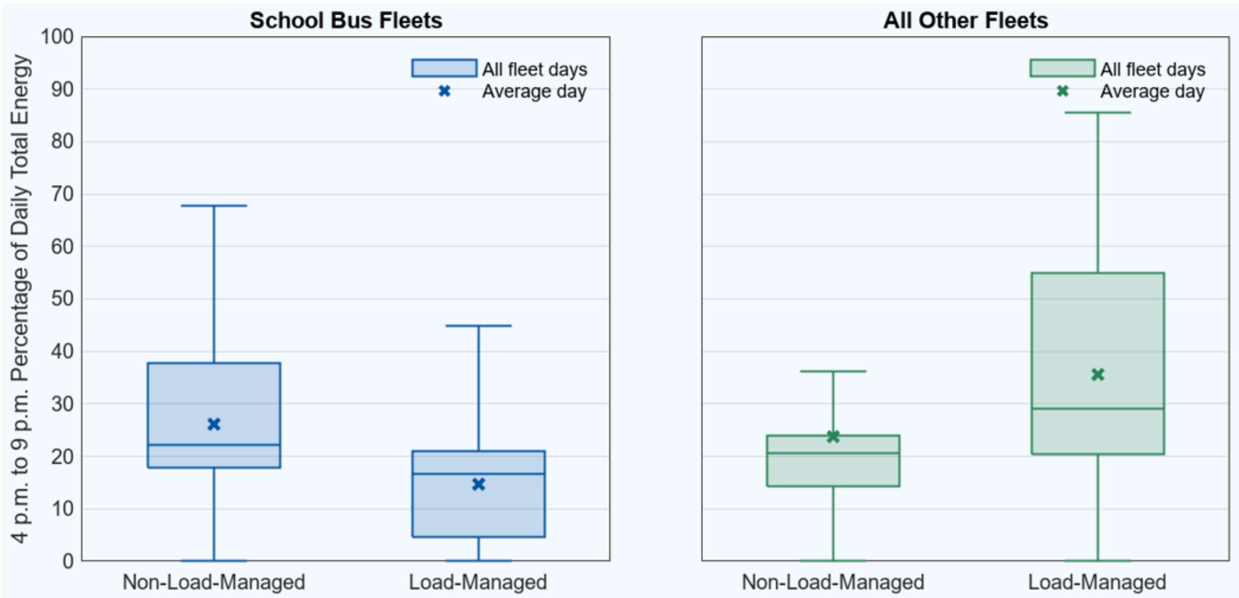


Dark shading intensity indicates average charging demand (in kilowatts) per 15-minute interval.
Colored regions indicate TOU periods.

The Evaluation Team compared NSP sessions under load management strategies to non-load-managed sessions for the 13 sites composed of school bus and non-school bus fleets in this analysis. This helps to identify how effective existing load management strategies are at shifting energy use away from the period between 4 p.m. and 9 p.m.

Figure 212 shows the percentage of each day's energy consumption occurring during the peak TOU period. Non-load-managed school buses average 26.1% of consumption between 4p.m. and 9 p.m. On the average load-managed day, average consumption drops significantly to 14.7% of overall consumption. For other market sectors (shown on the right of Figure 212) the average non-load-managed day has over 24% of consumption during the peak TOU period, compared to 35.6% for load-managed days. That non-load-managed sites have a lower proportion of consumption than load-managed sites may be due to intermittency issues on sites attempting to use load management and relatively few days available for the analysis. It is also possible that sites designated as load managed began that practice late in the year, and data is weighted towards their non-load-managed history. These comparisons help guide the Team's estimates of how much energy from non-load-managed days (and fleets) can shift to potentially save money and emissions. Though "All Other Fleets" is shown below, those fleets had relatively little operation overall availing less data to generate statistics as well as less operational experience.

Figure 212. SDG&E PYDFF Program Distribution of the Fraction of Daily EV Charging Load Occurring in the Peak TOU Period



The box and whisker plot represents the distribution of daily total energy consumed from 4 p.m. to 9 p.m. across one operating day by group, and diamonds indicate the average value for all operating days per group.

This analysis suggests that existing load management programs reduce the fraction of energy consumed between 4 p.m. and 9 p.m. and by that reduce the energy costs. However, outcomes vary substantially across sites (both load-managed and non-load-managed), suggesting that the value of load management depends on each site's operating patterns, charging flexibility, and chosen implementation of load management controls. Notably, the number of non-school bus fleets is very low, providing very little usable data at the time of reporting.

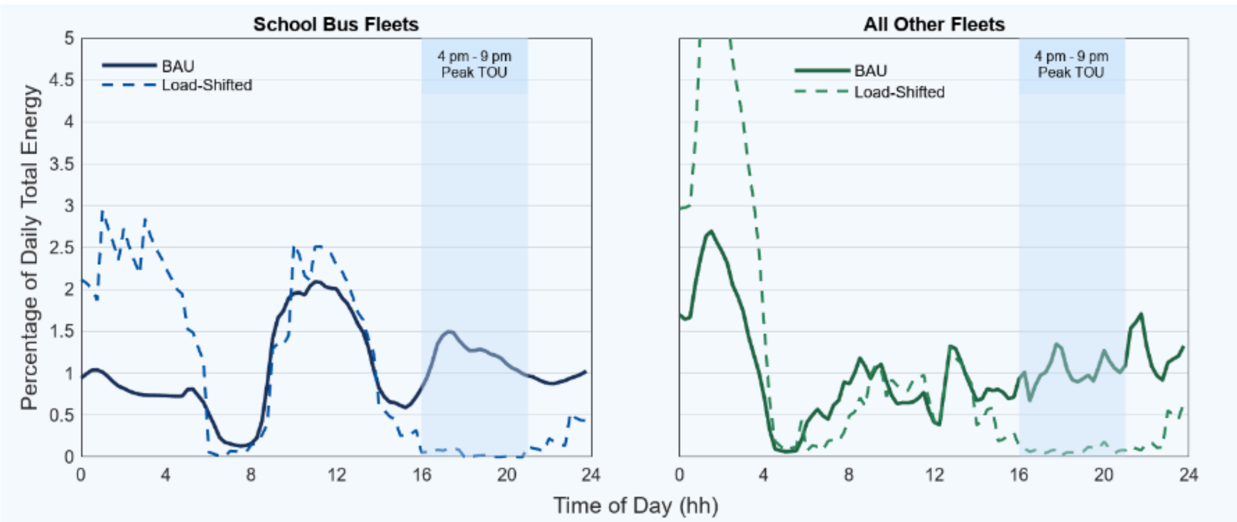
Potential Benefits of Optimal Load Management

The Evaluation Team analyzed AMI and NSP data to estimate the potential value of optimal load management, considering each site's observed operating patterns and potential ability to shift vehicle charging loads. This analysis only included days with energy consumption recorded in NSP charging session data. On average, each SDG&E school bus site had 288 such days, while SDG&E sites in other market sectors had 188 such days (reflecting the fact that vehicle fleets only operate certain days, and that some sites only had partial-year data).

The Evaluation Team developed and executed an optimization routine for each included operating day. This optimization shifted each site's energy consumption from the 4 p.m. to 9 p.m. peak time period into the lowest-cost hours of the day whenever there was unused charging capacity and vehicle charging availability during those hours. For hours in the same TOU rate period, the Team used emissions intensity (measured as CARB LCFS carbon intensity factors for smart charging programs) and BAU charging load as tiebreakers to determine vehicle charging priorities. The Evaluation Team used NSP charging session data to ascertain how many vehicles were plugged in and how many kilowatt-hours of energy could be shifted during each time period.

Figure 213 illustrates how optimally shifted loads differ from BAU loads, averaged across EY2023. For both school bus sites and other market sector sites, the average day's load can be almost completely shifted out of the high-cost 4 p.m. to 9 p.m. window (peak TOU period year-round). Load-managed sites prioritize early morning charging, as the super off-peak TOU period offers the lowest energy consumption costs.

Figure 213. SDG&E PYDFF Program Fraction of Daily EV Charging Load Occurring at Each 15-Minute Interval for the Average Day in this Analysis



Note: Line color indicates site market sector and dashed versus solid lines indicate whether the load is BAU or shifted.

The Evaluation Team estimated the cost reduction potential of this daily load shifting, within the following context:

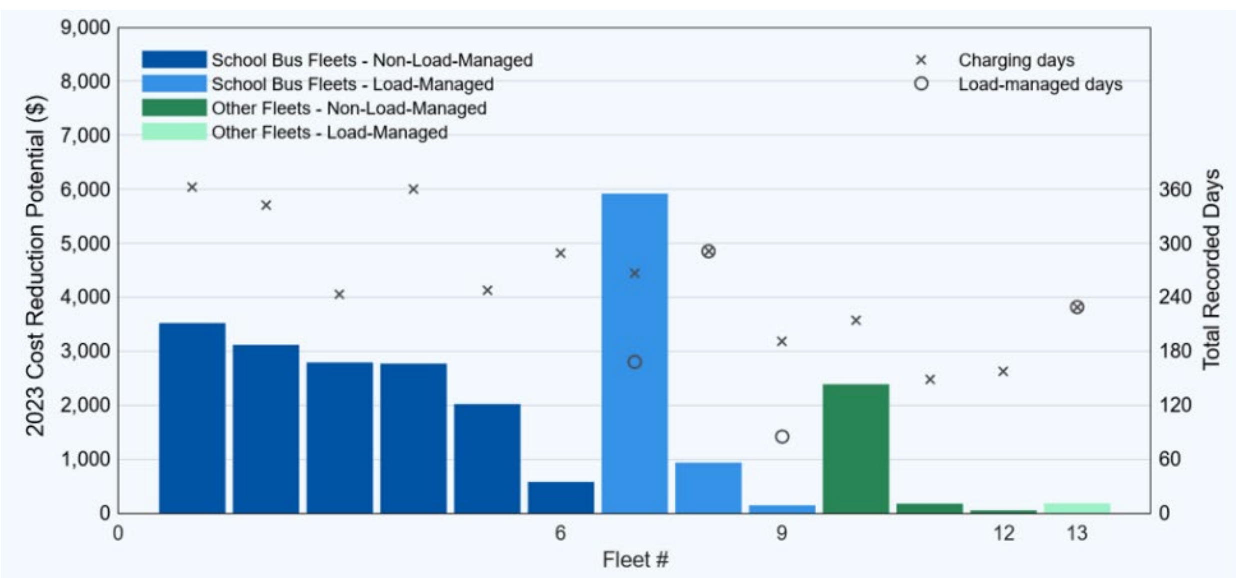
- This analysis considers only the volumetric (cost per kilowatt-hour) component of each site's electricity costs. Optimal load management has the potential to also reduce demand charge subscriptions, which could especially impact costs in lower-volume months. The cost-minimization approach developed in this analysis ensures that peak demand does not increase but does not yet consider potential cost savings resulting from demand reduction.
- These results only reflect the portion of the year for which each fleet operated and provided charging data; annualized projections of these cost reductions could be substantially higher for fleets that have less than a full year of charging data included in this analysis or that have not yet reached mature operations.
- These results only reflect the portion of each site's vehicle fleet that it electrified in EY2023. A fully electrified vehicle fleet would see higher cost reduction potential from load management.
- This analysis considers the cost-saving potential of load management, but it does not consider the potential of load management to generate revenue via LCFS Smart Charging credits.

- This analysis examined the real charging behavior at each site (i.e., actual recorded plug-in and unplug times) to determine charging opportunities and does not account for other operational or scheduling improvements for charging electrified fleets, which could enable more effective load management, resulting in higher potential cost reduction.

Figure 214 shows the cost reduction potential for each site in total dollars per year. Potential reductions in annual energy costs range from $600 to $3,500 for un-managed school bus sites and up to $2,400 for non-load-managed sites in other market sectors. Sites with load management still have cost reduction potential ranging from $100 to $5,900 in the school bus market sector and up to $200 in other market sectors. This unrealized potential may reflect inconsistent use of load management controls by fleets, variation in effectiveness of load management controls across vendors, or risk-averse preferences of fleet managers to charge as soon as possible upon each vehicle's return to base. This analysis suggests room for improvement in realizing the full benefits of smart charge management.

Some operators and or driving days do not allow for use of load management. However, in this case actual charging session data was used for this analysis. In terms of why fleets do not use load management, this often stems from lack of clarity of actual versus potential electricity costs as well as concern over ensuring vehicles charge under the watchful eye of staff still on site. Starting to charge vehicles later in the evening when limited staff is available to check status provides some fleets a concern over reliability.

Figure 214. SDG&E PYDFF Program Total 2023 Cost Reduction Potential of Each Site if it Used Optimal Load Management



Each bar represents one site. Bar colors indicate market sector and if the site uses load management.

Because lower-cost TOU periods often correspond to periods with relatively low carbon intensity estimates for grid electricity, optimizing load management for energy cost savings can have a secondary effect of reducing the resulting carbon emissions. Figure 215 shows estimated cost reductions and corresponding GHG emissions reductions for each site resulting from a cost-minimizing load management strategy (considering carbon intensity only as a tiebreaking factor when there is sufficient charging flexibility). In general, across sites, shifting charging load to reduce costs shows the potential to reduce GHG emissions by an even greater percentage than costs. Table 125 aggregates these results across the included sites. Overall, optimal load shifting could reduce school bus sites' collective energy consumption costs by 23.7% and attributed electricity grid GHG emissions by 21.4%. For other market sectors, it could reduce energy consumption costs by 19.8% and attributed electricity grid GHG emissions by 16.3%.

Figure 215. SDG&E PYDFF Program Potential Percentage Cost Reduction and Attributed GHG Emissions Reduction of Optimal Load Management

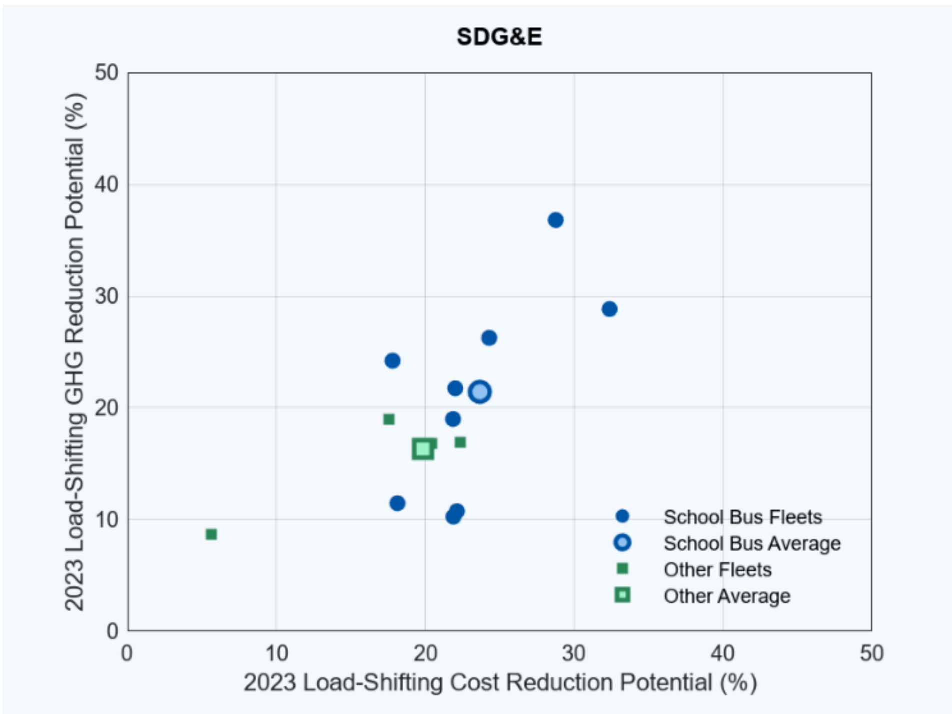


Table 125. SDG&E PYDFF Summary of Potential Cost and Attributed GHG Emissions Reductions, Aggregated across All Included Fleets

SDG&E	School Bus Fleets	All Other Fleets	All Fleets Combined
Total number of fleets	9	4	13
Total count of 2023 operating days	2,593	749	3,342
Cost Reduction Potential (%)	23.7%	19.8%	23.1%
GHG Reduction Potential (%)	21.4%	16.3%	20.5%

Highlights

- Charging data indicates that there is significant opportunity for most fleets to shift their charging energy use to lower-cost time periods depending on a site's operating patterns, charging flexibility, and implementation of load management software.
- Sites activated in EY2021 and EY2022 continue to grow consumption but have tapered off.
- Sites activated in EY2023 had very little usage in 2023 and are expected to grow considerably.
- Operational sites in EY2023 tripled overall demand in comparison to EY2022 as new, larger sites became operational.
- Nearly 30% of school bus charging sessions overlapped the 4 p.m. to 9 p.m. peak-rate period but have enough flexibility to delay charging to lower-cost time periods with effective load management; another 25% have some flexibility to shift to lower cost times.
- The number of load-managed sites grew from two in EY2022 to seven in EY2023; however, new sites displayed intermittent load management implementation.
- While more than 40% of sites began vehicle charging within 30 days of power availability, more than 18% took over 90 days, often driven by supply chain issues.

Petroleum Displacement

The Evaluation Team estimated petroleum displacement that is attributable to the vehicle electrification enabled by SDG&E's PYDFF program. The Team used DGE for reporting purposes. However, as the Transit Bus market sector primarily uses compressed natural gas (CNG) fuel, the Team needed to convert transit bus natural gas consumption into DGE units based on the CNG fuel's energy content.

Table 126 presents petroleum displacement impacts for the PYDFF Program through 2023, including estimated actual impacts for 2023, actual impacts for all sites program to date, and a 10-year forecast for program to date sites. The results include for the five market sectors represented in the program, the majority of which were Heavy-Duty Vehicles followed by Transit Bus. The program to date is over 1.3 million electric miles, estimated based on usage of nearly 2.1 MWhs. This translates into the displacement of over 220,00 DGE.

Table 126. SDG&E PYDFF Program Petroleum Displacement Summary

Market Sector	Usage (n=21)				Petroleum Displacement (DGE)		
	2023 Actual kWh	PTD Actual kWh	2023 Actual Use	PTD Actual Use	2023 Actual	PTD Actual	10-Year Projection
Airport GSE					50,377	59,763	488,975
Medium-Duty Vehicles					15,715	20,599	222,761
School Bus					82,355	116,832	692,029
Transit Bus					24,464	24,464	1,032,031
TSE					746	767	7,586
Total		**2,120,071**		**1,384,293 miles 31,289 hours**	**173,656**	**222,425**	**2,443,381**

Market Sector	Usage (n=21)				Petroleum Displacement (DGE)		
	2023 Actual kWh	PTD Actual kWh	2023 Actual Use	PTD Actual Use	2023 Actual	PTD Actual	10-Year Projection

Note: "2023 Actual" represents the data from all activated sites from program inception for the calendar year 2023. "PTD Actual" represents the data from all activated sites from program inception for all program years.

Highlights

- All operational sites in 2023 collectively achieved a total impact of over 170,000 gallons of petroleum displaced.
- The school bus sector contributed over 82,000 gallons displaced in EY2023 and is projected to account for more than a quarter of the petroleum displaced over 10 years.
- Over a 10-year period, the sites will displace more than 2,400,000 gallons of petroleum.

Greenhouse Gas and Criteria Pollutant Impacts

The Evaluation Team calculated reduced emissions from displaced fossil fuel use from ICE vehicles that were not in service because of PYDFF. First, we developed ICE counterfactual equivalents for each market sector, then calculated the emissions associated with these vehicles under conditions that otherwise matched the EVs, which provided a baseline. Although EVs have no tailpipe emissions, the mix of generation sources from the electric grid used includes renewable as well as fossil fuel power to supply electricity to the charging stations, with the latter primarily responsible for emitting GHGs and criteria pollutants into the atmosphere.

Table 127 shows GHG impacts from PYDFF for three time periods: (1) estimated reductions that reflect what program sites saved in 2023, (2) program to date reductions from all sites, and (3) a 10-year projection based on annualized data from all sites.

Table 127. SDG&E PYDFF Program GHG Reductions Summary

Market Sector	Usage (n=21)				GHG Reduction (MT)		
	2023 Actual[a] kWh	PTD Actual[b] kWh	2023 Actual Use	PTD Actual Use	2023 Actual	PTD Actual	10-Year Projection
Airport GSE					519	614	5,137
Medium-Duty Vehicles					101	134	1,524
School Bus					705	991	6,150
Transit Bus					162	162	7,518
TSE					6	6	65
Total		**2,120,071**		**1,384,293 miles 31,289 hours**	**1,494**	**1,907**	**20,394**

[a] "2023 Actual" represents the data for EY2023 from all sites activated in the program to date.
[b] "PTD Actual" represents the data from all activated sites from program inception for all program years.

Table 128 shows estimated reductions in local tailpipe emissions from ICE vehicles that this program displaced. The Transit Bus market sector showed the highest reduction in carbon monoxide (CO) emissions due to the assumption that the displaced buses ran on CNG. In addition, our analysis confirmed that airport GSE sites can achieve notable savings due to the poor emissions profile of a conventional GSE.

Table 128. SDG&E PYDFF Program Local Emissions Reductions, PTD Actual

Market Sector	PTD Sites Actual[a] (n=21)				
	HC (kg)	PM_{10} (kg)	$PM_{2.5}$ (kg)	ROG (kg)	CO (kg)
Airport GSE	75.0	90.2	83.0	90.7	3,684.3
Medium-Duty Vehicles	–	0.3	0.3	3.4	542.0
School Bus	–	2.4	2.3	10.6	304.8
Transit Bus	–	0.0	0.0	6.6	5,387.4
TSE	–	0.1	0.1	0.2	2.9
Total	**75.0**	**93.1**	**85.7**	**111.5**	**9,921.4**

[a] "PTD Actual" represents the data from all activated sites from program inception for all program years.

Table 129 shows the same information as Table 128 for 2023 actual. These are the localized emissions reductions that occurred based on actual Charge Ready Transport program operations this year.

Table 129. SDG&E PYDFF Program Local Emissions Reductions, 2023 Actual

Market Sector	2023 Actual[a] (n=21 sites)				
	HC (kg)	PM_{10} (kg)	$PM_{2.5}$ (kg)	ROG (kg)	CO (kg)
Airport GSE	64.4	76.4	70.3	77.9	3,114.2
Medium-Duty Vehicles	–	0.3	0.2	2.2	422.5
School Bus	–	1.7	1.6	7.5	215.6
Transit Bus	–	0.0	0.0	6.6	5,387.4
TSE	–	0.1	0.1	0.2	2.8
Total	**64.4**	**78.5**	**72.3**	**94.5**	**9,142.6**

[a] "2023 Actual" represents the data for EY2023 from all sites activated in the program to date.

Table 130 provides an estimate of savings over the 10-year period. These are the annualized reductions from all sites to date extended over a decade.

Table 130. SDG&E PYDFF Program Local Emissions Reductions, 10-Year Projection for PTD Sites

Market Sector	PTD Sites 10-Year Projected Impact (n=21 sites)				
	HC (kg)	PM_{10} (kg)	$PM_{2.5}$ (kg)	ROG (kg)	CO (kg)
Airport GSE	973.8	835.9	769.1	1,178.2	32,655.7
Medium-Duty Vehicles	–	3.8	3.5	43.4	5,888.0
School Bus	–	16.3	15.6	70.9	1,942.2
Transit Bus	–	1.9	1.9	281.3	229,736.9
TSE	–	1.1	1.0	2.9	37.3
Total	973.8	859.1	791.1	1,576.7	270,260.2

Table 131 shows counterfactual vehicle GHG emissions, emissions from the electricity used to charge the EVs, GHG emissions reductions, and percentage differences. Table 132 shows the net reductions of

NO_x emissions from using EVs based on the counterfactual and Utility emissions. The Evaluation Team estimated a total annualized GHG reduction of 79% but no reduction in NO_X from the use of EVs compared to counterfactual vehicles for EY2023. Reviewing the program to date reveals an estimated 83% actual reduction in GHG emissions and NO_x emissions.

Table 131. SDG&E PYDFF Program Counterfactual GHG Reductions

Market Sector	EY2023 Sites Annualized GHG (MT) (n=8)				PTD Sites GHG (MT) (n=21)			
	Counter factual	Utility	Reduction	% GHG Reduction	Counter factual	Utility	Reduction	% GHG Reduction
Airport GSE	–	–	–	–	669.0	54.6	614.4	92%
Medium-Duty Vehicles	41.5	10.2	31.2	75%	175.0	41.2	133.8	76%
School Bus	11.6	2.0	9.7	83%	1,236.0	244.8	991.3	80%
Transit Bus	946.9	198.3	748.5	79%	215.3	53.5	161.7	75%
TSE	–	–	–	None	8.1	1.9	6.2	76%
Total	**1,000.0**	**210.5**	**789.5**	**79%**	**2,303.5**	**396.0**	**1,907.4**	**83%**

Table 132. SDG&E PYDFF Program Counterfactual NO_x Reductions

Market Sector	EY2023 Sites Annualized NO_x (kg) (n=8)				PTD Sites NO_x (kg) (n=21)			
	Counter factual	Utility	Reduction	% NO_x Reduction	Counter factual	Utility	Reduction	% NO_x Reduction
Airport GSE	–	–	–	–	1,087.0	50.9	1,036.1	95%
Medium-Duty Vehicles	3	10	(6)	None	12.9	38.3	(25.4)	None
School Bus	10	2	8	81%	1,097.9	229.6	868.2	79%
Transit Bus	45	187	(141)	None	10.3	49.5	(39.1)	None
TSE	–	–	–	None	10.4	1.8	8.6	83%
Total	**58.5**	**198.2**	**(139.7)**	**None**	**2,218.5**	**370.1**	**1,848.4**	**83%**

Figure 216. SDG&E PYDFF Program Net Electricity Mix, Program to Date

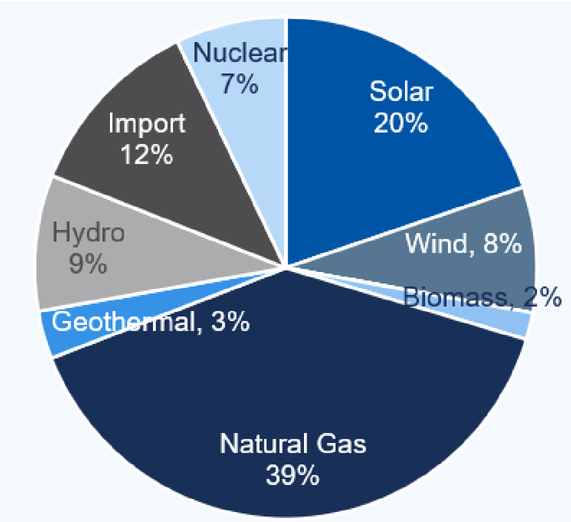


Figure 216 shows the annual program net electricity generation mix matching the hours when the EVs were charging. The CAISO grid mix continually changes depending on factors such as the level of total demand for power on the grid and the availability of fossil generation and variable renewable resources such as solar.

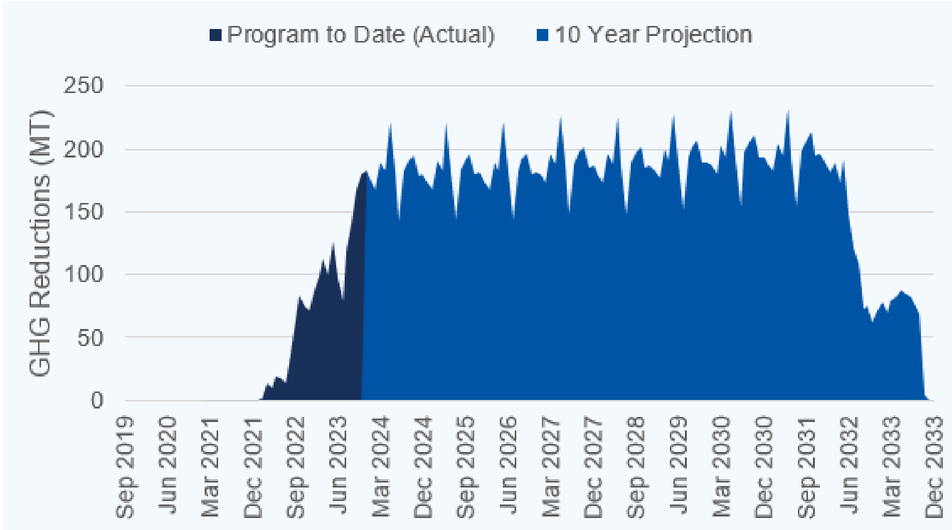
At this stage of the program, it appears that the vehicles were not charging predominantly during the peak hours of solar output when grid emissions were the lowest. More than 12% of the grid mix is comprised of electricity imports, which do not vary by time of day for analysis purposes but match the resource mix purchased for the California grid.[124]

Based on the real-time grid conditions when the charging occurred, the overall energy mix was about 49% zero-emissions or renewable sources of electricity (including solar, wind, hydro, geothermal, biomass, and nuclear) and 39% natural gas. The Evaluation Team expects that emissions reductions from these sites over 10 years will increase as the grid becomes cleaner. Additionally, the increased use of managed charging, where possible, would reduce emissions as EVs charge at off-peak times and grid power is supplied with greater amounts of renewable generation. Finally, emissions will further decrease with the addition of more charging sites and EVs in future evaluation years.

Figure 217 shows how program GHG reductions have increased to date and are likely to grow over time for all active sites. The analysis period ranges from the activation date of the first site in the program through the end of EY2023. The analysis incorporates the net reduction (counterfactual emissions minus utility emissions) for each fleet within the SDG&E PYDFF program. PTD emissions reductions appear in dark navy while anticipated benefits based on annualization appear in royal blue. As each site has its own starting date of operation, the 10-year sunset for each site appears as a gradual tapering off of program benefits between 2031 and 2033. While each year's operations appear similar, there are several key factors driving the variations such as seasonality of utility generation sources (high utility emissions will appear as a dip on the curves), holidays occurring on weekends versus weekdays, and sites that became operational late in 2023 having predicted operations year-round in future years.

[124] The power associated with imports comes from a mixture of renewables, hydro, nuclear, and natural gas power plants located outside of California (https://www.energy.ca.gov/data-reports/energy-almanac/california-electricity-data/2021-total-system-electric-generation).

Figure 217. SDG&E PYDFF Program Historical and Forecasted GHG Reductions for PTD Sites



Highlights

- Program to date results show an 83% reduction in GHGs and an 83% reduction in NO_x emissions.
- The greatest reduction in local emissions was for CO with more than 9,100 kg in 2023 and a projected 10-year reduction of more than 270,000 kg.
- Based on the real-time grid conditions when EV charging occurred, the overall energy mix contained about 49% zero emissions or renewable sources of electricity (including solar, wind, hydro, geothermal, biomass, and nuclear) and 39% natural gas.

Health Impacts

The Evaluation Team calculated public health impacts (as benefits and costs) of reductions in criteria pollutants from vehicle electrification. The pollutants we included in the analysis are primary $PM_{2.5}$ and precursors of secondary $PM_{2.5}$, including NO_x, SO_2, NH_3, and VOCs. This analysis considers only tailpipe emissions reductions rather than full lifecycle emissions (such as power plant emissions). The Evaluation Team used the U.S. Environmental Protection Agency's (EPA) COBRA to evaluate the health benefits associated with emissions reductions. COBRA estimates the county-level benefits for the county in which emissions are reduced. It also estimates the effect of the transport of emissions on all counties in the United States; however, this analysis includes only the effects of the emissions reductions in California. The Evaluation Team disaggregated the county-level effects to estimate the potential health benefits of sites for DACs and non-DACs.[125]

[125] DAC Census Tracts are defined as those included in in the SB 535 Disadvantaged Communities List (2022), this includes the DAC categories for CalEnviroScreen 4.0 Top 25%, CalEnviroScreen 4.0 High Pollution Burden Score and Low Population Count, and 2017 Disadvantaged Community (CalEnviroScreen 3.0 only).

Economic value depends on the health effects associated with the emissions, that is, whether they are associated with illnesses or death. The monetary value of the morbidity reductions associated with emissions reductions include avoided lost wages, avoided medical costs, and the amount of money people are willing to pay to avoid an illness or condition like respiratory disease. The value of the reduced mortality associated with emissions reduction is measured by the value of a statistical life, which uses value-of-life studies to determine a monetary value of preventing premature mortality. COBRA reports both a low and high impact, representing the uncertainties in the estimates.

The total value of the health benefits associated with emissions reductions is between $2,362 and $5,320. Table 133 shows the cumulative health benefits for counties in California associated with the emissions reductions realized by the electrification of EY2023 SDG&E PYDFF sites.

Table 133. SDG&E PYDFF Program California Health Benefits for EY2023 Sites

Health Endpoint	Change in Incidence (Annual Cases)		Monetary Value (Annual, 2023 Dollars)	
	Low	High	Low	High
Mortality	0.0002	0.0004	$2,315	$5,238
Avoided Medical Care				
Nonfatal Heart Attacks	< 0.0000	0.0002	$4	$38
Infant Mortality	< 0.0000	< 0.0000	$13	$13
Hospital Admits, All Respiratory	< 0.0000	< 0.0000	$2	$2
Hospital Admits, Cardiovascular	0.0001	0.0001	$3	$3
Acute Bronchitis	0.0003	0.0003	< $0	< $0
Upper Respiratory Symptoms	0.0052	0.0052	< $0	< $0
Lower Respiratory Symptoms	0.0037	0.0037	< $0	< $0
Emergency Room Visits, Asthma	0.0001	0.0001	< $0	< $0
Asthma Exacerbation	0.7867	0.7867	$1	$1
Lost Productivity				
Minor Restricted Activity Days	0.1616	0.1616	$17	$17
Work Loss Days	0.0276	0.0276	$7	$7
Total Health Effects	–	–	**$2,362**	**$5,320**

At the site level, the transit bus sector had the highest health benefits overall (56%), followed by the school bus (40%), and medium-duty vehicle (5%) sectors.

As part of this analysis, the Evaluation Team also examined health benefits within DACs, which may be disproportionately burdened by sources of pollution (including air pollution from ICE vehicles). Because COBRA estimates effects only at the county level, the Evaluation Team disaggregated the monetized health impacts by census tract using the relative population of each tract from the most recent American Community Survey. For example, we allocated 10% of the value of the health benefits to a census tract with 10% of the county's population. The Evaluation Team then estimated the total benefits allocated to DACs and non-DACs. This approach assumes that the benefits of emissions reductions are distributed evenly throughout the county. If the sites are located in DACs, and the emissions reductions are greater in the tracts near the sites, this approach understates the potential benefit to DACs. Additional information about emissions dispersion within counties would provide more-precise estimates of the health benefits to DACs and non-DACs.

In our analysis, most of the health benefits were in San Diego County, which had 66% of the total benefits, followed by Los Angeles County (11%), Riverside County (11%), Orange County (5%), and San Bernardino County (3%). San Diego County has the highest health benefit allocation because sites were located in the SDG&E territory; however, counties outside of the SDG&E territory also accrued health benefits when we accounted for air dispersion and transport of emissions. Overall, 14% of the total benefits were in DACs.

Highlights

- Cumulative monetary health benefits for counties in California realized by EY2023 PYDFF sites range from $2,362 for the low estimate and $5,320 for the high estimate.
- Sites in the transit bus sector had the highest health benefits overall.
- Most of the health benefits were in San Diego County, which had 66% of the total benefits, followed by Los Angeles County (11%), Riverside County (11%), Orange County (5%), and San Bernardino County (3%).
- Overall, 14% of the health benefits were in DACs.

Net Impacts

As part of the net impacts analysis, the Evaluation Team estimated program effects on participants to exclude impacts from actions that participants would have taken without the program (freeridership) and to include any program-attributable indirect impacts on participants (participant spillover) and nonparticipants (market effects). The team conducted three separate analyses to assess net impacts from the MDHD programs.

Enhanced Self-Report

The Evaluation Team based its approach for the MDHD programs' enhanced self-report NTG analysis on information obtained as part of in-depth surveys with participating fleet managers. The team conducted the survey via an online survey platform, Qualtrics, and delivered the survey using email contact information provided by SDG&E. The Evaluation Team used the CPUC nonresidential customer self-report NTG framework as the base to develop the MDHD fleet manager NTG methodology approach.[126] *Appendix A* details the MDHD fleet manager self-report NTG methodology. The Evaluation Team estimated the core component of the CPUC NTG methodology through three separate PAI site scores. The team used three separate sets of questions to assess three components of the core NTG ratio, with each PAI score on a 0.0 to 1.0 scale representing a different way of characterizing the SDG&E PYDFF program influence. The analysis included fleet manager responses from two of the five participating sites that were sent the survey.[127]

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[126] California Public Utilities Commission, Energy Division. February 20, 2015. *Methodological Framework for Using the Self-Report Approach to Estimating Net-to-Gross Ratios for Nonresidential Customers.*

[127] One transit site and one heavy-duty site completed the survey.

The Evaluation Team calculated the resulting self-report NTG for each site, prior to accounting for participant spillover, as the average of the PAI-1A, PAI-2, and PAI-3 score values. One minus the final core NTG ratio of 0.48 equals the 0.52 freeridership ratio for the PYDFF program.

For participant spillover, one responding participating fleet manager reported purchasing 10 additional electric school buses since they started participating in the SDG&E PYDFF program for which they did not receive funding from the SDG&E program and where they rated their SDG&E program participation as *extremely important* in their purchasing decision. The fleet manager reported that this additional fleet electrification activity received funding from two separate organizations; therefore, the Evaluation Team did not quantify spillover for the program. The final program level NTG ratio of 0.48 equals one minus the freeridership ratio plus the participant spillover ratio. These score values are presented in Table 134, along with the average final core NTG for the surveyed SDG&E PYDFF program sites.

Table 134. SDG&E PYDFF Program MDHD Fleet Manager NTG Analysis Results in EY2023

Fleet Manager Survey Completes (n)	Average of PAI-1A Score NTG	Average of PAI-2 Score NTG	Average of PAI-3 Score NTG	Average of Final Core NTG	Freeridership Ratio	Participant Spillover Ratio	Final NTG Ratio
2	0.50	0.45	0.50	0.48	0.52	0.00	0.48

Highlight

- The EY2023 program-level freeridership ratio is 0.52 and the participant spillover ratio is 0.00, resulting in a program-level NTG ratio of 0.48.

6.1.3. Lessons Learned

The team identified a number of lessons learned from EY2023. These lessons, presented below with key supporting findings and recommendations, may be applied to future program years and to other similar efforts. Note that these lessons were derived from a limited number of program participants across most but not all market sectors. Additional insights will be gained as more sites are completed in the coming years.

Although site costs and delays continue to challenge implementation, staff are committed to continued program adaptation to reflect the current market conditions.

Similar to previous evaluation years, site costs continue to be a challenge. In particular, materials costs which have been compounded by supply chain delays. Furthermore, long lead times for permitting were a challenge; however, staff developed a new permit route in 2023 to fast-track sites starting in 2024. In 2023, staff identified that small fleets, which represent a large percentage of the SG&E customer base, have more challenges with program awareness, infrastructure capacity, and limits with program design requirements than medium- and large-size businesses. Therefore, earned media, expanded outreach, and continued staff transparency with program successes and implementation challenges have become even more essential to foster positive customer relationships.

Site activation timelines have gotten longer in EY2023 relative to earlier evaluation years for a multitude of reasons.

The timeline for application to activation was 930 days on average in EY2023 compared to 751 days in EY2022 and 543 days in EY2021. In EY2022, the Design and Permitting phase was the longest at 316 days, followed by Construction Complete at 163 days. In EY2023, the Construction Complete phase more than doubled in length to 398 days, while Design and Permitting dropped by 38% to just 196 days. This shift was driven by two transit bus sites, which had an average timeline of 568 days for the Construction Complete phase and total activation timeline of 1236 days.

The extension of site activation timelines has been attributed to a number of factors, with the largest delays stemming from technology and construction issues. Fleet managers reported acquiring in compatible chargers and vehicles, mismatches in electrical system upgrades and charger requirements, and utility construction issues that led to a multi-year delay. In addition, supply chain delays continue with switchgear presenting the greatest difficulty for procurement. SDG&E has also noted the long lead time required for permit approvals and changes to customer site designs causing significant delays. Many sites activated in EY2023 were large and complex, making them inherently more time consuming to complete.

Policy uncertainty continues to impact utility planning, program participation, and customer choices in the EV market.

Staff expressed that customers are hesitant about fleet electrification because of barriers in understanding the fast-paced, ever-changing technology and regulatory landscape in California. These customers are apprehensive about committing to equipment that is not readily available, may not be compliant with certain standards as regulations shift during the time it takes to procure equipment, or is not known very well because it is new. To address this uncertainty during the program enrollment process, SDG&E staff prioritizes learning more about each customer's business models and specific electrification needs to provide advisory services given SDG&E's expertise and close involvement with the dynamic landscape of TE.

The PYDFF program is lagging behind reaching its goals for both total number of sites and EVs supported, influenced by small business challenges and legal hurdles.

In EY2023, eight sites with 78 charging ports were activated to support 227 vehicles, based on VAPs of activated sites. Five market segments are now supported by the program, with school bus fleets representing the highest participation (48% of sites), and TSE and GSE each representing one site (5%). The 21 total activated sites (260 charging ports) in the program to date meets 7% of the program's *per se reasonableness* goal of 300 sites and support 472 vehicles, which meets 16% of the program's *per se reasonableness* goal of 3,000 additional vehicles electrified.

The PYDFF program will make additional progress towards these goals as more sites reach activation. For example, the 35 contracts signed in the CRT program to date support 668 MDHD vehicles, which would meet 12% of the program's site goal and 22% of the program's vehicle goal.

Eighty-three percent of commercial customers in SDG&E's territory are classified as small businesses. As the program has progressed, SDG&E staff have noted that small businesses have more challenges with program awareness, infrastructure capacity, and limits with program design requirements than medium- and large-size businesses. In addition, some customers' legal teams find it very challenging to accept program participation agreements where no redlines are allowed, which can result in nine-to-twelve months of discussion before an agreement is signed.

Overall program spending is ramping up slowly, but spending in DACs remains absent.

SDG&E spent $4.9 million of the PYDFF program budget in EY2023, bringing total spending to $15.9 million out of $107 million of the approved program budget, or 14.8% of available funding. However, no sites in the PYDFF program-to-date are located in a DAC. In 2022, SDG&E submitted AL 4086-E requesting an update to the definition of DACs to SDG&E's more expansive service area definition; however, the CPUC denied this request citing the need for more comprehensive outreach. Although in 2023 staff continued to augment and prioritize DAC outreach (such as through targeted events in specific locations and with presentations given in Spanish), they did not gain significant traction with DAC participants and plan to re-submit proposed adjustments to the DAC definition in 2024. Ultimately, SDG&E program staff are concerned about meeting existing DAC requirements given the limited number of state-defined DACs in SDG&E's service area. With the program maturing, this is resulting in having to turn away some non-DAC customers that want to participate in the program because the majority of the remaining noncommitted funds must be spent on DACs.

> **Recommendation:** The Evaluation Team found that the vehicle counts observed during site visits tend to be significantly lower than customers' VAPs (even when compared with the expected annual procurement). Taking a proactive approach to tracking progress towards the VAP (with an annual customer contact about vehicle procurement, for example), would allow Utilities to ensure that customers are following their VAP, which could contribute to improved program performance with respect to energy consumption, petroleum displacement, emissions reductions, and health impacts.

> **Recommendation:** Utilities are significantly lagging in their progress toward site goals and are spending their allocated budgets more slowly than expected. Ongoing lessons learned by Utility staff and from evaluation findings should be incorporated into programs to promote improvements. To ensure changes can be implemented in a timely manner, Utilities should continue to communicate recommendations for updates to program design and metrics to regulators and other stakeholders. For many changes, regulatory support will be needed to implement these recommendations. An example of a potential barrier is the cost threshold metric the Utilities use to determine whether to accept or reject a site into the programs. These metrics are in terms of dollars per charging port and dollars per vehicle—based on CPUC decisions—and vary by Utility. Ultimately, the thresholds reduce the number and diversity of participants which is an unnecessary constraint in the current early market stage of electric MDHD vehicles. Utilities need greater flexibility in program design to meet the overarching goals of the SRP related to advancing TE.

The PYDFF program sites are helping to displace petroleum, reduce GHG and local emissions, and achieve health impacts overall and within DACs.

The PYDFF Program sites accounted for a program to date impact of more than 222,400 gallons of petroleum with the school bus sector accounting for nearly half of the petroleum displaced in EY2023. In addition, the Program resulted in a reduction of nearly 1,907 MT of GHGs program to date. These sites all positively contributed to lowering local emissions, with CO reduction being the most prominent, achieving a reduction of 9,142 in E2023. Overall, 14% of the health benefits are in DACs with the monetary health benefits in EY2023 from sites ranging from $2,362 to $5,320.

Though overall demand increased significantly, installed EV ports are underutilized, and the majority of fleet operators are not implementing load management.

Across EY2023 operational sites, 4 MW of new charging capacity was installed, bringing total capacity for the program to date sites to 8.5 MW. Overall demand doubled to 1.6 kW in EY2023. However, peak demand never exceeded 1.6 MW in EY2023, or 19.2% of installed capacity. Many fleet operators said they had not yet received some or all of their vehicles, leading to a lower overall demand across sites.

Seven of 21 operational sites in the program-to-date exhibited the use of load management, shown by sharp increases in load beginning after 9 PM, when the peak rate time period ends. This is the highest percentage (33%) of total sites across utility programs. However, new sites displayed intermittent load management implementation, showing a learning curve for fleet managers. It is expected that the impacts of load-managed sites will grow next year as fleet managers become more familiar with the process and as new load-managed sites come online. On a monthly basis, 54% of fleet charging sessions occurred during the peak rate time period of 4 p.m. to 9 p.m., resulting in negative impacts on operational costs and grid congestion. However, 30% of charging sessions have enough flexibility to avoid charging during that peak rate time-period.

Not all EVSPs offer load management capability, and utility bills may not be available to fleet operators so they can understand the cost impacts of time of use. During site visits almost every operator had a disconnect between what they expected the electricity to cost versus their actual costs. However, most fleet operators are aware of TOU pricing, regardless of knowing their own usage trends and costs.

> **Recommendation**: Utilities should continue to contact customers on an annual basis (at minimum) following site activation to ensure that sites are proactively identifying load management opportunities. The Evaluation Team recommends focusing on school bus sites—which typically do not manage load—and large sites such as those with greater than 1 MW installed capacity—which have the greatest opportunity to manage load. By identifying and documenting reasons why customers are not actively managing load, program staff and the Evaluation Team can build more-targeted recommendations for addressing load management barriers.

TTM and BTM infrastructure costs continue to vary widely between sites. Program participants continue needing Utility infrastructure incentives.

Across 12 financially closed out sites, Utility spending resulted in an average infrastructure cost of $267,545 per site, $1,246 per kilowatt, and $24,276 per vehicle when including TTM and BTM infrastructure but excluding EVSE cost. The all-in costs paid by the customer and SDG&E vary widely between sites, with an average of $602,861 per site. EVSE was the largest cost across the sites accounting for nearly half of the total, followed by BTM, then TTM.

6.2. Schools and Parks Pilots

6.2.1. Overview

This overview provides a detailed description of the SDG&E Schools and Parks Pilots; summaries of the Pilot implementation process, performance metrics, program materials, and budget; and a timeline of major milestones. Following the overview are detailed findings, highlights, and lessons learned.

Pilot Description

Schools Pilot: Through its Schools Pilot, SDG&E has offered the direct installation of and incentives for installing 184 L2 charging and 12 DCFCs at 30 schools and educational institutions. SDG&E is aiming for the Pilot to have 40% of installations within DACs.[128] The Pilot has a turnkey ownership model, where SDG&E offers to install, own, operate, and maintain the charging stations. The charging stations are required to use Time of use (TOU) rate pricing. Site hosts can opt to own the chargers and are then eligible for a rebate equivalent to the cost that SDG&E would pay to install EVSE under the SDG&E turnkey model.

Schools Pilot Targets

- 184 L2 and 12 DCFC charging stations
- 30 schools
- 40% in DAC locations

Schools Pilot Design Goal

Empower schools to offer public charging to staff, students, parents, and the greater community.

Parks Pilot: Through its Parks Pilot, SDG&E will aim to install 74 light-duty public chargers in 12 state parks and beaches within its service territory and 66 light-duty public chargers at 10 city and county park sites. SDG&E will build, own, operate, and maintain the charging stations, which will use a TOU rate. SDG&E developed an awareness campaign to inform the public of the availability of these chargers.

Parks Pilot Targets

- 74 charging stations at 12 state parks and beaches
- 66 charging stations at 10 city and county parks
- 50% overall in DAC locations (all city and county sites must be in DACs)

Parks Pilot Design Goal

Encourage parks and beaches to charge their own fleets and offer charging to staff and patrons.

Implementation

As interested customers became aware of the Schools Pilot—through SDG&E marketing efforts, word of mouth, or directly from an SDG&E account manager—they could choose to submit an application as the first step in the implementation process. There was no application process for the Parks Pilot, as SDG&E completed outreach for recruitment directly to eligible municipalities and the DPR. Starting in 2022 and continuing in 2023, SDG&E staff were focused on implementing the Pilots.

128 As per AL 2876-E, SDG&E found that only 27 census tracts in its territory were considered DACs (using the top quartile in CalEnviroScreen statewide definition). However, the service territory definition produces a broader definition and leads to a calculated 180 DAC census tracts in SDG&E service territory.

Figure 218 shows the implementation process for the Schools and Parks Pilots. Note that the customer agreement step is slightly different for state parks than the processes for municipal parks and for the Schools Pilot, since the DPR expects to approve an MPA agreement that will apply to all state parks in SDG&E service territory participating in the Parks Pilot. Each individual site will have site addendums to the master agreement based on specific site needs and designs.

Figure 218. SDG&E Schools and Parks Pilots Implementation Process

IDENTIFYING POTENTIAL SITES

1. SDG&E uses Google Earth to identify good candidates for the pilot
2. SDG&E asks eligible school district or municipality to pick their top five sites for EVSE
3. SDG&E conducts desktop reviews of top five sites to narrow choice to two

PARTICIPATION AGREEMENT

1. Customer commits to participation agreement

SITE WALK AND DESIGN

1. SDG&E completes site walk of two potential sites
2. SDG&E assesses both sites and customer and SDG&E determine best fit for the pilot
3. SDG&E drafts design
4. Customer reviews and approves design

CONTRACT AND PERMITS

1. SDG&E finalizes design and environmental considerations
2. SDG&E issues full contract to customer
3. SDG&E submits requests for and acquires permits

CONSTRUCTION AND ACTIVATION

Program Performance Metrics

The Cadmus team reviewed sites participating in SDG&E's Schools Pilot and Parks Pilot and analyzed them by pilot status. Table 135 and Table 136 provide the count of sites by completion status in SDG&E's Schools Pilot and Parks Pilot, respectively, in EY2023 and for the pilot to date.

Table 135. SDG&E Schools Pilot Complete Site Count by Status

Site Status	EY2023	Pilot to Date
Utility Construction Complete	6	15
Activated	8	15
Operational	8	15
Closed Out	4	5

Table 136. SDG&E Parks Pilot Complete Site Count by Status

Site Status	EY2023	Pilot to Date
Utility Construction Complete	1	9
Activated	1	9
Operational	1	9
Closed Out	3	8

In EY2023, all SDG&E Schools and Parks Pilots sites that were activated became operational. Figure 219 shows the locations and DAC status of EY2023 Schools and Parks Pilots' activated sites. Note that multiple sites in a single location will appear as a single point in Figure 219. The Schools Pilot signed an additional 4 contracts, raising the total number of contracts signed to date to 27. The Parks Pilot continues to report 11 contracts signed to date as no additional contracts were signed in EY2023.

Figure 219. SDG&E Schools Pilot (Left) and Parks Pilot (Right) EY2023 Activated Charging Stations

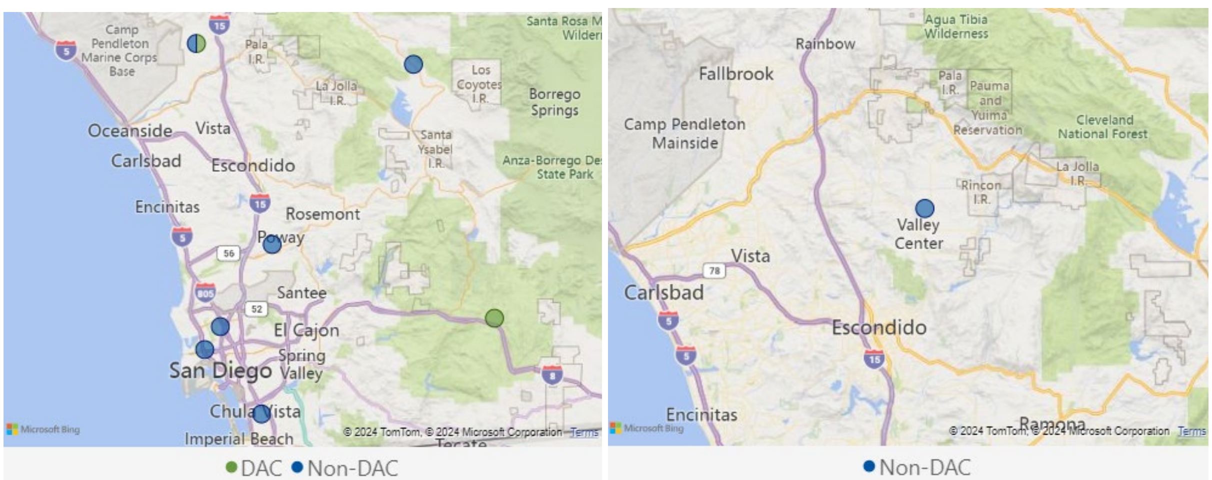


Table 137 presents site-level data by Pilot program, showing DAC status and number of ports for the sites activated in EY2023 and in the program to date. The cumulative percentage of DAC sites is 47%, which exceeds the Pilot's *per se reasonableness* DAC metric of 40%. The Schools Pilot deployed an additional 68 charging ports (63 L2 and 5 DCFC ports), bringing the total number of ports installed to date to 134 (127 L2, 7 DCFC).

As displayed in Table 137, in EY2023, ten additional charging ports (10 L2) were installed by the Parks Pilot, increasing the total number of charging ports installed to date to 65 (59 L2, 6 DCFC). The SDG&E Parks Pilot site activated in EY2023 sits outside of a DAC, lowering the percentage of DAC sites to date to 89%. SDG&E's Parks Pilot has separate *per se reasonableness* DAC goals for charging sites located in city or county parks versus state parks; a goal of 100% for city and county charging sites and 50% for sites located at a state park or beach.[129] For SDG&E's Parks Pilot to date, all activated sites located at a city or

[129] SDG&E's Parks Pilot allows participation from publicly accessible parks located on tribal lands but has not defined a DAC goal related to tribal parks.

county park are located within a DAC. The Parks Pilot site activated in EY2023 that sits outside of a DAC is located on tribal land.

Table 137. SDG&E Schools and Parks Pilots Activated Site Data in EY2023 and Pilot to Date

Pilot	EY2023				Pilot to Date			
	Activated Sites inside DAC	Activated Sites outside DAC	L2 Charging Ports	DCFC Charging Ports	Activated Sites inside DAC	Activated Sites outside DAC	L2 Charging Ports	DCFC Charging Ports
Schools	2	6	63	5	7	8	127	7
Parks	-	1	10	-	8	1	59	6

As shown in Table 138, the 15 activated sites to date in SDG&E's Schools Pilot meet 50% of the Pilot's goal of 30 sites. These activated sites support 127 L2 ports meeting 69% of the Pilot's goal of 184 L2 charging ports and seven DCFC ports meeting 58% of the Pilot's goal of 12 DCFC charging ports. The 27 customer contracts signed to date could satisfy 83% of the Pilot's site goal.

Table 138. SDG&E Schools Pilot Site and Port Per se Reasonableness Goal Progress

Pilot Metric	*Per se Reasonableness* Goal	Pilot to Date
Activated Sites	30	15
L2 Ports	184	127
DCFC Ports	12	7

As displayed in Table 139, the nine activated sites to date in SDG&E's Parks Pilot meet 41% of the Pilot's goal of 22 sites. These activated sites support 59 L2 ports, meeting 50% of the Pilot's goal of 120 L2 charging ports and 6 DCFC ports, meeting 30% of the Pilot's goal of 20 DCFC charging ports[130]. The eleven customer contracts signed to date could satisfy 50% of the Pilot's site goal.

Table 139. SDG&E Parks Pilot Site and Port Per se Reasonableness Goal Progress

Pilot Metric	*Per se Reasonableness* Goal	Pilot to Date
Activated Sites	22	9
L2 Ports	120	59
DCFC Ports	20	6

The CPUC established six phases in the program timeline per the SB 350 reporting template. Table 140 shows the median durations by program phase for EY2023 and pilot to date activated sites in SDG&E's Schools Pilot. In EY2023, the median number of calendar days by phase for the Schools Pilot ranged from 4 days for Activation to 381 days for Design and Permitting. Median durations across pilot in EY2023 were similar to those for pilot to date in the Pilot.

[130] DCFCs are limited to colleges and universities.

Table 140. SDG&E Schools Pilot, Median Calendar Days per Phase

CPUC Program Phase	Median Calendar Days	
	EY2023	Pilot to Date
Application Review	25	24
Site Assessment	195	189
Contract Issuance	20	22
Design and Permitting	381	351
Construction Complete	94	64
Activation	4	3

Table 141 shows the median durations by program phase for EY2023 and pilot to date activated sites in SDG&E's Parks Pilot. The median number of calendar days per phase for the one Parks Pilot site in EY2023 ranged from one day for Application Review and Activation to 602 days for Site Assessment. Application Review and Activation phases were substantially quicker in EY2023 (one day) compared to pilot to date medians (24 and eight days, respectively). However, Construction Complete for the EY2023 activated site took more than double the time to complete (154 days) than the pilot to date median. It took nearly three times longer for the EY2023 site to complete Site Assessment (602 days) compared to the pilot to date median of 201 days.

Table 141. SDG&E Parks Pilot, Median Calendar Days per Phase

CPUC Program Phase	Median Calendar Days	
	EY2023	Pilot to Date
Application Review	1	24
Site Assessment	602	201
Contract Issuance	27	23
Design and Permitting	213	213
Construction Complete	154	77
Activation	1	8

Program Materials Summary

In 2023, SDG&E completed ME&O for both the Schools and Parks Pilots.

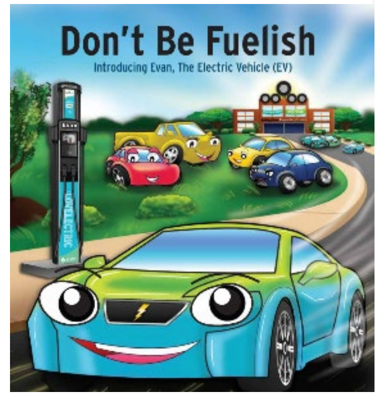
Schools Pilot and Parks Pilot

In 2023, SDG&E ran a paid advertising campaign that ran social media banner ads and video streaming ads to promote awareness of EVs and the charging options offered in San Diego as part of the Power Your Drive for Schools and the Parks and Beaches Pilots, reaching over 20 million impressions in 2023.

Schools Pilot

Starting in 2022 and continuing in 2023, SDG&E helped sponsor the annual iVIE (Innovative Video in Education) Student Awards Film Festival, hosting the #LOVELECTRIC category. As part of the #LOVELECTRIC category, students from elementary through high school competed to create educational videos about the benefits of EVs.

Figure 220. *Don't Be Fuelish* Children's Book Cover



SDG&E designed and published a children's book (shown in Figure 220) called *Don't Be Fuelish* that helps students become familiar with the equipment installed at their schools and highlights some key benefits of EVs, such as pollution and noise reduction. SDG&E made this book available to teachers, and SDG&E staff visited selected participating schools to read the books to students directly.

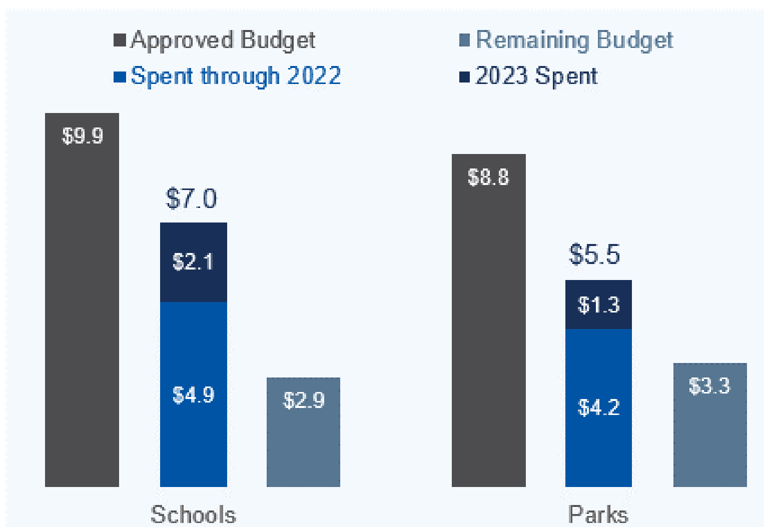
Parks Pilot

To commemorate SDG&E's first public EV chargers installed on tribal lands, in 2023 SDG&E hosted a public event with leaders from the San Pasqual Band of Mission Indians, showcasing the charging stations at the San Pasqual Ball Park. The event was covered by multiple media outlets such as NBC 7, KUSI, ABC, KPBS Radio, and KOGO Radio.

Budget Summary

As shown in Figure 221, from inception through the end of 2023, SDG&E spent $7.0 million of the $9.9 million approved budget for the Schools Pilot and $5.5 million of the $8.8 million approved budget for the Parks Pilot. Parks Pilot spending continues to be lower than in 2022 because the primary activities have focused on negotiations with the DPR for state park sites and ongoing maintenance for established local municipal parks sites.

Figure 221. SDG&E Schools and Parks Pilots Budget (Millions USD) as of Dec. 31, 2023

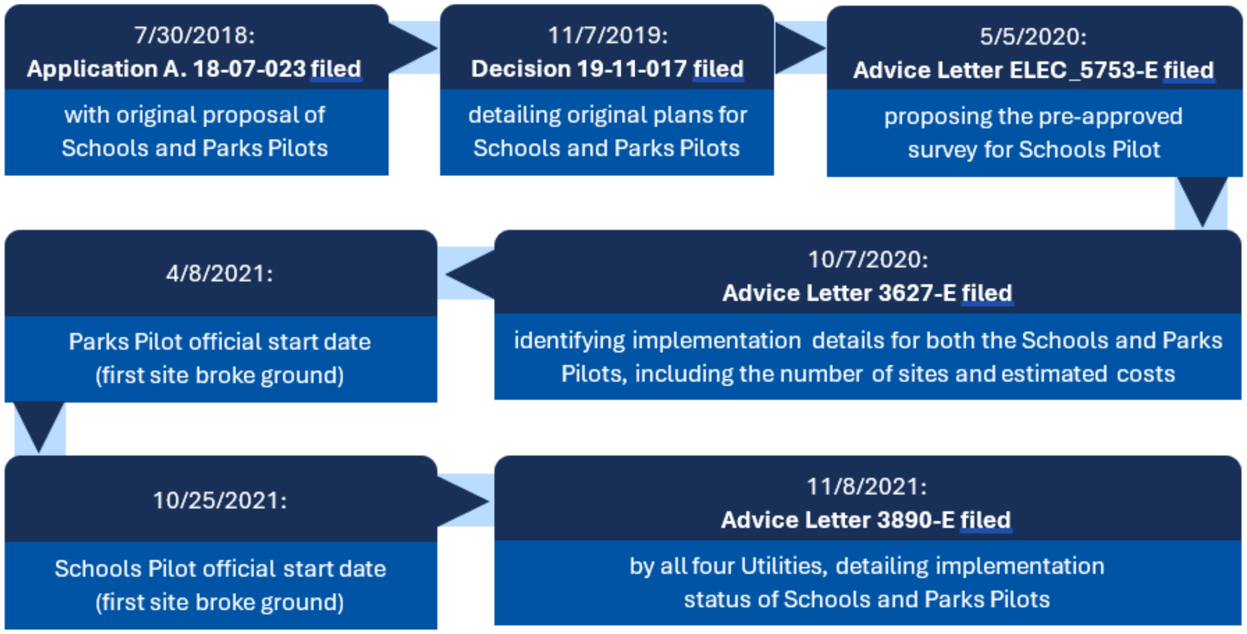


Timeline

Since the beginning of the pilots SDG&E has filed three Advice Letters: one pertaining to the Schools Pilot and two to both Schools and Parks Pilots. In 2023 SDG&E did not have any major milestones or filings and was focused on securing a master agreement and constructing sites.

Figure 222 shows all major milestones since the beginning of the Pilots.

Figure 222. SDG&E Schools Pilot and Parks Pilot Key Milestones



6.2.2. Findings

This section provides findings from analyses of the incremental EV adoptions, site visits and site costs, grid impacts, petroleum displacement, GHG and criteria pollutant reductions, and health impacts, as well as insight from Utility staff interviews.

Table 142 summarizes key impact parameters for EY2023 as well as for the program to date. Annual estimates of impacts are provided for metrics calculated as part of the impact evaluation. Additionally, the table provides estimates of impacts across all sites included in the program population through the end of 2023.

Table 142. SDG&E Schools and Parks Pilots Impacts Summary

Impact Parameter	EY2021 Sites[a]	EY2022 Sites[a]	EY2023 Sites[a]	EY2023 Sites Percentage in DAC	PTD Sites Actual	PTD Sites Actual Percentage in DAC
Population of Activated Sites	5	10	9	22%	24	58%
Sites included in analysis (#)	3	10	9	22%	24	58%
Charging Ports Installed (#)	16	89	76	18%	199	56%
Electric Energy Consumption (MWh)	30	147	212	2.5%	693	71%
Petroleum Displacement (GGE)	2,643	12,167	16,048	2.5%	58,203	73%
GHG Emission Reduction (MT GHG) [b]	18	94	126	2.5%	432	72%
PM_{10} Reduction (kg)	0.10	0.48	0.68	2.5%	2.23	71%
$PM_{2.5}$ Reduction (kg)	0.09	0.44	0.63	2.5%	2.05	71%
ROG Reduction (kg)	1.69	8	9.72	2.5%	37.86	74%
CO Reduction (kg)	54	253	343	2.5%	1.256	73%

Impact Parameter	EY2021 Sites[a]	EY2022 Sites[a]	EY2023 Sites[a]	EY2023 Sites Percentage in DAC	PTD Sites Actual	PTD Sites Actual Percentage in DAC

[a] Energy consumption, petroleum displacement, and emissions reductions are based on annualized data. Pilot to date results in the table are based on actual data (see *Appendix A* for more details). The one site in EY2021 was not included in the EY2021 Evaluation Report due to insufficient data but is included in PTD impact results in this report.

[b] GHGs include CO_2, CH_4, and N_2O multiplied by their respective GWP as defined by IPCC AR5 (see *Appendix A* for more details).

Incremental EV Adoption

The Evaluation Team estimated the effect of the public charging stations on household EV adoption for neighboring populations[131] with a two-stage analysis: (1) historical analysis of public EV charging impacts on vehicle ownership, and (2) analysis of ownership attributable to SDG&E Schools and Parks Pilots' investments. See *Appendix A* for the details of Stage 1 analysis.

Using the impact estimates from the Stage 1 analysis,[132] the Evaluation Team estimated the impact of SDG&E investments in public charging on EV ownership. By the end of 2023, 15 charging stations in SDG&E's Schools Pilot and nine charging stations in its Parks Pilot were activated. We estimated the impact of these stations based on annual EV registrations as well as pilot to date cumulative EV registrations.

SDG&E Schools Pilot

Based on the composite measure of public charging access, the Evaluation Team calculated the change in access to public charging due to SDG&E's Schools Pilot investment for each CBG where investments affected access. Table 143 shows that the pilot to date average change in access per affected CBG was 17.7, and the average change in the number of chargers (ports) was 7.3 per affected CBG. For reference, the average change in access across all CBGs in California was 0.57 between 2015 and 2020. The average normalized EV annual registration per 1,000 households was 27.9 in the affected CBGs in 2020.

131 There are two main channels through which the availability of public charging networks may affect EV purchases. The first is a network effect, through which EV owners gain increased access to the public charging stations because of the stations' placement at destinations such as workplaces, commercial establishments, schools, and parks. The Evaluation Team expects the availability of EV charging equipment at convenient locations (for midday charging away from home) to increase the convenience of owning an EV (such as lessening range anxiety) and to increase the probability of EV ownership. The second channel is a neighborhood effect on the driving population living in areas neighboring the public EV charging stations. The Evaluation Team expects the availability of nearby charging infrastructure to reduce the cost of EV ownership by providing alternatives to home charging. We expect that public EV charging will have the biggest impact on residents of multifamily buildings, many of whom will have limited access to EV charging equipment, or on low-income households, who may be unable to afford home EV charging equipment. The public charging access may boost EV ownership through both channels and there may be positive interactive effects between the channels that boost the overall impact of public charging networks. The Evaluation Team focused on analyzing the second channel and will analyze the impacts for the first channel separately when data become available.

132 The State 1 analysis used vehicle registration data from 2015 to 2020, the most recent period with complete information at the census block group level. The EY2023 estimates assume the impact of utility-specific stations remains unchanged over time, which may not reflect actual market and technological changes.

Table 143. SDG&E Schools Pilot Summary Statistics of Effects on CBGs

Pilot	CBG Mean (Standard Deviation)			
	Change in Composite Measure of Access[a]	Change in Number of Chargers[a]	Normalized Annual EV Registrations[b]	Number of Households[c]
SDG&E Schools Pilot	17.67	7.34	27.89	447.80
	(38.88)	(4.45)	(27.33)	(248.97)
CBGs (N)	17	17	17	17

These values are averages for the CBGs whose access to public charging was affected by SDG&E investments.

[a] Change in composite measure of access and number of chargers is from 2020 to 2023.

[b] Normalized annual EV registrations are average annual values in the affected CBGs in 2020 per 1,000 households.

[c] Number of households is based on 2015–2019 American Community Survey (ACS).

Sample standard deviations are in parentheses.

The Evaluation Team calculated the impact of the Schools Pilot Utility charging investments on neighboring EV ownership.[133] This involved combining the OLS and IV-2SLS regression estimates of the impact of public charging access on EV registrations from Stage 1, with the estimates of the CBG changes in public charging access and household counts. The impacts of the SDG&E investments on EV registrations will depend on the extent to which investments increased access in the affected CBGs and the number of households in the CBGs.

Table 144 shows estimates of the annual and pilot-to-date EV registrations attributable to the Utility Schools Pilot charging investments.[134] Based on the OLS long differences model, SDG&E School Pilot investments in charging facilities increased EY2023 annual EV registrations by 7.7 vehicles and pilot-to-date cumulative EV registrations by 11.8 vehicles. Based on the IV-2SLS long differences model, the School Pilot investments increased annual EV registrations by 35.6 vehicles and pilot-to-date cumulative EV registrations by 54.8 vehicles. The Evaluation Team prefers the IV-2SLS-based estimates because they account for the potential endogenous siting decisions of public charging (i.e., siting public charging infrastructure in locations with higher- or lower-than-average expected rates of EV adoption). These estimates reflect the 15 activated Schools Pilot facilities operating for a whole year.

133 In Stage 1, the Evaluation Team estimated the impact of public EV charging access on EV ownership. For Stage 2, we built on the Stage 1 analysis and conducted an attribution analysis of Utility-specific investments. A notable benefit of this approach is that it also applies to evaluations of other programs that lead to increased EV charging access, which ensures methodological consistency.

134 The long differences model estimates indicate the impact of public charging on EV registration over five years. The team divided these estimates by five to annualize them.

Table 144. SDG&E Schools Pilot EV Registrations Attribution

EY2023 Annual Increase of EV Registrations Driven by the Utility Program		PTD Cumulative Increase of EV Registrations Driven by the Utility Program	
OLS	IV-2SLS	OLS	IV-2SLS
7.65	35.59	11.78	54.81
(2.92)	(14.50)	(3.38)	(16.80)

Note: The table shows the EV registrations attributable to the utility investments in public charging infrastructure. The left panel shows the impacts of utility investments since 2020 on registrations in EY2023. The right panel shows the cumulative impacts of utility investments since 2020 on EV registrations in EY2021, EY2022, and EY2023. The Evaluation Team based these estimates on the OLS and IV-2SLS long differences models. The Team estimated the OLS long differences model using data for all CBGs in the analysis sample. We estimated the IV-2SLS long differences model only for CBGs in the 20 largest California cities. The long differences estimates are five-year estimates, which the team divided by five to annualize. For each affected CBG, the Evaluation Team calculated the increase in annual registrations as the product of the regression-based access coefficient divided by five, multiplied by the change in composite public charging access from utility investments (between baseline 2020 and EY2023), multiplied by the number of CBG households (in thousands). Robust standard errors clustered at the block group level are in parentheses.

As in EY2022, the SDG&E Schools Pilot investments in public charging had economically meaningful impacts on EV ownership in EY2023. Across all 17 affected CBGs, the total number of EV registrations is about 474 (17*27.89), so the preferred IV-2SLS regression estimates the SDG&E Schools Pilot to date cumulative impact to be an increase in EV registrations of about 11.6% (54.81/474). An average of 28 EV registrations per CBG puts these CBGs in the 50th percentile of the EV registration distribution of CBGs, implying an average level of baseline EV registration.

SDG&E Parks Pilot

The Evaluation Team used the same approach it used for the Schools Pilot to calculate the change in public charging access due to SDG&E's Parks Pilot investment for each CBG where the investments affected access. Table 145 shows that the pilot to date average change in the composite measure of access was 8.8 per affected CBG, and the average change in the number of chargers was 6.4 per affected CBG. The average normalized EV annual registration per 1,000 households was 15.7 in the affected CBGs in 2020.[135]

[135] Averages of the median income and percentage of multifamily housing units in affected CBGs puts the CBGs in the second median income quartile and the third multifamily housing quartile.

Table 145. SDG&E Parks Pilot Summary Statistics of Effects on CBGs

Pilot	CBG Mean (Standard Deviation)			
	Change in Composite Measure of Access[a]	Change in Number of Chargers[a]	Normalized Annual EV Registrations[b]	Number of Households[c]
SDG&E Parks Pilot	8.75	6.41	15.66	401.10
	(3.97)	(2.76)	(13.04)	(169.62)
CBGs (N)	17	17	17	17

These values are averages for the CBGs whose access to public charging was affected by SDG&E's investments.

[a] Change in composite measure of access and number of chargers is from 2020 to 2023.

[b] Normalized annual EV registrations are average annual values in the affected CBGs in 2020 per 1,000 households.

[c] Number of households is based on 2015–2019 American Community Survey (ACS).

Sample standard deviations are in parentheses.

Table 146 shows estimates of the annual and pilot to date EV registrations attributable to the Utility Parks Pilot charging investments.[136] Based on the OLS long differences model, SDG&E's investments in the Park Pilot charging facilities increased EY2023 annual EV registrations by 2.3 vehicles and pilot to date cumulative EV registrations by 10.6 vehicles. Based on the IV-2SLS long differences model, SDG&E's investments increased EY2022 annual EV registrations by 6.5 vehicles and pilot to date cumulative EV registrations by 24.4 vehicles. The Evaluation Team prefers the IV-2SLS-based estimates because they account for the potential endogenous siting decisions for public charging infrastructure (i.e., siting infrastructure in locations likely to have below- or above-average rates of EV adoption). These estimates reflect the operation of nine activated Parks Pilot facilities over one year.

Table 146. SDG&E Parks Pilot EV Registrations Attribution

EY2023 Annual Increase of EV Registrations Driven by the Utility Program		PTD Annual Increase of EV Registrations Driven by the Utility Program	
OLS	IV-2SLS	OLS	IV-2SLS
2.29	10.63	6.49	24.40
(0.34)	(1.67)	(0.55)	(2.66)

Note: The table shows the EV registrations attributable to the utility investments in public charging infrastructure. The left panel shows the impacts of utility investments since 2020 on registrations in EY2023. The right panel shows the cumulative impacts of utility investments since 2020 on EV registrations in EY2021, EY2022, and EY2023. The Evaluation Team based these estimates on the OLS and IV-2SLS long differences models. The Evaluation Team estimated the OLS long differences model using data for all CBGs in the analysis sample. We estimated the IV-2SLS long differences model for CBGs in the 20 largest California cities. The long differences estimates are five-year estimates, which the Evaluation Team divided by five to annualize. For each affected CBG, the Evaluation Team calculated the increase in annual registrations as the product of the regression-based access coefficient divided by five, multiplied by the change in composite public charging access from utility investments (between baseline 2020 and EY2023), multiplied by the number of CBG households (in thousands). Robust standard errors clustered at the block group level are in parentheses.

As in EY2022, the SDG&E Parks Pilot investments in public charging had less impact on EV ownership than the Schools Pilot investments in public charging. Across all 17 affected CBGs, the total annual

[136] The long differences model estimates indicate the impact of public charging on EV registration over five years. The team divided these estimates by five to annualize them.

number of EV registrations is about 415 (17*24.4), so the EY2023 impact of the SDG&E Parks Pilot boosts EV registrations by 2.6% (10.6/415), and the pilot to date impact boosts EV registrations by 5.9% (24.4/415). The Evaluation Team expected the Parks Pilot to have a relatively smaller impact, as metrics reflecting charging facility access (number of stations, number of chargers, and distance to the stations) were about 50% lower than those for Schools Pilot charging facilities. Compared to EY2022, the percentage increase in EV registration has not changed significantly, primarily due to minimal increase in active charging stations and the affected CBDs.

Highlights

- In EY2023, the SDG&E Schools and Parks Pilots' investments in public charging infrastructure led to an increase of 55 and 24 EVs, respectively, for households neighboring the infrastructure.
- The Schools Pilot had a greater impact than the Parks Pilot, mainly due to the accessibility to the Schools Pilot charging facilities, which had more charging stations and chargers and shorter distances to the stations.

Site Visit Findings

The Evaluation Team visited all sites activated in 2023 including eight School Pilot sites and one Park Pilot site. During these site visits, the Team documented the number of ports installed in EY2023 (73 L2 and 5 DCFC), installed charging capacity (757 kW), and parking spaces within reach of charging cords (114) including one or more Americans with Disabilities Act (ADA) compliant spaces per site. This brings the total port count to 199 and installed capacity to more than 2 MW. Figure 223 and Table 147 show ports and capacity based on site visits in 2023 and prior years.

Figure 223. SDG&E Schools and Parks Pilots Ports and Capacity Observed in 2023 and Prior Years

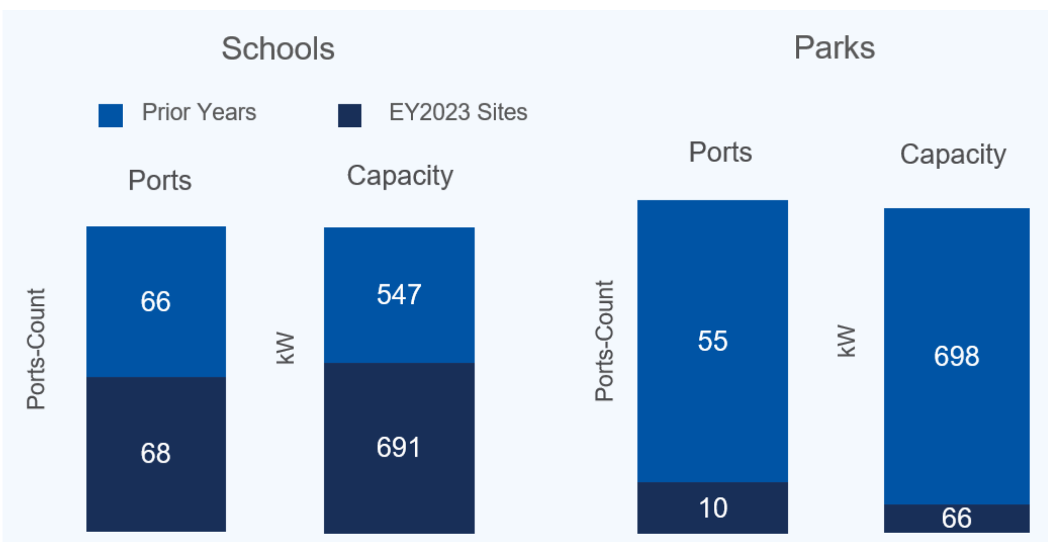


Table 147. SDG&E Schools and Parks Pilots Ports and Capacity Observed during Site Visits

Pilot	L2 Ports	DCFC Ports	Capacity (kW)	ADA Spaces	Connector
School 1	8	2	178	1	J1772, CCS, CHAdeMO
School 2	9	3	209	2	J1772, CCS, CHAdeMO
School 3	6	-	40	2	J1772
School 4	10	-	66	1	J1772
School 5	8	-	53	2	J1772
School 6	6	-	40	2	J1772
School 7	4	-	26	1	J1772
School 8	12	-	79	2	J1772
Park 1	10	-	66	2	J1772
Total	**73**	**5**	**757**	**15**	J1772, CCS, CHAdeMO

This year saw an additional 757 kW of charging capacity installed across nine sites, two of which were higher-education schools that included both L2 and DCFC ports. SDG&E was able to activate several sites this year, accounting for some of the most rural charging in the territory as exhibited in Figure 224.

Figure 224. SDG&E Parks Pilot Rural - Tribal Charging Location

Many of SDG&E's sites continue to exhibit higher access to charging based on ratios of parking spaces within reach of charging ports; examples are shown in Figure 225 through Figure 228.

Figure 229 compares the number of ports to the number of parking spaces within reach of these ports for both Pilots. Higher access ratios potentially may increase utilization of charging infrastructure through facilitating turnover of charging ports and enabling resiliency in the event one or more ports are unavailable for use.

K-12 school sites are intended for use by school staff and visitors and not listed as public. Schools may further use signage to restrict public charging, as shown in Figure 225.

Figure 225. SDG&E Schools and Parks Pilots Example of School Limiting Use of Charging by Public

Figure 226. SDG&E Schools and Parks Pilots Example of High Access L2 Charging Layout

Another site provided both L2 and DC Fast Charging, although the latter often inherently caters to faster turnover and less need for access. The benefit of this will be interesting to consider in coming years of EV market development through energy trends seen in the *Grid Impacts* section.

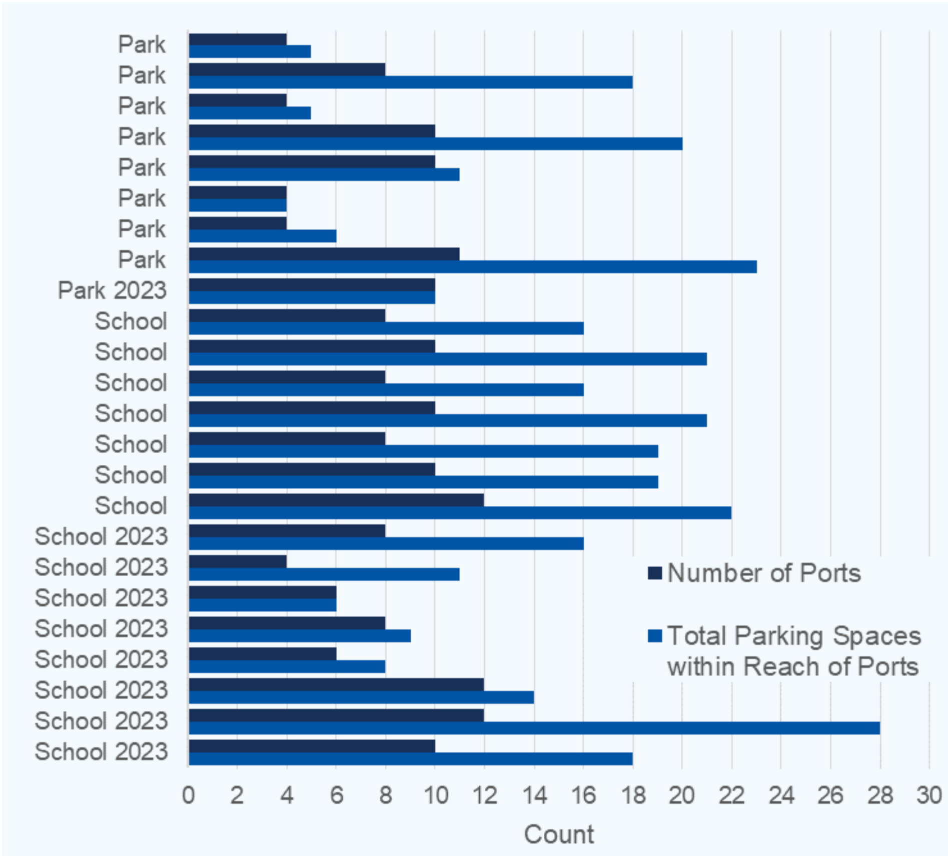
Figure 227. SDG&E Schools and Parks Pilots High-Access Location with L2 and DCFC Ports

Figure 228 may represent the most impressive access for a DCFC charging installation to date at four parking spaces per charger. These chargers have among the shortest charging cords in the industry. Only a few feet longer of cords could potentially provide significantly more access. In addition to the school, this location is nearby business and residential areas and may significantly anchor charging for one of the southern-most charging locations in the United States.

Figure 228. SDG&E Schools and Parks Pilots Example of Already High Access, and Even Higher with Longer Cords

Figure 229 shows the number of ports and the number of spaces that can access these ports for the sites the Evaluation Team visited. Overall, these sites average 1.7 parking spaces within reach of a charging port. Three EY2023 sites exceeded two parking spaces that can be reached by a single port. One of those sites solely served L2 charging. This site layout spread out the EVSE and placed them one parking space away from the corners.

Figure 229. SDG&E Schools and Parks Pilots Charging Port Availability by Site for PTD Sites



Unique to SDG&E's portfolio of AB 1082 Schools and AB 1083 Parks Pilots sites is that the utility owns all the infrastructure of the sites. A single NSP has been contracted for all the sites and acts as customer-of-record. At the time of site visits, many EVSE were energized but unavailable to public access once all construction aspects were completed due to significant delays in commissioning. However, the brand of hardware is programmed to allow several free charging sessions per EVSE (L2 and DCFC) to facilitate installation and commissioning. Creative EV drivers at many sites have learned key fobs are able to begin charging sessions. The Evaluation Team does not typically speak with site hosts to learn about their background for these sites. At least two points of contact made an effort to connect during the site visits in hopes of learning when the charging would be available for their staff after or to otherwise expedite their already lengthy wait. Without unfettered access to an NSP and direction to investigate, the evaluator is overall unable to pin down what has led to such significant commissioning delays, sometimes on the order of approaching and over a year.

Given that SDG&E owns the infrastructure, the Utility's NSP directly passes on current TOU rates to EV drivers. All EV drivers receive a message that may help influence their charging habits in a way that benefits VGI, reducing on-peak charging. This too may be seen in the *Grid Impacts* section below. Idle fees were not noted at the time of this report.

Highlights

- As in past years, extended commissioning delays at times approaching 18 months has led to low use for the community, questionable perception impacts, and free energy to some drivers.
- Using a single NSP to operate these sites in addition to past SDG&E sites (network and maintenance) may have created a vacuum allowing commissioning delays.
- Several sites were built in rural areas, enhancing EV charging access.
- All sites provide TOU pricing to drivers, potentially improving benefiting VGI.

Site Costs

The Evaluation Team conducted a cost analysis on 13 sites—including five school sites and eight park sites—with fully closed out finances as of December 31, 2023. These sites, which were activated in 2021, 2022, and 2023, had an average of 8 ports and 78 kW of installed capacity.

Figure 230 shows the distribution of site-level costs of the 13 sites. The horizontal lines of the boxes show the 25th, 50th, and 75th percentile of sites; the "x" represents the mean site cost; and the three panels are defined as follows:

- **All-in Costs.** The total cost of capital and installation borne by SDG&E and the customer, calculated by summing actual TTM cost paid by SDG&E, BTM cost paid by the customer or by SDG&E, and estimated EVSE costs.[137]
- **Ratepayer-Funded Costs.** All site costs borne by SDG&E, calculated by summing actual TTM cost paid by SDG&E, BTM cost paid by SDG&E, and estimated EVSE rebate paid by SDG&E.
- **Utility Infrastructure Costs.** Site costs borne by SDG&E for TTM and BTM.[138]

[137] EVSE equipment costs are estimated by the Evaluation Team using an assumption of $3,000 per port for L2 ports and $45,000 per port for DCFC ports.

[138] Values are the same as the Ratepayer-Funded Costs, without the inclusion of the EVSE estimates.

Figure 230. SDG&E Schools and Parks Pilots Program Costs Organized by Three Perspectives, Across 13 Closed-out PTD Sites

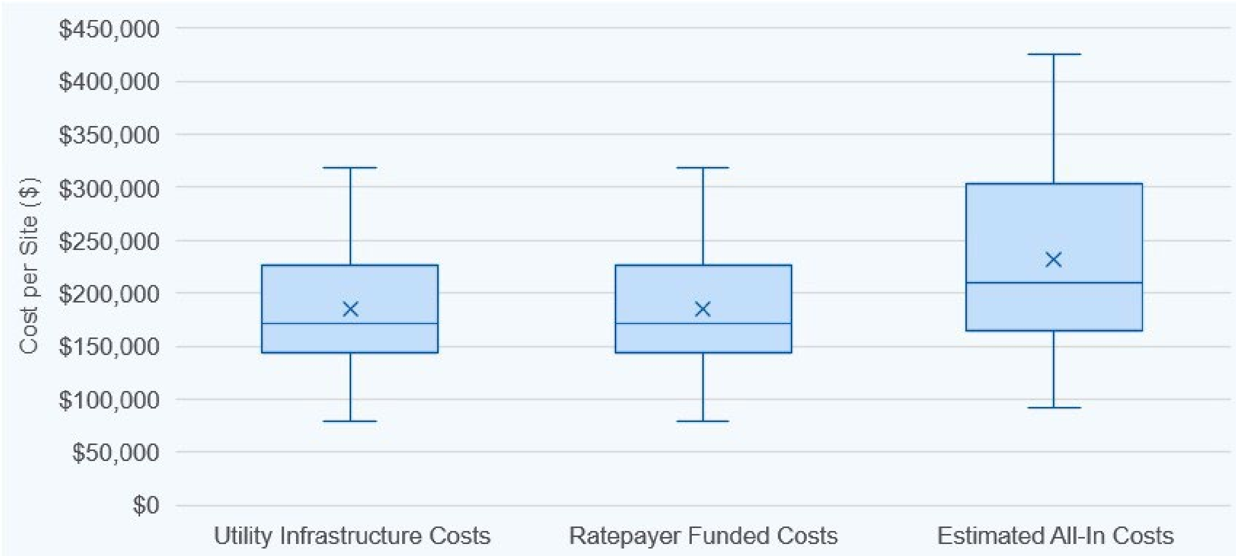


Figure 231 shows average all-in costs for the 13 sites. BTM is the largest cost across the sites, followed by EVSE and then TTM. Together, the average all-in TTM, BTM, and EVSE cost is $236,622.[139]

Figure 231. SDG&E Schools and Parks Pilots Average All-In Costs, across 13 Closed-out PTD Sites

[139] Calculated by summing all TTM, BTM, and EVSE costs borne by SDG&E and the customer, then dividing by 13 sites.

Figure 232 shows the distribution of Utility infrastructure costs (corresponding to the far-left panel in Figure 230) presented per site and per kilowatt. The average Utility infrastructure cost of TTM and BTM borne by SDG&E across sites was $193,468 per site[140] and $3,705 per kilowatt.[141]

Figure 232. SDG&E Schools and Parks Pilots Average All-In Costs across 13 Closed-out PTD Sites

Highlights

- All-in Costs paid by the customer and SDG&E vary widely between sites, with an average of $236,622 per site. EVSE was the largest cost across the sites, followed by BTM, then TTM.
- The average cost of SDG&E-sponsored TTM and BTM across sites was $193,468 per site and $3,705 per kilowatt.

Grid Impacts

This year, the SDG&E Parks and Schools reporting is broken into separate sections with this first section dedicated to school sites. The Evaluation Team determined grid impacts for the SDG&E Schools Pilot program based on the analysis of energy consumed by operational charging stations installed by the program through the end of 2023, combined with charging session data from the NSPs.

Data Sources

The primary data source used in this section is the energy usage data provided in regular 15-minute intervals from the AMI. Other data sources include customer bills, and data provided by NSPs. There are several important differences between AMI and NSP data. While the AMI data reflects only energy

140 Calculated by summing all TTM and SDG&E-sponsored BTM costs and dividing by the number of sites. Number reflects maximum infrastructure rebate offered for sites that have not yet applied for rebates, which may vary significantly from actual infrastructure rebate amount paid.

141 Calculated by summing all TTM and SDG&E-sponsored BTM costs and dividing by the sum of installed capacity.

usage, NSP data includes energy usage, session start and stop time, the duration of a vehicle's connection to a charging port, the duration of a vehicle actively pulling power, and the specific port used for a session. An AMI meter does however track standing loads (such as those the EVSE uses for communications, cooling, active power converters, solenoids, and screens), which NSPs typically cannot do. When AMI data is missing from the dataset, the Evaluation Team uses NSP data to fill the gaps.

Summary of Grid Impacts

Table 148 presents the estimated SDG&E Schools Pilot program grid impacts.

Table 148. SDG&E Schools Pilot Program Grid Impacts

Impact Parameter	2023 Actual	PTD Actual	10-Year Projection
Operational Sites	15	15	15
Installed Charging Capacity, kW	691	1,238	1,238
Electric Energy Consumption, MWh	312	338	4,857
On-Peak (4 p.m. to 9 p.m.) MWh (percentage of total)	63 (20%)	66 (20%)	N/A
Maximum Demand, kW (date and time)	311 (9/21/23: 9:30 a.m.)	311 (9/21/23: 9:30 a.m.)	N/A
Maximum On-Peak Demand, kW (date and time)	199 (10/10/23: 4 p.m.)	199 (10/10/23: 4 p.m.)	N/A

The remainder of this section offers detailed findings on actual consumption, demand, and charging session–oriented trends of the combined sites for EY2023.

Energy Trends

Sites in the SDG&E Schools Pilot reached a total consumption of 312 MWh in 2023, leading to a pilot to date total of 338 MWh. Eight sites were activated in EY2023, yielding 15 total activated sites through the end of December 2023. Demand peaked at 199 kW in aggregate across all sites at 4 p.m. on October 10, 2023, compared to 1,238 kW of installed capacity, indicating that there is considerable room for additional growth. The Evaluation Team attributes this gap between installed capacity and demand to the adoption rate of these charging stations by EV drivers, as discussed later in this section. Figure 233 plots daily energy consumption and maximum demand values for the program.

Figure 233. SDG&E Schools Pilot Monthly Energy Consumption and Maximum Demand

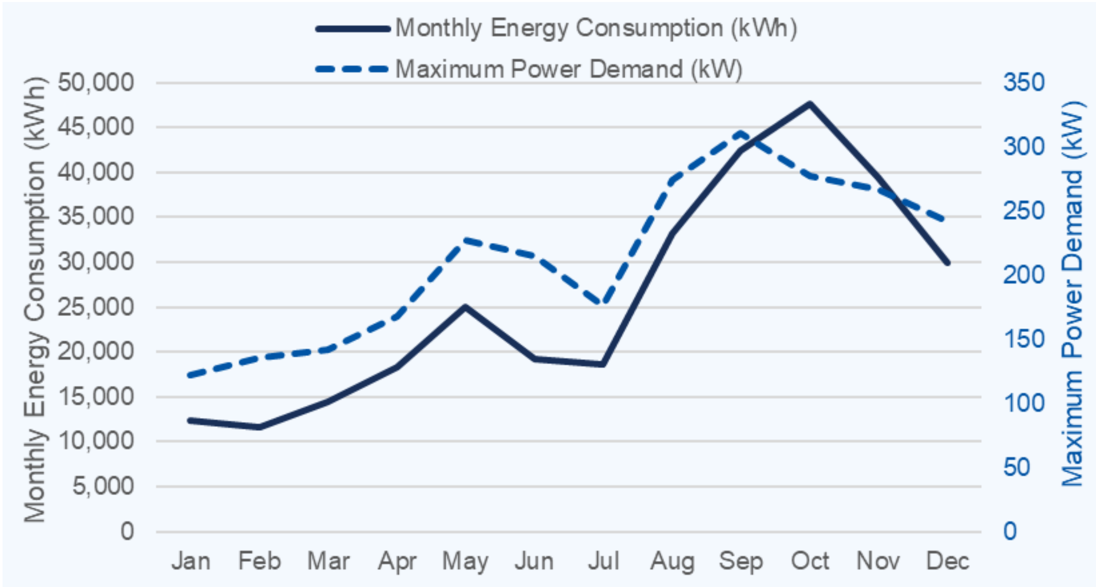
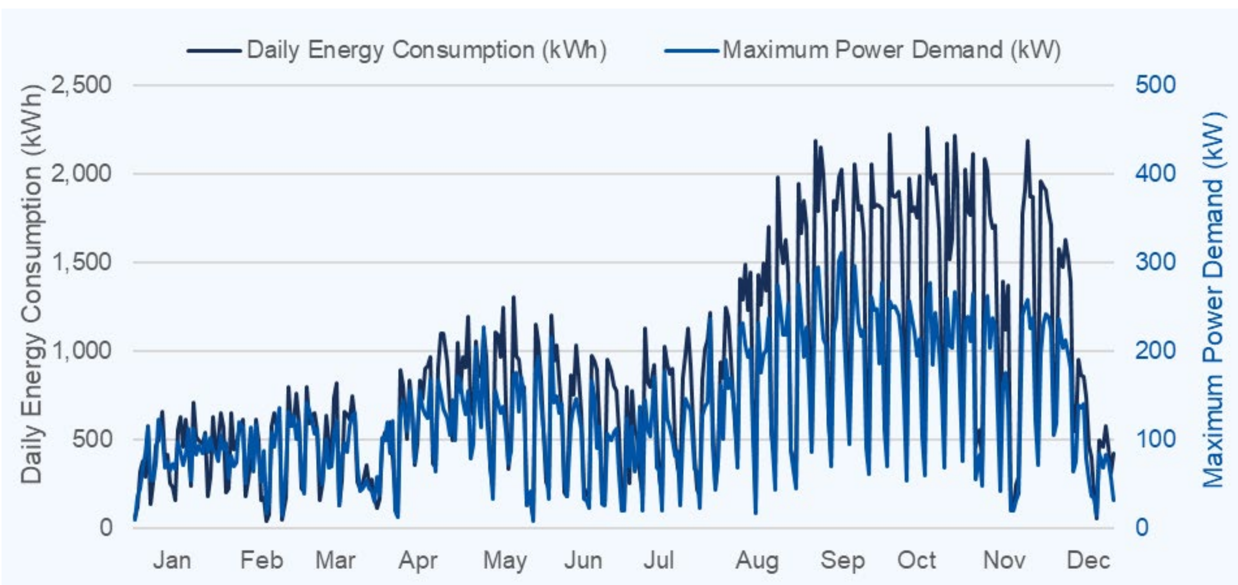


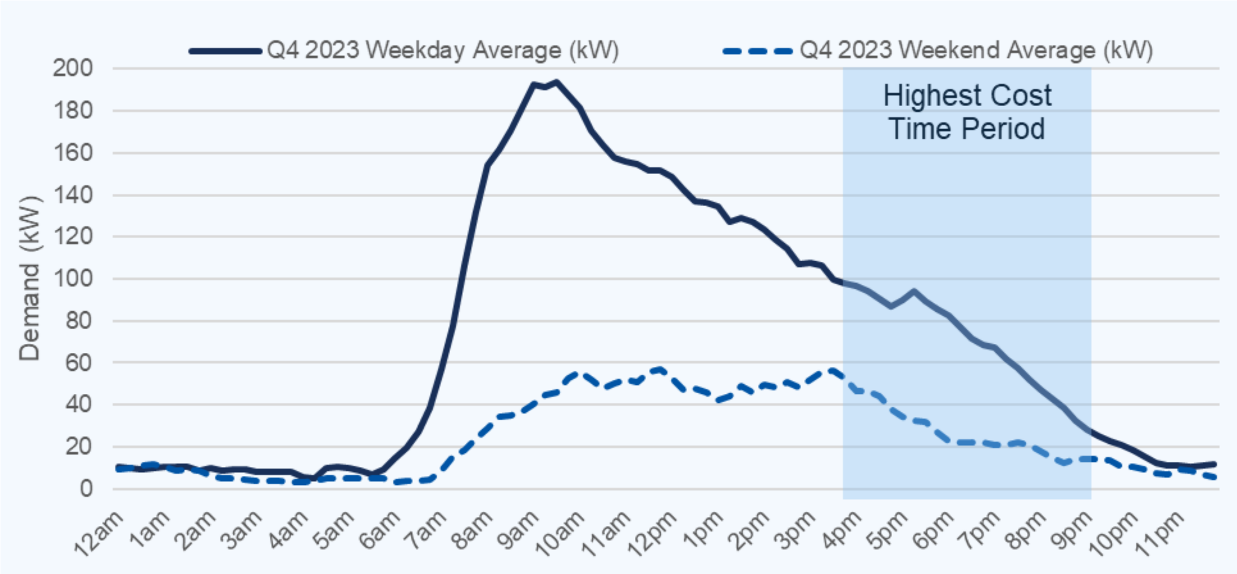
Figure 234 shows that consumption has peaked at almost 2.5 MWh, while maximum demand has been fairly stable around 250 kW for the last quarter of 2023. Both forms of measure tapered off in December with the holidays, but it will be interesting to follow these growth patterns.

Figure 234. SDG&E Schools Pilot Daily Consumption and Maximum Demand, Pilot to Date Sites



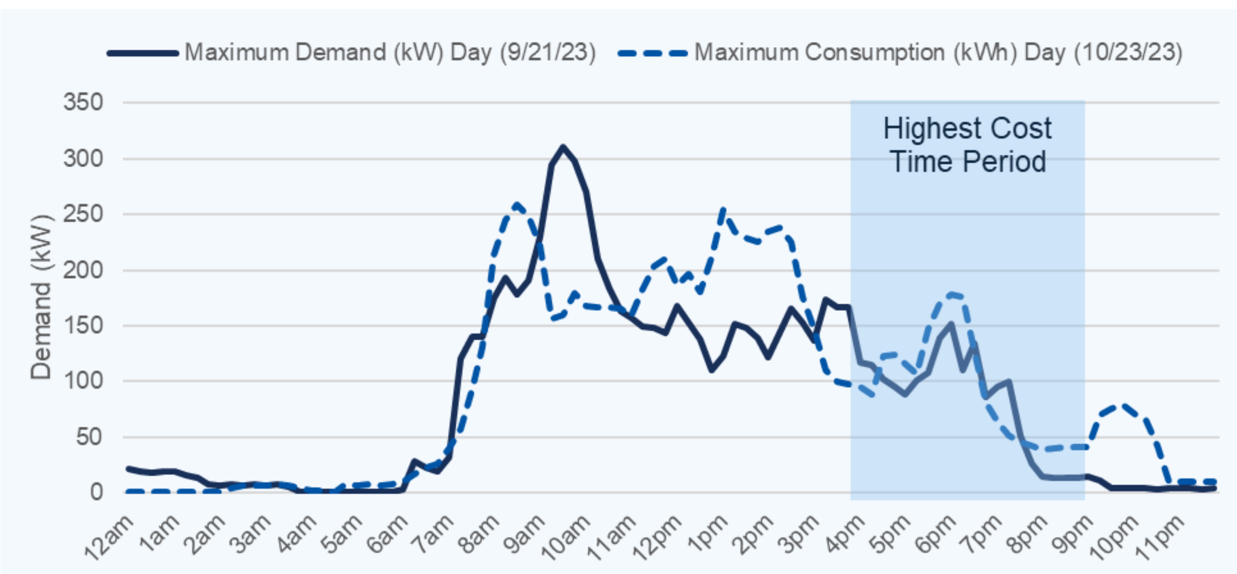
Though these are workplace-oriented sites that would expect to see activity focused during the week, there is some usage at other times as well. Many weekend days are seeing their demands at different times as opposed to regular daily patterns. Weekends only topped 1 MWh on a few days but are also trending up toward an average of around 500 kWh per day. This averages out to a relatively flat period from 10 a.m. through 4 p.m. as shown in Figure 235. Weekdays show a pattern of demand aligning closely with workday activities, showing a strong ramp up from 7–9 a.m. then slowly tapering off the rest of the day.

Figure 235. SDG&E Schools Pilot Average Weekday and Weekend Q4 2023 Load Curves



The days representing highest demand (9/21/23) and consumption (10/23/23) provide additional perspective into how EV drivers are using these sites. These two days' usage curves are shown in Figure 236. September 21 demonstrates a slightly different shape in its morning demand ramp-up. The highest consumption day (October 23) may have had a special schedule, with significant consumption mid-afternoon, a spike entering the evening, and even some late evening charging.

Figure 236. SDG&E Schools Pilot Highest Demand and Consumption Days Load Curve

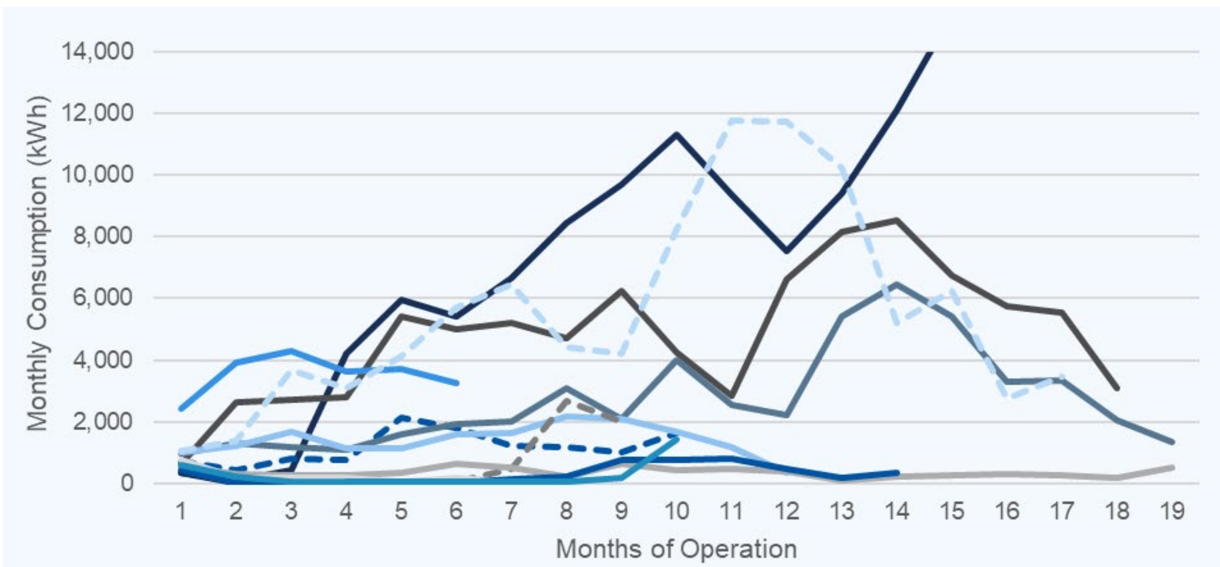


Usage Trends

Figure 237 shows sites' monthly consumption by their operational age. One limit of this perspective is that some schools are limited to L2 charging while others also include DC Fast Charging, which shows usage that is less defined by typical workplace charging patterns.

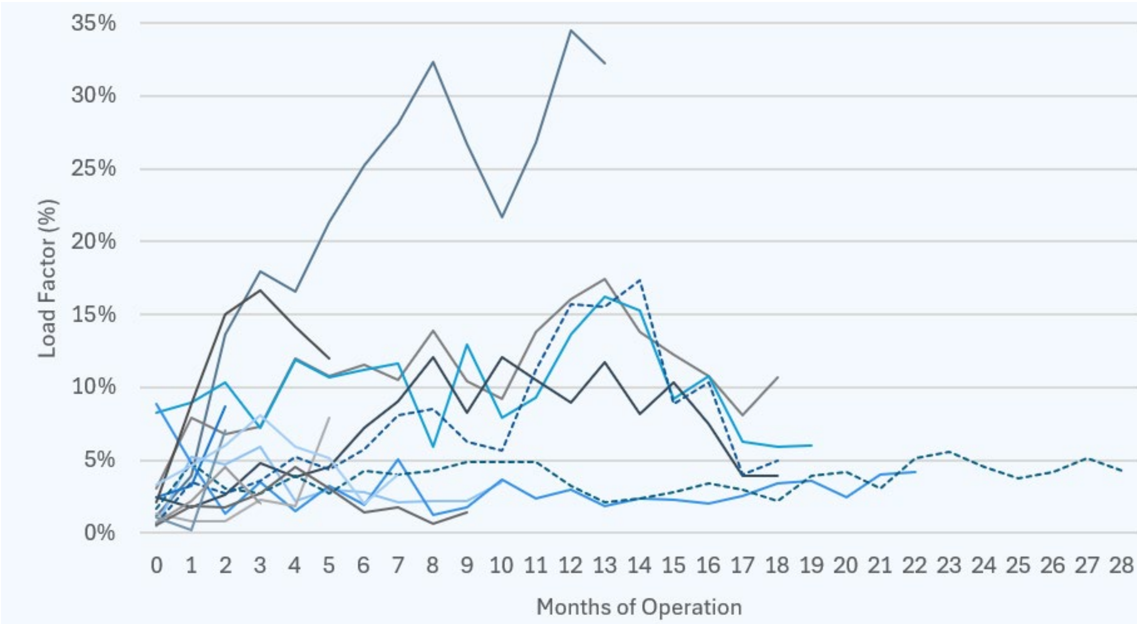
Several sites show monthly consumption below 2 MWh for one to two years, while others show more of an obvious growth trend. As discussed in the *Site Visit Findings* sections of this and last years' reports, many of these sites struggled with delays in commissioning. The time a site that was powered up and fully functioning could wait until it was fully accessible to EV drivers could approach or sometimes even surpass 12 months. Some erratic trending is partially due to the vendor SDG&E uses for hardware and as an NSP, which allows approximately 10 free charging sessions on each port to facilitate commissioning by on-site staff.

Figure 237. SDG&E Schools Pilot Monthly Energy Consumption Based on Site's Operational Time



Throughout the latter half of 2023, just over 100 daily charging sessions was typical before heading into the holiday period as shown in Figure 238. Given that several of these sites were new for 2023, more time is needed to see the impact these sites have on the surrounding community. Growth in consumption and charging sessions may indicate that people are becoming more aware of these charging stations and either incorporating them into their charging habits or having this new charging availability influence their decision to trade a conventional vehicle for a PEV.

Figure 238. SDG&E Schools Pilot Monthly Load Factor Based on Site's Operational Time



On average, sites are used well below their maximum load capacity on a month-over-month basis, with all sites but one utilized at less than 20% of their maximum theoretical load. Only one site has exceeded 20% load factor in the months since its activation, reaching over 30% in two months. This may be driven by the public frequently accessing the site during times when the site is not in session, such as during summer breaks or after hours, demonstrating that the ancillary benefits offered by school sites may provide additional benefit to taxpayers even if chargers are being used outside of the framework set in initial expectations.

Figure 239. SDG&E Schools Pilot Daily Charging Sessions

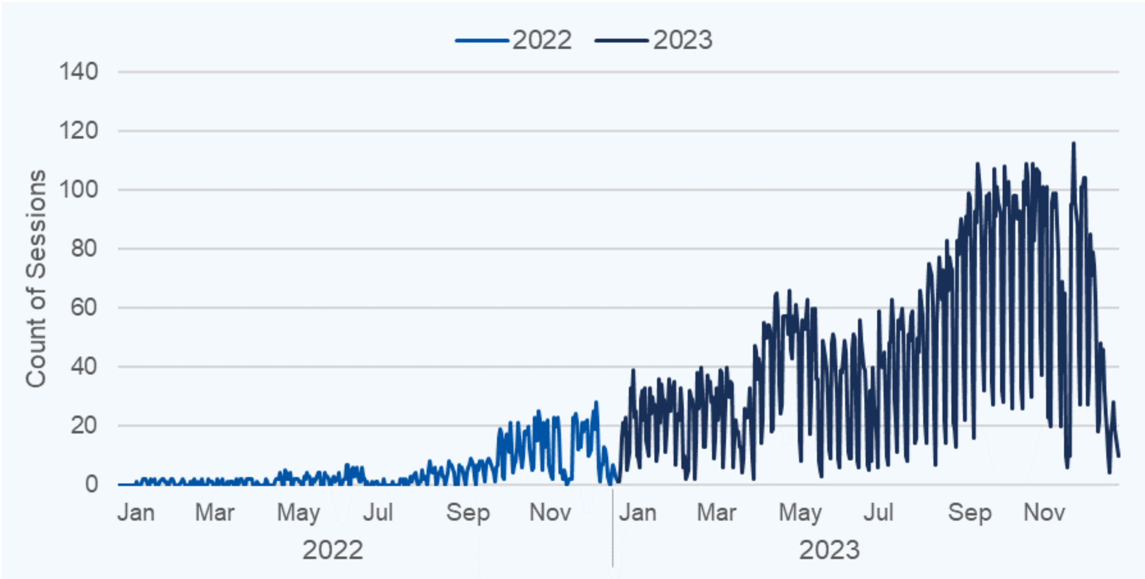
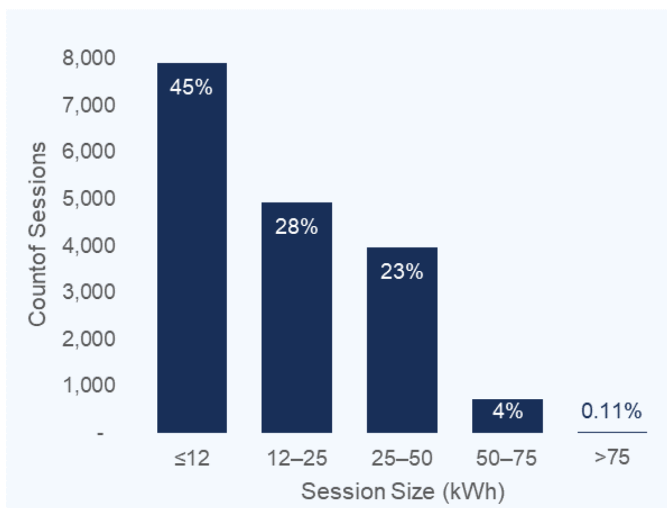


Figure 239 shows the daily charging session count since inception of the Schools pilot. At the end of 2022 the daily count reached 20 sessions; by the end of 2023 it almost reached 120 daily sessions.

As seen in Figure 240, nearly half of all charging sessions were fairly small (up to 12 kWh) while over a quarter were significantly larger (>25 kWh). Continuing to watch how these trends develop in future years will be interesting as vehicle battery sizes continue to grow.

Figure 240. SDG&E Schools Pilot Charging Session Count by Consumption Size



SDG&E Parks Pilot

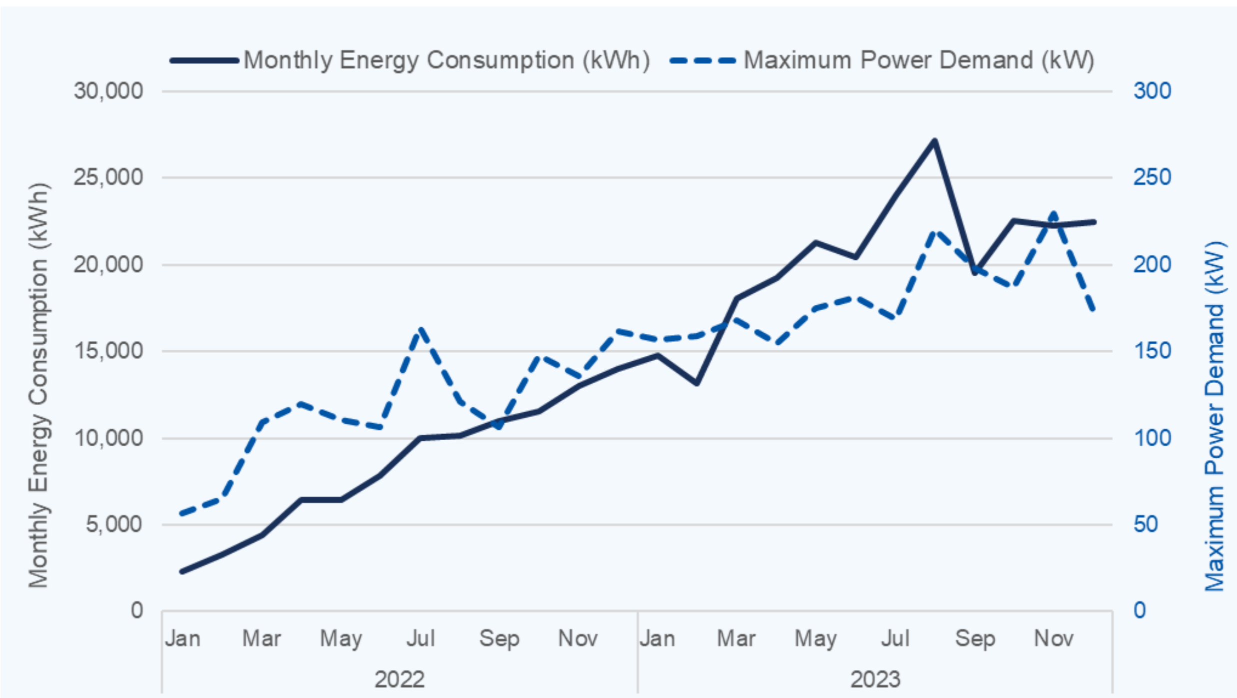
As previously mentioned, this year the SDG&E Parks and Schools reporting is broken into separate sections, with this section focused on parks. A summary of the included parks sites along with key consumption and demand parameters is shown in Table 149.

Table 149. SDG&E Parks Pilot Grid Impacts

Impact Parameter	2023 Actual	PTD Actual	10-Year Projection
Operational Sites	9	9	9
Installed Capacity (kW)	66	764	N/A
Electric Energy Consumption, MWh	245	356	2,847
On-Peak (4 p.m. to 9 p.m.) MWh (and % of total)	55 (22%)	82 (23%)	N/A
Maximum Demand, kW (with date and time)	229 (11/29/23 1:45 p.m.)	229 (11/29/23 1:45 p.m.)	N/A
Maximum On-Peak Demand, kW (with date and time)	168 (7/21/23 7:30 p.m.)	168 (7/21/23 7:30 p.m.)	N/A

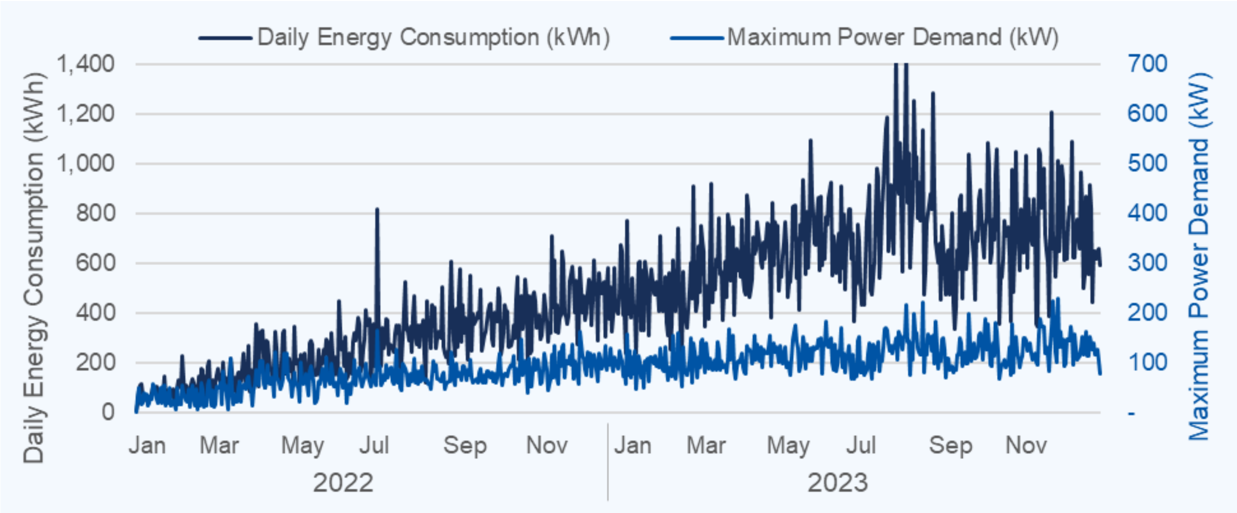
Whereas in the last report the combined programs finished the year reaching 20 MWh and 100 kW, Parks consumed over 20 MWh monthly for several months in EY2023 and reached over 200 kW in demand, with a total installed capacity of 765 kW. The increasing trends in monthly consumption and maximum demand can be seen in Figure 241.

Figure 241. SDG&E Parks Pilot Monthly Energy Consumption and Maximum Demand



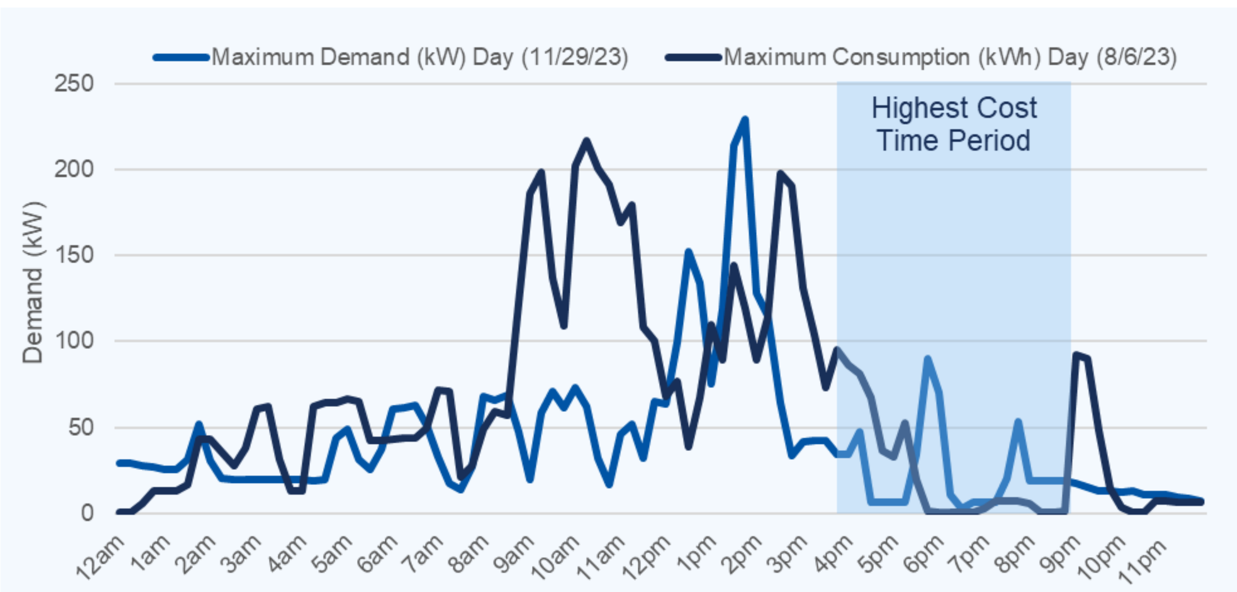
Daily consumption appears to peak in the summer as shown in Figure 242, but we see lower recurring maximums the rest of the year while fluctuating from approximately 500 kWh to 1000 kWh daily. Maximum demand appears to be growing as well, showing a slightly different trend than consumption.

Figure 242. SDG&E Parks Pilot: Daily Consumption and Maximum Demand



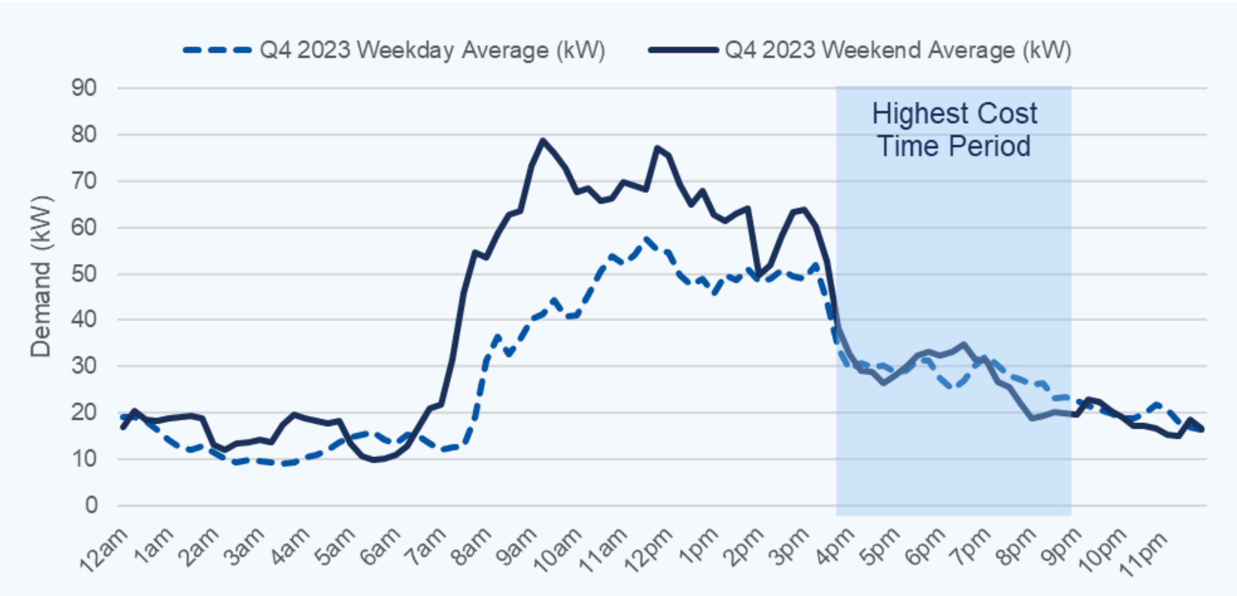
A handful of days reached over 200 kW of demand, with the highest on a Wednesday (11/29/23) shown in Figure 243. That Wednesday had a particularly substantial spike midday. The highest consumption day (8/6/23) showed significant morning activity from 8 a.m. to 11 a.m. in addition to several charging sessions very early in the day and one late at night.

Figure 243. SDG&E Parks Pilot Highest Demand and Consumption Days



All of these sites bill EV drivers based on SDG&E's EV-oriented TOU tariff. In theory, this should influence when EV drivers charge at these sites. Speaking with EV drivers could be an informative means of outreach to assess how TOU rates apply to a broad demographic and to better understand their needs. The average demand on weekdays and weekends drops significantly at 4 p.m. when TOU rates substantially increase in cost. The comparison depicted in Figure 244 shows that EV drivers make greater use of charging at parks during the weekend, resulting in just over 25% more consumption on average (860 versus 680 kWh).

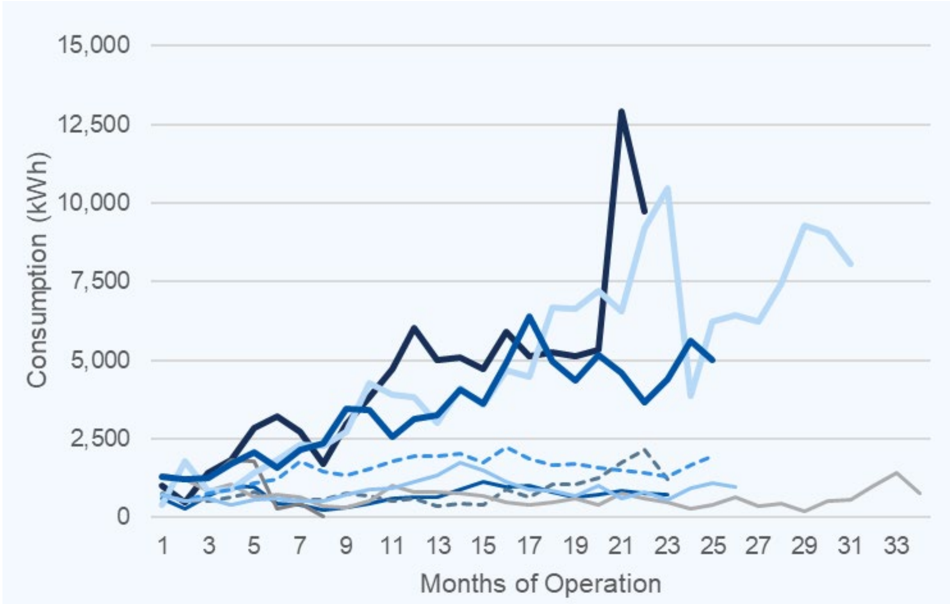
Figure 244. SDG&E Parks Pilot Weekday versus Weekend Average Demand



Usage Trends

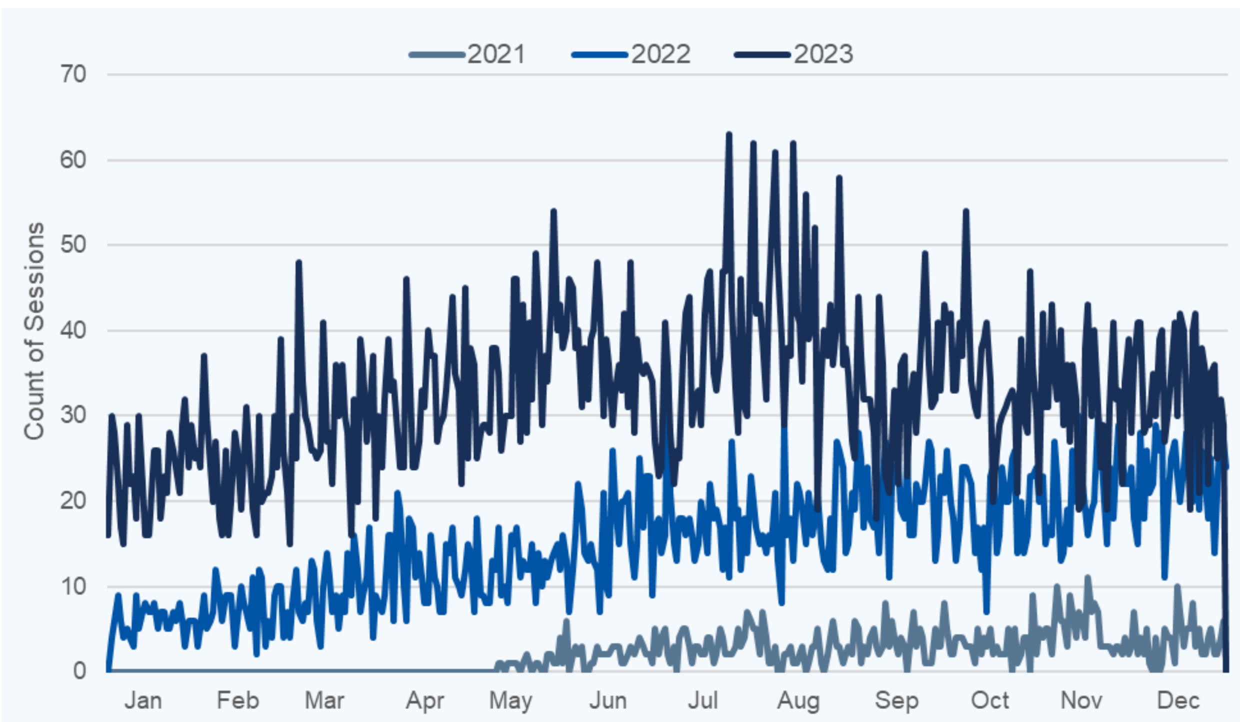
Figure 245 shows sites' monthly consumption based on operational age (the figure is organized by first month of operations for each site as opposed to the calendar month). This allows comparison of sites based on their age and may also help characterize how long it takes for a public charging location to be adopted by the EV community. Five sites appear to have reached stable monthly consumption under 2.5 MWh after operational lifetimes of nearly two years. Several others show much more prominent growth, surpassing 5 MWh of monthly consumption.

Figure 245. SDG&E Parks Pilot Monthly Consumption based on Sites' Operational Time



Building on growth rates of monthly consumption, Figure 246 shows that this portfolio is clearly increasing in utilization as measured by daily charging sessions that are increasing year-over-year. Daily fluctuations are more challenging to characterize, but the number of charging sessions looks fairly flat over the final four months, averaging almost 1,200 monthly sessions across all sites.

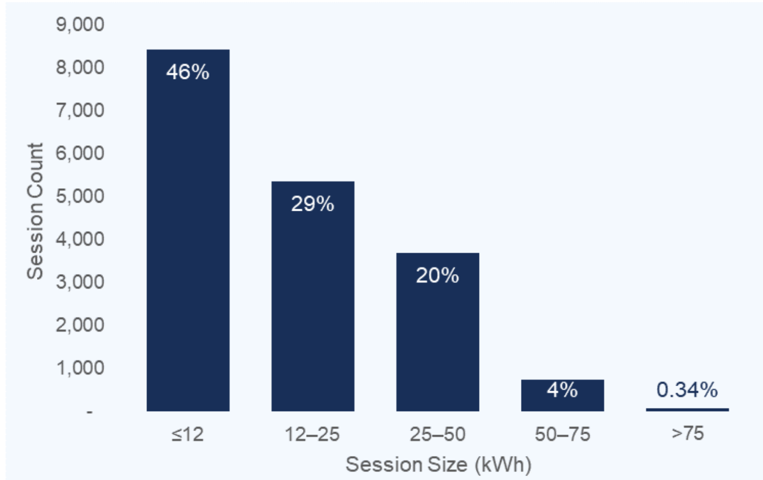
Figure 246. SDG&E Parks Pilot Daily Charging Sessions for PTD sites



As shown in Figure 247, most charging sessions are relatively small (<12 kWh), while sessions over 25 kWh account for approximately 25%. These statistics will be of particular note to watch develop in relation to other trends such as the increasing size of batteries available as well as if more people adopt EVs without home charging.

Overall, the portfolio has some trends that seem to have stabilized, while others will continue to develop as the surrounding communities adapt to the new charging resources.

Figure 247. SDG&E Parks Pilot Daily Charging Session Count by Consumption Size



Highlights

- Consumption data indicates that most sites are still growing their user base.
- TOU rates seem to be influencing charging behavior based on an abrupt load drop at 4 p.m.

Petroleum Displacement

The Evaluation Team estimated program-induced petroleum displacement attributable to the 15 Schools Pilot and nine Parks Pilots using three key pieces of information: electricity used for EV charging, calculated EV annual miles traveled, and equivalent annual counterfactual vehicle petroleum fuel consumption. From this information, we estimated the reduction in equivalent gallons of petroleum attributable to the Schools and Parks Pilots. Table 150 presents the Schools and Parks Pilots' petroleum displacement impacts for the sites through 2023, including estimated actual impacts for 2023, actual impacts for all sites pilot to date, and a 10-year forecast for pilot to date sites.

Table 150. SDG&E Schools and Parks Pilots Petroleum Displacement Summary

DAC	Usage				Petroleum Displacement (GGE)		
	2023 Actual (kWh)	PTD Actual (kWh)	2023 Actual (miles)	PTD Actual (miles)	2023 Actual	PTD Actual	10-Year Projection
Inside DAC	372,869	492,782	1,109,055	1,464,581	31,825	42,229	329,052
Outside DAC	184,106	201,173	549,302	600,338	14,555	15,973	213,971
Total	**556,974**	**693,954**	**1,658,357**	**2,064,920**	**46,380**	**58,203**	**543,023**

Note: "2023 Actual" represents the data from all activated sites from program inception for the calendar year 2023. "PTD Actual" represents the data from all activated sites from program inception for all program years.

Highlights

- All operational sites in 2023 collectively achieved a pilot to date impact of over 58,000 gallons of petroleum, with 72% within DACs.
- Over a 10-year period, the sites will displace more than 540,000 gallons of petroleum.

Greenhouse Gas and Criteria Pollutant Impacts

The Evaluation Team calculated reduced emissions from displaced fossil fuel use from ICE vehicles that were not in service because of the SDG&E Schools and Parks Pilots. The team first developed one ICE counterfactual, then calculated the emissions associated with these vehicles under conditions that otherwise matched the EVs in order to provide a baseline. Although EVs have no tailpipe emissions, the fossil-fuel power plants that supply electricity to the vehicle chargers still release some GHGs and criteria pollutants.

Table 151 presents the GHG reduction resulting from the 15 operational Schools Pilot sites and nine operational Parks Pilot sites in 2023, along with the PTD and 10-year totals, by impact location. Overall, the Pilots resulted in 79% reduction of GHG emissions (432 MT total) relative to the counterfactual to date (547 MT), with 71% of the impact within DACs.

Table 151. SDG&E Schools and Parks Pilot GHG Reductions Summary

DAC	Usage				GHG Reduction (MT)		
	2023 Actual[a] (kWh)	PTD Actual[b] (kWh)	2023 Actual Use (miles)	PTD Actual Use (miles)	2023 Actual	PTD Actual	10-Year Projection
Inside DAC	372,869	15,585	1,109,055	1,464,581	235	310	2,561
Outside DAC	184,106	616,248	549,302	600,338	112	123	1,755
Total	**556,974**	**631,834**	**1,658,357**	**2,064,920**	**347**	**432**	**4,316**

[a] "2023 Actual" represents the data from all activated sites from program inception for the calendar year 2023.
[B] "PTD Actual" represents the data from all activated sites from program inception for all program years.

Overall, of the local emissions, the Pilots had the highest impact in reducing CO, resulting in an estimated annualized reduction of 343 kg and a projected 10-year reduction of more than 14,000 kg (Table 152).

Table 152. SDG&E Schools and Parks Pilot Local Emissions Net Reductions

Emissions	EY2023 Sites (n=9)			PTD Sites (n=24)	
	Inside DAC	Outside DAC	Total	Actual	10-Year Projection
PM_{10} (kg)	0.017	0.66	**0.68**	2.23	21.4
$PM_{2.5}$ (kg)	0.015	0.61	**0.63**	2.05	19.7
ROG (kg)	0.24	9.48	**9.72**	37.9	450.1
CO (kg)	8.5	334	**343**	1,256	14,271

[a] Columns may not sum to total due to rounding.

Figure 248 shows the current mix of electricity from the CAISO grid used for charging vehicles in the SDG&E Schools and Parks Pilots sites.[142] Based on the real-time grid conditions when the EV charging occurred, the overall energy mix contained about 56% zero emissions or renewable sources of electricity (including solar, wind, hydro, geothermal, biomass, and nuclear), 35% natural gas, and 9% imports. With the CAISO grid adding more renewables to meet the Renewable Portfolio Standard, the GHG and criteria pollutant emissions will continue to decrease over time.

Figure 248. SDG&E Schools and Parks Pilot Net Electricity Mix, Pilot to Date

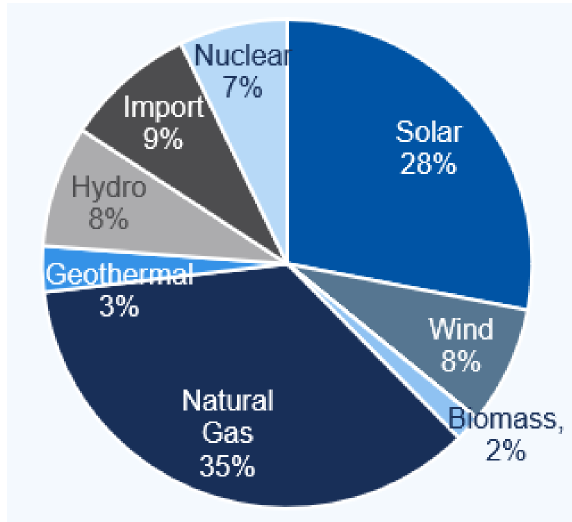
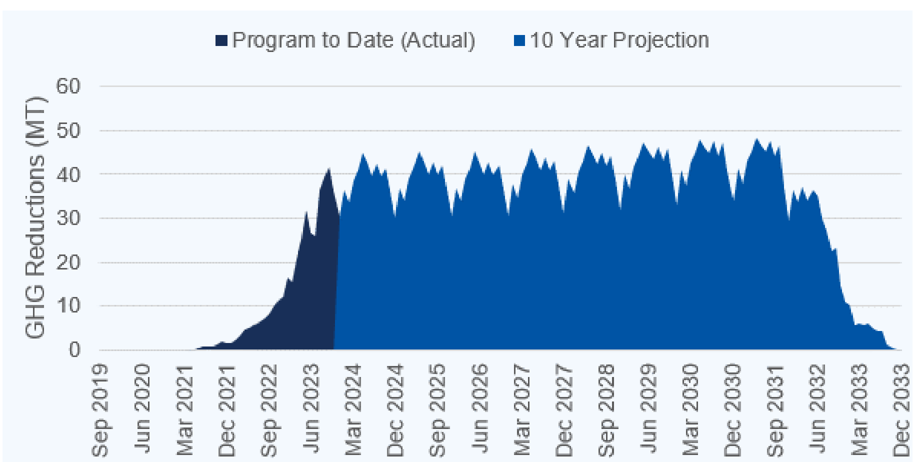


Figure 249 shows how Pilot GHG reductions have increased to date and are expected to grow over time for all activated sites. The analysis period ranges from the date that the first site in the Pilots were activated through the end of 2023. The analysis incorporates the net reduction (counterfactual emissions minus utility emissions) for each site in the schools and parks pilots. Pilot to date emissions reductions are shown in dark navy while anticipated benefits based on annualization are presented in royal blue. As each site has its own starting date of operation, the 10-year sunset for each site is observed as a gradual tapering off of Pilot benefits in 2032. While each year's operations appear similar, there are several key factors driving the variations such as seasonality of utility generation sources (high utility emissions will appear as a dip on the curves), holidays occurring on weekends versus weekdays, and sites that became operational late in 2023 having predicted operations year-round in future years.

Figure 249. SDG&E Schools and Parks Pilot Historical and Forecasted GHG Reductions, Pilot to Date Sites



142 The power associated with imports comes from a mixture of hydro, nuclear, and natural gas plants located outside the CAISO grid.

Highlights

- The Schools and Parks Pilots have resulted in a 79% reduction of GHG to date with 71% of the impact occurring within DACs.
- The greatest reduction in local emissions was CO with a reduction of 343 kg in 2023 and a projected 10-year period reduction of more than 14,000 kg.
- Based on the real-time grid conditions when the EV charging occurred, the overall energy mix contained about 56% zero emissions or renewable sources of electricity (including solar, wind, hydro, geothermal, biomass, and nuclear) and 35% natural gas.

Health Impacts

The Evaluation Team calculated public health impacts (as benefits and costs) of reductions in criteria pollutants from vehicle electrification. Pollutants included in the analysis are primary $PM_{2.5}$ and precursors of secondary $PM_{2.5}$, including NO_x, SO_2, NH_3, and VOCs. This analysis considered only tailpipe emissions reductions rather than full lifecycle emissions (such as power plant emissions). We used the U.S. EPA's COBRA to evaluate the health benefits associated with the emissions reductions. COBRA estimates the county-level benefits for the county in which emissions are reduced. It also estimates the effect of the transport of emissions on all counties in the United States; however, this analysis includes only the effects of the emissions reductions in California. The Evaluation Team disaggregated the county-level effects to estimate the potential health benefits of sites for DACs and non-DACs.

Economic value depends on the health effects associated with the emissions, that is, whether they are associated with illnesses or death. The monetary value of the morbidity reductions associated with emissions reductions include avoided lost wages, avoided medical costs, and the amount of money people are willing to pay to avoid an illness or condition like respiratory disease. The value of the reduced mortality associated with emissions reduction is measured by the value of a statistical life, which uses value-of-life studies to determine a monetary value of preventing premature mortality. COBRA reports both a low and high impact, representing the uncertainties in the estimates.

The total value of the health benefits associated with the emissions reductions is between $300 and $676. Table 153 shows the cumulative health benefits for all impacted counties in California associated with the emissions reductions realized by the electrification of EY2023 SDG&E Schools and Parks sites.

Table 153. California Health Benefits for SDG&E Schools and Parks EY2023 Sites

Health Endpoint	Change in Incidence (Annual Cases)		Monetary Value (Annual, 2023 Dollars)	
	Low	High	Low	High
Mortality	< 0.0000	< 0.0000	$294	$666
Avoided Medical Care				
Nonfatal Heart Attacks	< 0.0000	< 0.0000	$1	$5
Infant Mortality	< 0.0000	< 0.0000	$2	$2
Hospital Admits, All Respiratory	< 0.0000	< 0.0000	< $0	< $0
Hospital Admits, Cardiovascular	< 0.0000	< 0.0000	< $0	< $0

Health Endpoint	Change in Incidence (Annual Cases)		Monetary Value (Annual, 2023 Dollars)	
	Low	High	Low	High
Acute Bronchitis	< 0.0000	< 0.0000	< $0	< $0
Upper Respiratory Symptoms	0.0007	0.0007	< $0	< $0
Lower Respiratory Symptoms	0.0005	0.0005	< $0	< $0
Emergency Room Visits, Asthma	< 0.0000	< 0.0000	< $0	< $0
Asthma Exacerbation	0.7856	0.7856	< $0	< $0
Lost Productivity				
Minor Restricted Activity Days	0.0206	0.0206	$2	$2
Work Loss Days	0.0035	0.0035	$1	$1
Total Health Effects	–	–	**$300**	**$676**

As part of this analysis, the Evaluation Team also examined health benefits within DACs, which may be disproportionately burdened by sources of pollution (including air pollution from ICE vehicles). Because COBRA estimates effects at only the county level, the Evaluation Team disaggregated the health benefits by census tract using the relative population of each tract from the most recent American Community Survey. For example, we allocated 10% of the value of the health benefits to a census tract with 10% of the county's population. The Evaluation Team then estimated the total benefits allocated to DACs and non-DACs. This approach assumes an even distribution of emissions reduction benefits throughout the county. If the sites are located in DACs, and the emissions reductions are greater in the tracts near the sites, this approach would understate the potential benefit to DACs. Additional information about emissions dispersion within counties would provide more precise estimates of the health benefits to DACs and non-DACs.

San Diego County had the highest proportion of overall benefits with 66% of the total, followed by Los Angeles County (11%), Riverside County (11%), Orange County (5%), and San Bernardino County (3%). Overall, 14% of the benefits were in DACs.

Highlights

- The monetary health benefits from EY2023 SDG&E Schools and Parks Pilots sites range from a low estimate of $300 to a high estimate of $676.
- San Diego County had the highest proportion of overall benefits, with 66% of the total, followed by Los Angeles County (11%), Riverside County (11%), Orange County (5%), and San Bernardino County (3%).
- Overall, 14% of the benefits are in DACs.

Utility Insights

In addition to monthly check-in calls with key SDG&E staff to discuss the status of the Schools and Parks Pilots, the Evaluation Team conducted a close-out interview with SDG&E staff in March 2024 to review overall Pilot challenges and successes in 2023. In the following section, these challenges and successes are grouped by those that apply to both Pilots, followed by those that only apply to one Pilot or the other.

Schools Pilot and Parks Pilot

Starting 2021 SDG&E staff reported that site construction costs were higher than anticipated. These costs were compounded by labor constraints, material costs, and permitting delays. Being several years into implementation and dealing with the reality of increasing costs, the Pilot staff have since learned to account for these increased costs when planning; however, they continue to strain program budgets:

- **Construction Labor Costs and Supply.** Staff noted that construction labor costs have increased as inflation has risen. In addition, continued from 2021 and 2022, it has been difficult to secure a sufficient labor force since COVID-19.
- **Material Costs**. Staff also reported that most site materials have been generally more expensive than originally anticipated in 2018 (when the Pilot funding caps were decided).
- **Delays in Permitting**. Continued from 2022, in 2023, staff noted significant delays in the Division of the State Architect's permitting approval process, which also increased administrative costs. These delays were compounded because SDG&E staff must adapt to different parameters required by different jurisdictions across their territory.

Unlike previous years, SDG&E staff noted three new cross-Pilot challenges in 2023:

- **Permitting Costs.** As more sites have moved to the construction phase (particularly through the Schools Pilot), SDG&E Pilot staff noted an inconsistency in permitting costs across different municipalities and jurisdictions, with some building permits being much more costly than originally anticipated. These inconsistencies make it harder to plan site costs and help potential site hosts understand upcoming costs.
- **Inspection Costs.** In 2023, SDG&E staff noted that inspection costs at the end of the site's construction are starting to rise, which caused unexpected strain on some site budgets near the end of completion.
- **EVSP Staff Turnover.** In 2023, a key EVSP that supports several sites throughout both the Schools and Parks Pilots experienced a high amount of staff turnover. This led to prolonged delays when a completed site needed commissioning, maintenance, or other service; not only because of EVSP staff availability, but also because once new staff were brought on board, SDG&E staff had to take the time to educate them and catch them up on the status of the Pilots and sites.

Schools Pilot

Despite these challenges, SDG&E staff reflected key areas of success in engaging, enrolling, and constructing school sites:

- **Interest Beyond Light Duty.** In 2022 and continuing into 2023, SDG&E Schools Pilot staff were integrated into managing other EV customer offerings such as PYDFF. Therefore, when customers expressed interest in fleet electrification, SDG&E staff were able to promote the PYDFF program alongside the Schools Pilot to help schools participate in both offerings.

- **School Curriculum.** In 2023, SDG&E officially launched the school curriculum along with a children's book starring an EV character who is new to a school of mostly ICE vehicles. In addition to making this book available to participating schools, SDG&E staff also hosted book readings at local schools.
- **School Site Satisfaction and Engagement.** As SDG&E was completing school sites in 2023, they were able to receive feedback from school staff. They noted that completed sites were satisfied with their sites and some schools were interested in more sites.
- **Expanded Interest in EVs.** SDG&E staff noted that in 2022 and 2023 that several K–12 schools that had already completed site installations through the Pilot reached back out to SDG&E hoping to acquire more private (non-public-facing) Utility-owned EVSE infrastructure because now that they have on-site chargers, they are seeing an increase in charger usage; not just from existing staff that purchased EVs since the chargers were installed, but also from new hires that were attracted to the district in part because of the availability of charging. In addition, previous participants are actively recommending the Pilot to other schools, which SDG&E staff noted is especially effective at gaining traction within the same school district.

Parks Pilot

Though the plan in 2021 was for all Utilities to enter into a collective participation agreement with the DPR, in 2022 the Utilities ultimately separated their efforts and SDG&E started coordinating with the DPR's state-level office independently, because not all Utility legal teams—including SDG&E's—were comfortable with the terms of the final draft of the master agreement for joint use. These negotiations continued through 2023, with SDG&E staff noting key challenges with implementing the Parks Pilot at the state level in 2023:

- **Staff Turnover.** Continued from EY2021, when DPR staff transitioned, SDG&E staff had to reorient the new staff member on the purpose of the Pilot, all steps completed to date, and next steps needed. These staffing challenges caused SDG&E to start from the beginning of the process to address new staff preferences.
- **Negotiations between Legal Teams.** Continued from EY2022, after SDG&E staff helped orient new DPR staff to the contracting process, the final decisions on which parties assume responsibility for costs, liabilities, and risks remains to be worked out between SDG&E's and the DPR's legal teams.
- **Headquarter versus Site Specific Priorities.** As the master agreement was developed further throughout the year, additional DPR staff became involved in the negotiation process as required. This included beginning to engage DPR staff that work at individual state parks in different jurisdictions. Through these joint negotiations in 2023, SDG&E staff realized that headquarter DPR staff and site-level DPR staff have different priorities: where headquarter staff are focused on enforcing policies and compliance, site-level staff are more interested in what is most beneficial for their given park. Though ultimately both parties' considerations are necessary to come to a workable agreement, this DPR staff disconnect prolonged master agreement negotiations.

Though state DPR negotiations continue, SDG&E staff are hopeful for a signed agreement in 2024. Additionally, SDG&E's unique experience with serving local[143] parks through the Parks Pilot has already been a successful effort that allowed SDG&E staff to foster committed, positive, long-term relationships with their local customers:

- **Strengthened Connections.** Though most local construction was completed in 2021, in 2023 SDG&E staff continued to successfully work with the local park participants to respond to site host requests to repair installed equipment and answer questions about the technology, usage, and other TE topics.
- **Identify Opportunities for Further Engagement.** SDG&E staff reported that these trusted relationships have allowed them help customers fast-track sites (both EV and non-EV) that require SDG&E's approval, insight, or support, further strengthening the relationship beyond the Parks Pilot.
- **Local Champions.** In 2023, SDG&E staff noticed self-appointed local champions at different local sites that are proactive about ensuring that the chargers are working correctly and promoting them outside of SDG&E's efforts.

Highlights

- **Schools & Parks:** Similar to previous evaluation years, site costs continue to be a challenge. In particular, securing construction labor as well as the rising labor and materials costs, which continue to be compounded by supply chain delays.
- **Schools & Parks**: New challenges in 2023 included inconsistent permitting costs, a rise in inspection costs, and EVSP staff turnover, which led to delays in commissioning, maintenance, or other services for sites.
- **Schools:** To support schools' continued and growing interest in EVs beyond LDVs, SDG&E staff promote the PYDFF program alongside the Schools Pilot to help schools participate in both offerings.
- **Schools:** Some participating schools continue to reach back out to SDG&E hoping to acquire more private (non-public-facing) utility-owned EVSE infrastructure once they have on-site chargers.
- **Parks:** Though multiorganizational coordination remained a challenge, ultimately, SDG&E was able to make progress towards a master agreement for state sites.
- **P**arks: SDG&E staff remain committed to building and maintaining strong customer relationships and fostering local champions through continued support such as repairing installed equipment, answering questions about the technology, usage, and other TE topics as needed.

[143] Local is defined as city and county parks.

6.2.3. Lessons Learned

The team identified several lessons learned. These lessons, presented below with key supporting findings and recommendations, may be applied to future Pilot years and to other similar efforts.

Schools and Parks Pilots

The Schools Pilot sites are helping to displace petroleum, reduce GHG and local emissions, and achieve nominal health impacts overall and within DACs.

The SDG&E Schools and Parks Pilots' sites achieved a pilot to date impact of over 58,000 gallons of petroleum, with 72% of the impact within DACs. In addition, the Pilots resulted in a reduction of 432 MT of GHGs, with 71% of the impact within DACs to date. These sites all positively contributed to lowering local emissions, with CO reduction being the most prominent, achieving a reduction of 1,256 kg. Overall, 14% of the health benefits are in DACs, and the monetary health benefits from EY2023 SDG&E Schools and Parks Pilots' sites range from $300 to $676.

Long-term engagement with customers, like those interested in the Schools and Parks Pilots, lends itself to positive relationship building.

To support schools' continued and growing interest in electrification beyond LDVs, SDG&E staff promote the PYDFF program alongside the Schools Pilot to help schools participate in both offerings. As a result, some participating schools continue to reach back out to SDG&E hoping to acquire more private (non-public-facing) Utility-owned EVSE infrastructure once they have on-site chargers. In addition, despite the challenges at the state level, SDG&E staff have built strong ties with customers through the Parks Pilot. SDG&E remains committed to building and maintaining these customer relationships and fostering local champions through continued support such as by repairing installed equipment and answering questions about TE technology.

Higher-than-expected site costs and delays continue to strain continue to challenge implementation.

SDG&E began the Schools and Parks Pilots during the COVID-19 pandemic, which caused unprecedented economic impacts across nearly every market. These changes were so significant that the estimates SDG&E had created for Decision 19-11-017 (which mandated the Schools and Parks Pilots at their determined funding levels) did not reflect actual costs for implementation. Similar to previous evaluation years, school and park site costs continued to present a challenge. Securing construction labor and absorbing rising labor and materials costs were compounded by supply chain delays. In 2023 inconsistent permitting costs, an increase in inspection costs, and EVSP staff turnover also led to delays in site commissioning, maintenance, and other services.

SDG&E Schools and Parks Pilots continued to successfully promote regional EV adoption.

In 2023, the Schools and Parks Pilots increased the number of operational sites by eight and one respectively to bring the total to 15 and 9 for the Pilots to date. This continued investment in public charging infrastructure led to an increase of 55 and 24 EVs, respectively, in neighboring households. With more accessibility to charging facilities (because of a greater number of charging stations and chargers and a shorter distance to charging stations), the Schools Pilot had a greater impact than the Parks Pilot this past year.

Parks Pilot

Although state-level cross-jurisdiction coordination remains a challenge, SDG&E staff's commitment to the development of the Parks Pilot shows progress.

The original plan for the Parks Pilot in 2021 was for all Utilities to enter into a collective participation agreement with the DPR; however, in 2022, the Utilities separated their efforts, because not all Utility legal teams—including SDG&E's—were comfortable with the terms of the final draft of the master agreement for joint use. Through independent negotiations with the DPR's state-level office in 2023, SDG&E staff realized that state-level and site-level DPR staff have different priorities: whereas state-level staff are focused on enforcing policies and compliance, site-level staff are more interested in what is most beneficial for their given park. Though state DPR negotiations continue, SDG&E staff are hopeful for a signed agreement in 2024.

6.3. Vehicle-to-Grid Pilot

6.3.1. Overview

This section provides an overview of SDG&E's V2G Pilot, including background and goals, completed activities, and status. Following the overview are detailed findings, highlights, and lessons learned.

Pilot Description

SDG&E designed this Pilot to accelerate the market growth and adoption of V2G technologies, support the goal of enabling EVs to function as distributed energy resources, potentially improve the Utility load factor, and reduce GHGs and criteria pollutants. With the V2G Pilot, SDG&E also aimed to address the barriers of upfront financing costs and insufficient return on investments, first-mover risk aversion for pre-commercial technology, unproven charger and vehicle interoperability, and lack of industry standardization.

School bus fleets provide a favorable use case for V2G, with predictable usage patterns and traditionally sitting idle during peak demand periods and summer months when grid constraints are highest. This use pattern allows school buses to take advantage of favorable TOU off-peak Utility rates. Electric school buses also have large batteries for energy storage, making them potential candidates for V2G assets.

The critical barriers for school bus fleets are reliability, vehicle and infrastructure costs, and the uncertainty and complexity of V2G technology integration. While V2G technology utilization and development are outside Utility control, the Pilot could have a positive impact on these factors and increase confidence in electric school bus and V2G technology by producing the following assets:

- TOU pricing structure or other programs for site hosts
- Planning, design, and ongoing Pilot data collection and management
- Installation of V2G-enabling infrastructure, including chargers
- Coordination between multiple stakeholders of varying roles related to V2G and smart charging

Through these Pilot activities, SDG&E intended to reduce peak demand at the site, send electricity back to the grid when needed, quantify charger utilization rates and the number of critical peak events when V2G is in use, and demonstrate successful implementation of V2G technology.

Pilot Implementation

In 2017, SDG&E solicited a request for information to aid in conceptualizing the V2G Pilot and then selected finalists to participate in a request for proposals. SDG&E selected the proposal of First Priority GreenFleet, whose team included the school bus OEM, Lion Electric; site host, CVUSD; and charging provider, BTC Power.

In January 2018, SDG&E filed Application 18-01-012, which included the V2G Pilot, with the goal of helping SDG&E understand how it can use EVs as distributed energy resources to improve the load factor and reduce GHG emissions and local air pollution. In the application, SDG&E submitted a request to install, maintain, and own charging infrastructure associated with the electrification of 10 school buses capable of V2G operation and bid into the CAISO markets. The Pilot became the first to employ

V2G-enabled school buses to participate in the CAISO energy market, using 25 kW (discharging) V2G bidirectional chargers.

In August 2019, the CPUC approved the Pilot with a budget of $1.7 million. In April 2020, SDG&E filed AL 3528-E requesting three modifications to the Pilot, which the CPUC accepted in May 2020:

- Install V2G charging stations at an existing service line rather than at a separate service line
- Use DCFC EVSE rather than alternating current (AC)
- Reduce the number of V2G buses from 10 to 6

In a second Advice Letter, SDG&E assumed the project management role from First Priority GreenFleet and due to Rule 21 requirements, replaced BTC Power with Nuvve as the charging provider. SDG&E selected Nuvve because it offers a DCFC charger produced by Rhombus, which uses a ground-mounted inverter instead of an onboard inverter. The final Pilot team included several organizations:

- **SDG&E:** Project manager
- **CVUSD:** Site host
- **Lion Electric:** School bus provider
- **Nuvve:** Charging provider
- **Baker Electric:** Construction manager
- **ViriCiti:** School bus telematics provider

Figure 250. SDG&E V2G Pilot CVUSD Site Layout

In the summer of 2021, Baker Electric installed the Nuvve DCFCs and they became operational with unidirectional capability. Due to multiple delays with the various technology integrations, bidirectional commissioning was completed in June 2022.

Figure 250 shows the layout of the CVUSD site for this Pilot, with the school bus parking area and charger locations circled in red.

Table 154 shows the Lion Electric school buses that CVUSD procured for this Pilot. Lion Electric retrofitted the five LionC buses from L2 unidirectional capability to DCFC V2G-capability. The LionD bus had DCFC V2G capability off the production line.

Table 154. SDG&E V2G Pilot CVUSD School Bus Summary

Quantity	Manufacturer	Model	Battery Capacity (kWh)	Driving Range (miles)	Charge/Discharge Rate (kW)	Charging Time (hours)
5	Lion Electric	LionC	132	100	25	5 to 9
1	Lion Electric	LionD	210	155	45	2.5 to 5

The six Rhombus V2G bidirectional chargers are each rated for a power output of 60 kW. The chargers communicate with the aggregator, electric grid, and electric bus and meet the following V2G certification and regulation standards:

- UL 1741: Standard for inverters, converters, controllers, and interconnection system equipment for use with distributed energy resources.
- IEEE 1547: The technical specifications for, and testing of, the interconnection and interoperability between Utility electric power systems and distributed energy resources.

Figure 251 and Figure 252 show CVUSD's Lion Electric buses and Nuvve chargers, respectively.

While the selected Nuvve Rhombus chargers have a 60-kW power output, CVUSD's first generation LionC buses only accept up to 25 kW, and the third generation LionD buses are limited to 45 kW.

Figure 251. SDG&E V2G Pilot Lion Electric School Bus

Photos provided by Cajon Valley Union School District

Due to unforeseen challenges, several Pilot design changes have been necessary since approval:

- CVUSD's five LionC buses needed to be retrofitted to accept DC power and allow for bidirectional charging and discharging.
- The maximum bus discharge power resulted in the site being unable to participate in CAISO's program, which has a minimum export power requirement of 100 kW. This threshold would have required all six chargers to export at least 17 kW simultaneously, which would likely be a rare occurrence. However, the site was eligible for SDG&E's ELRP and Critical Peak Pricing (CPP) program, which calls critical peak events when energy and demand charges spike. When participating sites choose to reduce demand, they receive compensation and avoid increased electrical costs during these events. The ELRP requires a minimum power output of 25 kW per hour, which is calculated as an average demand over the hour. CVUSD's school bus routes typically end by 4:30 p.m., enabling buses to participate by discharging when they return to the bus yard.
- At the time of commissioning, the building and EV chargers shared the same SDG&E billing meter on the AL-TOU rate, with separate research meters for the chargers. In this configuration, the chargers were not eligible for the EV rate, resulting in high charging costs for the site. This configuration initially enabled the electric school buses to discharge to the building to offset load during CPP program events and provide resiliency when needed. In response to CVUSD's concern over high charging costs and the CPUC's recent sub-metering protocol, SDG&E reconfigured the meters and put the chargers on the electric vehicle high-power (EV-HP) rate, producing cost savings for CVUSD.
- After switching the chargers to the EV-HP rate, SDG&E determined that there was no added value for the site to participate in the CPP program compared to the EV-HP rates. However, if the Utility calls a CPP program event separate from an ELRP event, the vehicles can support building load reduction, which is still on the AL-TOU rate, potentially yielding vehicle-to-building benefits.

Figure 252. Nuvve DCFC

Photos provided by Cajon Valley Union School District

- Due to parking space length constraints at CVUSD's other V2G site installed under the PYDFF program, CVUSD moved three of its new, third-generation Lion Electric buses with longer chassis to the Pilot site. These third-generation buses have BMW batteries, which can accommodate up to a 45-kW charge/discharge rate, while the first-generation buses can only achieve a 25-kW charge/discharge rate.
- Nuvve and Lion Electric's adoption of ISO 15118-20 during the term of this Pilot required extending the software development timeline to allow for bidirectional operation.

Pilot Timeline and Status

Due to the commissioning and bidirectional capability delays, SDG&E extended the evaluation data collection period for the V2G Pilot through December 2023.

During the summers of 2022 and 2023, the site participated in SDG&E's ELRP, which offers compensation for load shedding and allows customers to export power to the grid (such as through EVs) between 4 p.m. and 9 p.m. from May 1 to October 31. SDG&E notified Nuvve and the customer about these events the evening before each one. SDG&E provides $2.00 per kilowatt-hour exported or shed compared to a baseline and calls events up to 60 hours per year. During EY2023, the Pilot participated in seven ELRP events, providing 975 kWh back to the grid and earning approximately $1,950. The site plans to continue ELRP participation moving forward, but this report concludes evaluation activities.

Pilot Materials Summary

In EY2023, SDG&E completed ME&O for the V2G Pilot, publishing a blog post on NewsCenter. The blog posts received over 1,900 views (from over 1,400 unique visitors). SDG&E did not use paid advertisements for this marketing effort.

Pilot Costs

Table 155 summarizes total Utility costs for the V2G Pilot through December 2023. Including all cost elements, the Pilot spent approximately 96% of its approved budget of $1.7 million.

Table 155. SDG&E V2G Pilot Costs Through December 2023

Direct Costs			All Cost Elements		
All Costs	Capital	O&M	All Costs	Capital	O&M
$1,378,458	$764,981	$613,478	$1,634,591	$957,129	$677,462

6.3.2. Findings

The Evaluation Team performed in-depth interviews, driver surveys, and an impact analysis for the Pilot in EY2023 including grid impacts, petroleum displacement, and GHG and criteria pollutant emissions reductions.

Impact Findings

Table 156 summarizes key impact parameters for EY2023, EY2022, as well as for the Pilot-to-date. Annual estimates of impacts are provided for metrics calculated as part of the impact evaluation.

Table 156. SDG&E V2G Pilot Summary Impacts

Impact Parameter	Annualized EY2023 [a]	Annualized EY2022	Pilot-to-Date Actual
Charging Ports Installed (#)	6	6	6
Electric Energy Consumption (kWh)	46,452	25,933	78,981
Electricity Generation (kWh) [b]	1,437	1,413	2,850
Maximum Power Demand (kW)	172.32	125.76	172.32
Petroleum Displacement (DGE)	3,951	N/A	6,718
GHG Emission Reductions (MT CO_2e) [c]	33	N/A	57
PM_{10} Reduction (kg)	0.1	N/A	0.1
$PM_{2.5}$ Reduction (kg)	0.1	N/A	0.1
ROG Reduction (kg)	0.4	N/A	0.6
CO Reduction (kg)	10.5	N/A	17.7

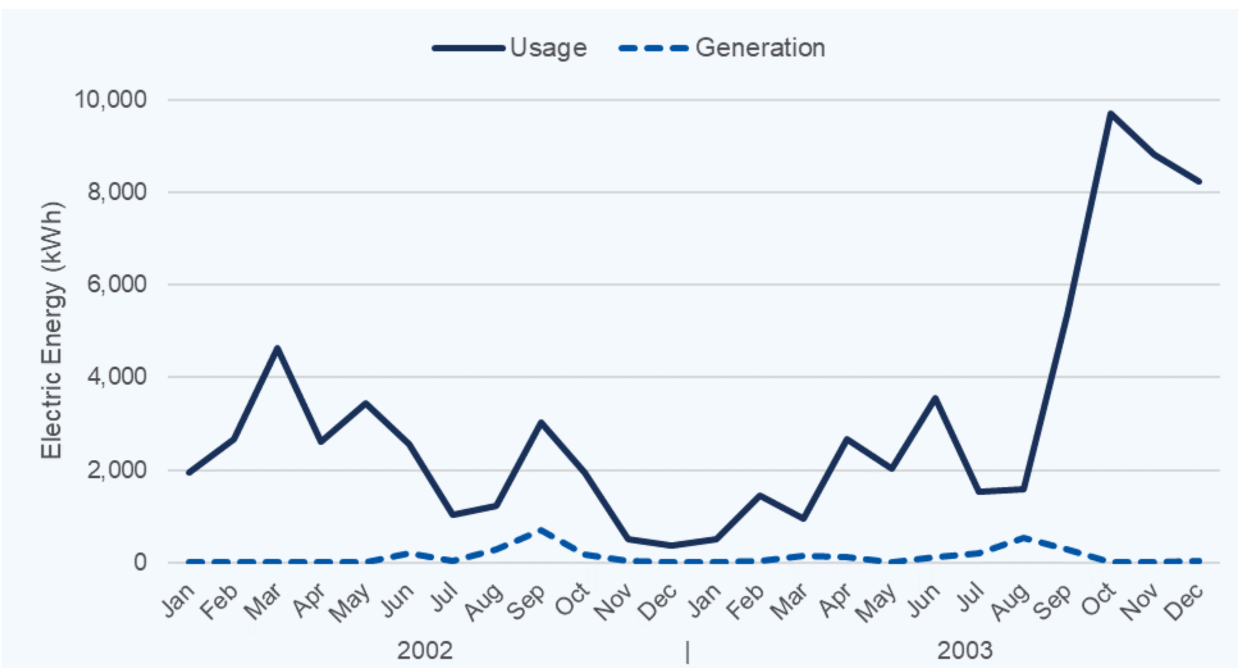
[a] Energy consumption, petroleum displacement, and emissions reductions are based on utility AMI data. PTD results in the table are based on actual data since January 1, 2022 (see *Appendix A* for more details).

[b] The Evaluation Team calculated electricity generation from the charger check meter.

[c] GHGs include CO_2, CH_4, and N_2O multiplied by their respective GWP as defined by IPCC AR5 (see *Appendix A* for more details).

Figure 253 shows the V2G DCFC electric usage and generation since January 1, 2022. The site did not use the DCFCs and electric school buses consistently until mid-2023 due to several software and hardware issues but achieved near steady-state operations in October 2023.

Figure 253. SDG&E V2G Pilot DCFC Electric Usage and Generation (Program to Date)

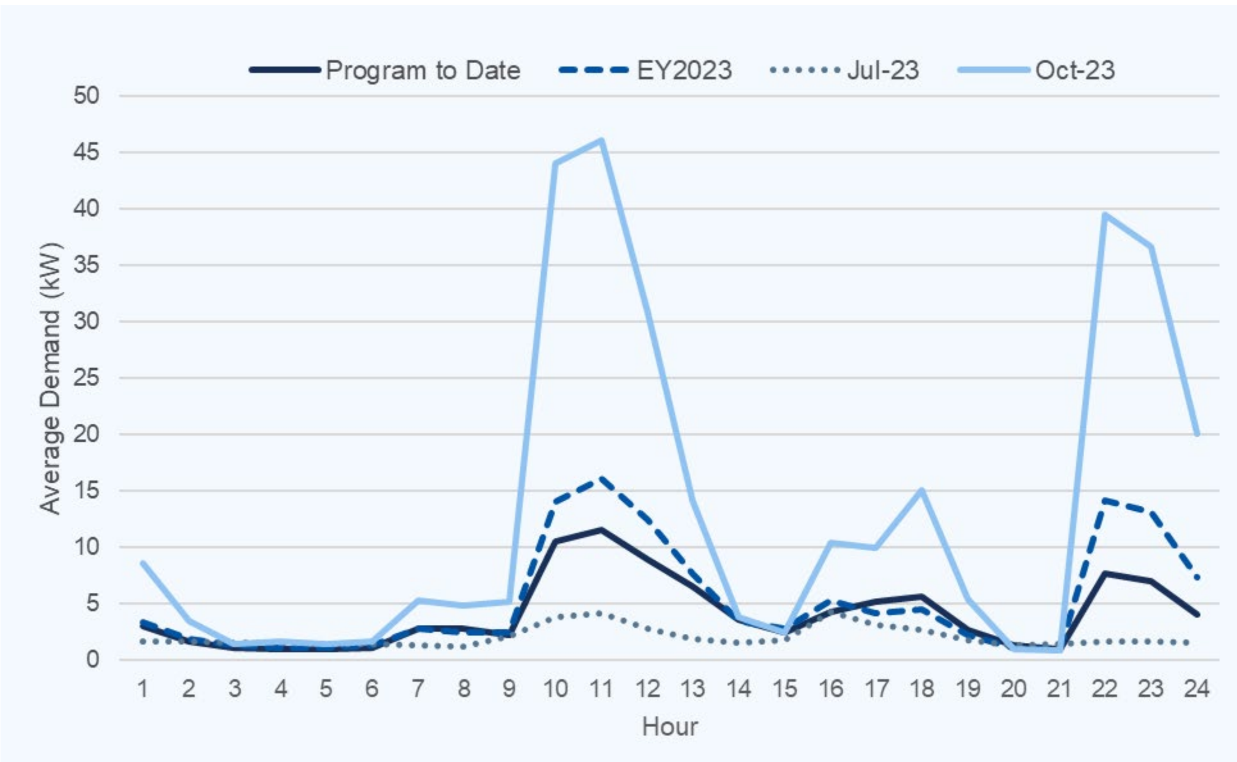


V2G Pilot Charging Load Shapes

Figure 254 compares the overall average DCFC hourly load shapes for the V2G Pilot. Since the team did not have access to the L2 AMI data or individual DCFC NSP data from Nuvve, these load shapes are based on the utility EV check meter. According to the site host, October 2023 is a representative month of steady-state vehicle and DCFC operations and some individual days in October reached over 100 kW during peak charging hours.

While most of the charging occurs during non-peak hours, the site could benefit from charge management to decrease demand during the 4 p.m. to 9 p.m. peak period.

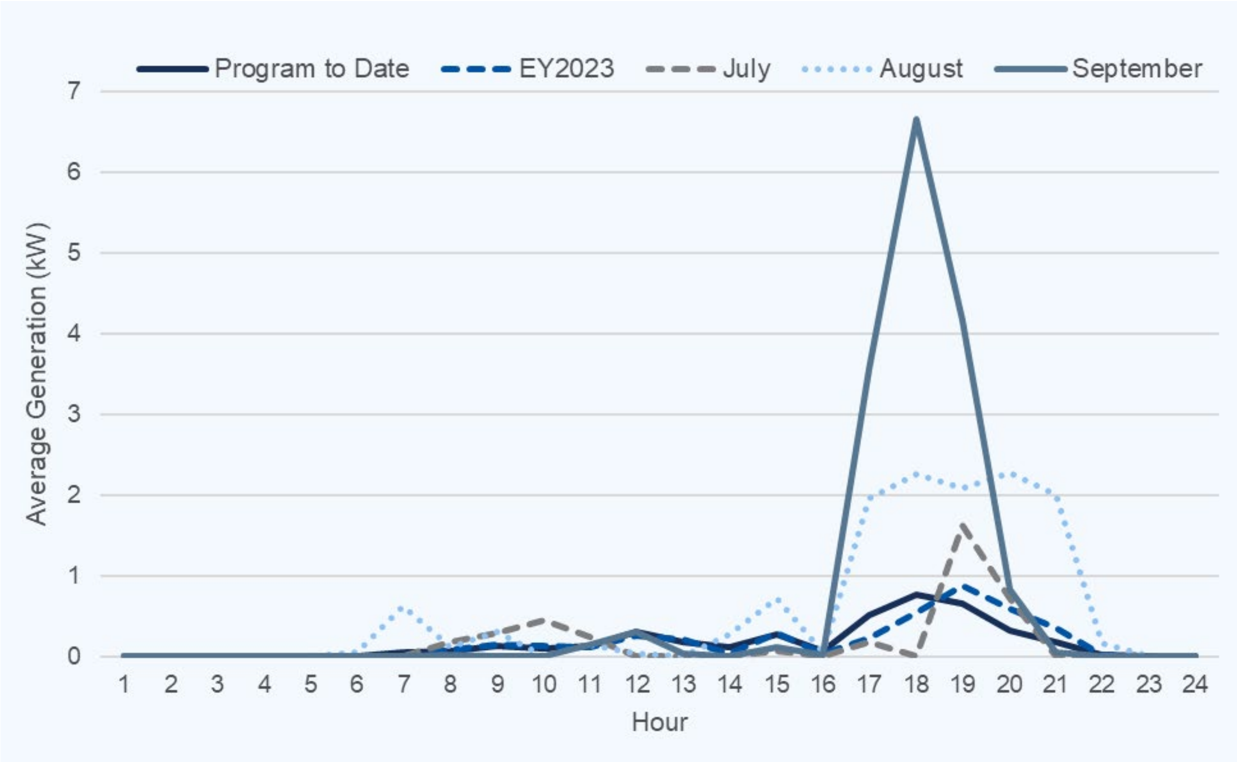
Figure 254. SDG&E V2G Pilot DCFC Charging Load Shapes



V2G Electric Generation

Figure 255 compares the PTD, EY2023, and summer month electric generation load shapes from the six, 60 kW bidirectional DCFCs. Based on the Utility EV check meter, the total electric energy generation for the V2G Pilot from January 1, 2022, through December 31, 2023, was only 2,850 kWh, with most of the generation occurring during ELRP event months (July, August, and September). The total generation represents only 4% of the total DCFC energy consumption. Future V2G projects could expand generation beyond the limited ELRP event periods and potentially use electricity generation to offset other site and building demand.

Figure 255. SDG&E V2G Pilot DCFC Electric Generation Load Shape



Electric School Bus Telematics

The Evaluation Team reviewed Lion Electric's online Lion Beat vehicle telematics platform data, including odometer readings, trip reports, charging session start and end state of charge, and battery state of health. CVUSD does not currently have access to Lion Beat and is using Nuvve's FleetBox software to access charging data. The Evaluation Team noted several instances of misalignment among the various data sources. Table 157 compares the electric school bus odometer readings for each bus between the dashboard, Lion Beat telematics data, and ViriCiti telematics data. Table 158 shows the Lion Beat electric school bus trip report summary, including driving duration and trip distance.

Table 157. SDG&E V2G Pilot School Bus Odometer Reading Comparison

Bus	Manual Odometer (miles)	Lion Beat (miles)	ViriCiti (miles)
520	26,717	16,159	15,177
521	16,109	12,341	7,645
522	20,473	20,294	10,954
523	20,217	25,886	1,753
524	22,352	20,997	14,228
526	12,129	8,256	

Table 158. Lion Beat Telematics V2G Pilot School Bus Trip Report (Program to Date)

	Count	Driving Duration (hours)	Trip Distance (miles)
Total	8,053	2,127	46,012
Average	–	0.26	6
Maximum	–	0.98	75

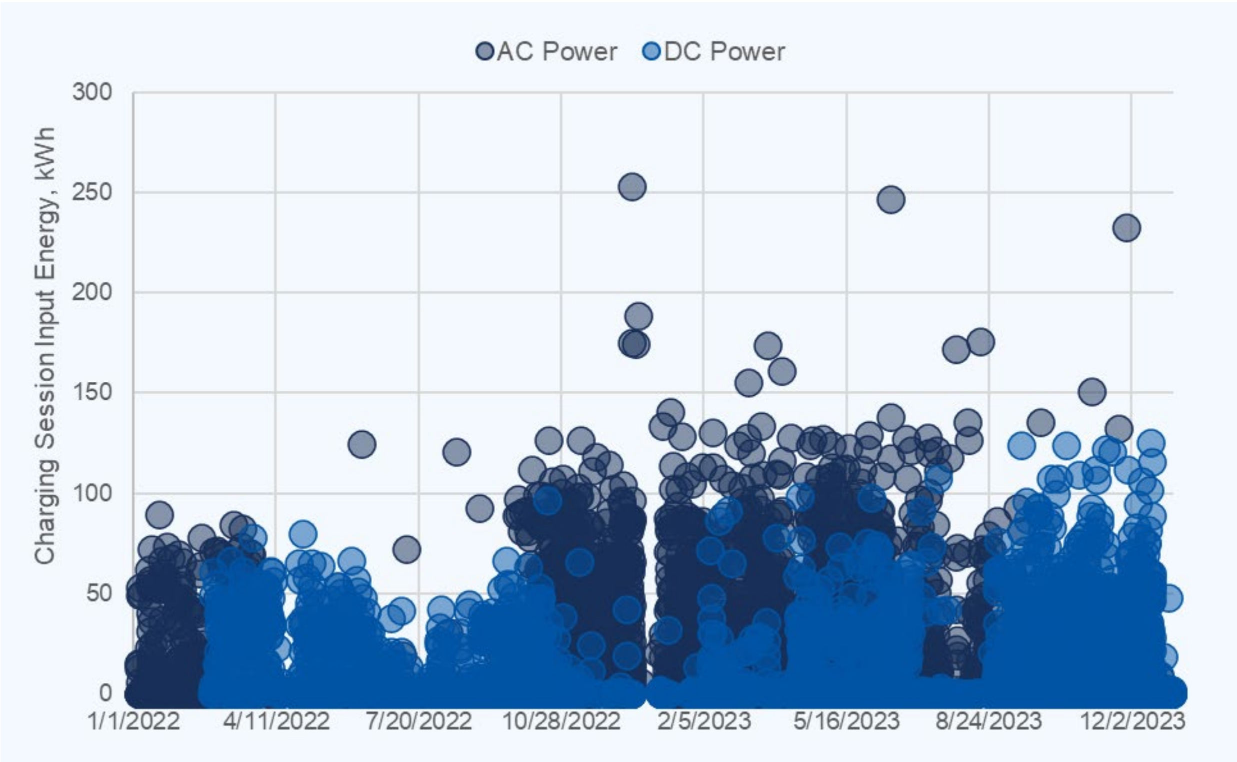
Table 159 shows the charging session summary, based on the Lion Beat telematics data, including a comparison of the L2 AC and V2G DCFC charging input energy. According to the telematics data, the average session starting state of charge is 69% and most sessions are topping off battery capacity. Figure 256 compares the AC and DC charging session input power since January 1, 2022. Since September 2023, the six V2G DCFCs have been providing most of the site's charging power. According to the site host, the site is no longer using the L2 AC chargers.

While helpful for comparison purposes, the Lion Beat charging data is significantly different from the utility billing data and was not used in the impact analysis.

Table 159. Lion Beat Telematics V2G Pilot Charging Sessions

Parameter	Total	Average per Session	Maximum per Session
Count	9,471	–	–
Electric Energy Added, kWh	77,922	8	253
AC Energy Added, kWh	43,601	10	253
DC Energy Added, kWh	34,321	7	125
Start State of Charge	–	69%	100%
End State of Charge	–	74%	100%

Figure 256. Lion Beat Telematics V2G Pilot Electric School Bus Charging Session Input Power Source



In the EY2022 evaluation report, the Evaluation Team noted that battery degradation due to V2G operation was of concern to stakeholders. The Team reviewed the battery state of health data from Lion Beat and observed little to no measurable impact after three years. It remains unclear how extended V2G operation will impact battery life and the Pilot also has minimal bidirectional activity. Table 160 summarizes the battery state of health data from the Lion Beat telematics data.

Table 160. Lion Beat Telematics V2G Pilot Battery State of Health

Bus Number	Manufacturer Year	Date Begin	Capacity Begin (kWh)	Odometer Begin (Miles)	Date End	Capacity End (kWh)	Odometer End (Miles)	Percentage Difference (%)
524	2019	1/1/21	111.3	6,881	1/1/24	109.1	20,017	-2%
521	2019	1/1/21	111.1	6,134	1/1/24	112.4	11,705	1%
526	2021	12/1/21	158.9	291	1/1/24	154.1	7,429	-3%
520	2019	1/1/21	110.3	6,020	12/1/23	112.1	14,874	2%
522	2019	1/1/21	112.8	7,566	1/1/24	109.6	20,289	-3%
523	2019	1/1/21	113.5	6,230	6/1/23	108.8	25,133	-4%
Average								**-2%**

Highlights

- The total electric energy generation for the V2G Pilot was 2,850 kWh, with most of the electric energy generated during ELRP events in July, August, and September.
- The V2G Pilot site did not achieve steady-state electric school bus or DCFC operation until October 2023 because of several vehicle and charger software and hardware issues.
- The Evaluation Team noted significant discrepancies between the various data sources for the Pilot and NSP data was unavailable.
- So far, telematics data does not indicate significant battery state of health impacts from the bidirectional charging operation.

Utility Insights

The Evaluation Team spoke with the SDG&E Pilot representative in January 2024. This section summarizes Utility insights into V2G challenges and lessons learned during the third year of the Pilot.

- The Pilot successfully participated in the ELRP in 2022 and 2023 and will continue its participation going forward.
- The Pilot allowed SDG&E to establish a streamlined pathway for interconnection site applications. While policies existed before the Pilot, no sites had undertaken the process. As of the interview, four sites have gone through the process, which now takes about one month between application submission and approval.
- The interconnection process went more smoothly than anticipated, and other sites have replicated it. This pilot demonstrated what grant funding can do for school bus fleets, and it laid the groundwork for other V2G projects in California.
- The most significant challenges for the Pilot were charger, bus, and battery software interoperability and integration. Changes in standards from the time of approval to implementation resulted in site delays. Interoperability out of the box between charger, bus, and battery software will be critical for future V2G projects.

Highlights

- The Pilot demonstrated successful participation in the ELRP.
- The Pilot’s success laid the groundwork for other V2G projects.
- V2G is possible but comes with challenges in interoperability.
- Interoperability of buses, chargers, and battery software is critical for a successful demonstration.

Site Host Insights

The Evaluation Team spoke with the CVUSD team in January 2024 and noted the following site host insights.

- School buses charge midday after their morning route because they do not hold enough charge to complete both morning and afternoon routes on one charge.
- Charging needs have impacted daily schedules. Sometimes routes need to charge, and the buses may not have enough charge to keep up.
- Standard bus operation did not affect availability to discharge during ELRP events because the Utility generally called events after completion of the afternoon routes.
- Reported co-benefits from the Pilot include reduced air pollution and quieter bus loading zones.
- The site hosts reported being somewhat satisfied with the Pilot, citing charging and equipment reliability as major issues. Equipment issues improved towards the end of 2023. Site hosts need to check vehicle charge daily to confirm that charging has been successful.
- Challenges notwithstanding, the Pilot has positively impacted the site's electrification plans. CVUSD plans to continue growing its EV fleet and expand V2G operations and potentially CAISO participation.
- CVUSD is interested in considering benefits from net metering moving forward.
- CVUSD recommended that other similar sites consider future expansion when building out their charging infrastructure.

Highlights

- The Pilot had many equipment issues at the start, many of which have recently been resolved.
- Electric school bus charging needs have impacted operations.
- The site's operating schedules did not affect ELRP participation.
- Site hosts reported being somewhat satisfied with the Pilot.
- The Pilot has positively affected site electrification plans; the site plans to expand V2G operations.

Driver and Maintenance Staff Insights

This section includes details about the Pilot challenges, lessons learned, and recommendations from the driver and maintenance staff survey. The survey is described in *Appendix A*.

- Respondents reported operational challenges, with concerns centering around charging operations and battery capacity during standard operations.
- Respondents reported incidents of a bus entering into a reduced power mode while driving. The survey questionnaire did not specify whether this was a single or multiple incidents.
- Bus range was a concern for respondents, with only one respondent satisfied with the vehicle range.

- Eight respondents reported driving the same route every day, and 11 reported driving variable routes.

Highlight

- Respondents reported low satisfaction with the electric buses and charging equipment and frequent charging issues.

V2G Market Potential

To estimate the V2G market potential based on available data from this Pilot, the Evaluation Team considered three financial modeling scenarios based on actual site operations: ELRP, net metering, and peak shaving. Using Lion Beat data, the team first estimated how much energy typically remained in the bus batteries after all daily driving was complete. Table 161 shows the average battery state of charge at the start of each charging session, which is approximately 58% across the fleet.

Table 161. V2G Pilot Bus Average State of Charge at Start of Charging

Bus Number[a]	Average Start Charge State	Maximum Charge Added (kWh)
521	58%	128
524	57%	130
525	56%	138
526	67%[a]	176
520	50%	136
522	58%	156
523	58%	151
Average	**58%**	**145**

[a] Bus 526 has a larger battery than the rest of the fleet.

The ELRP financial analysis assumes that the fleet participates in ten ELRP events per year. Sometimes buses return to base early enough to complete charging before ELRP events (which often begin at 4 p.m.), in which case the Team used the full battery capacity in our calculations. With an average remaining capacity, a bus could generate just over $1,100 annually based on ten ELRP events. If it could fully charge in advance of an ELRP event, that value could increase to over $2,500 per bus.

The net metering analysis considered using the buses as distributed energy resources given that the fleet has an interconnection agreement and is allowed to send energy back to the grid at its discretion. The analysis assumed that buses would discharge during the SDG&E on-peak period of 4 p.m. to 9 p.m. for 260 weekdays per year. The team used a compensation value of $0.15 per kilowatt-hour based on the cost parity between TOU periods. The average remaining bus capacity could generate over $2,000 annually, while a fully charged bus may be able to achieve close to $5,000 annually.

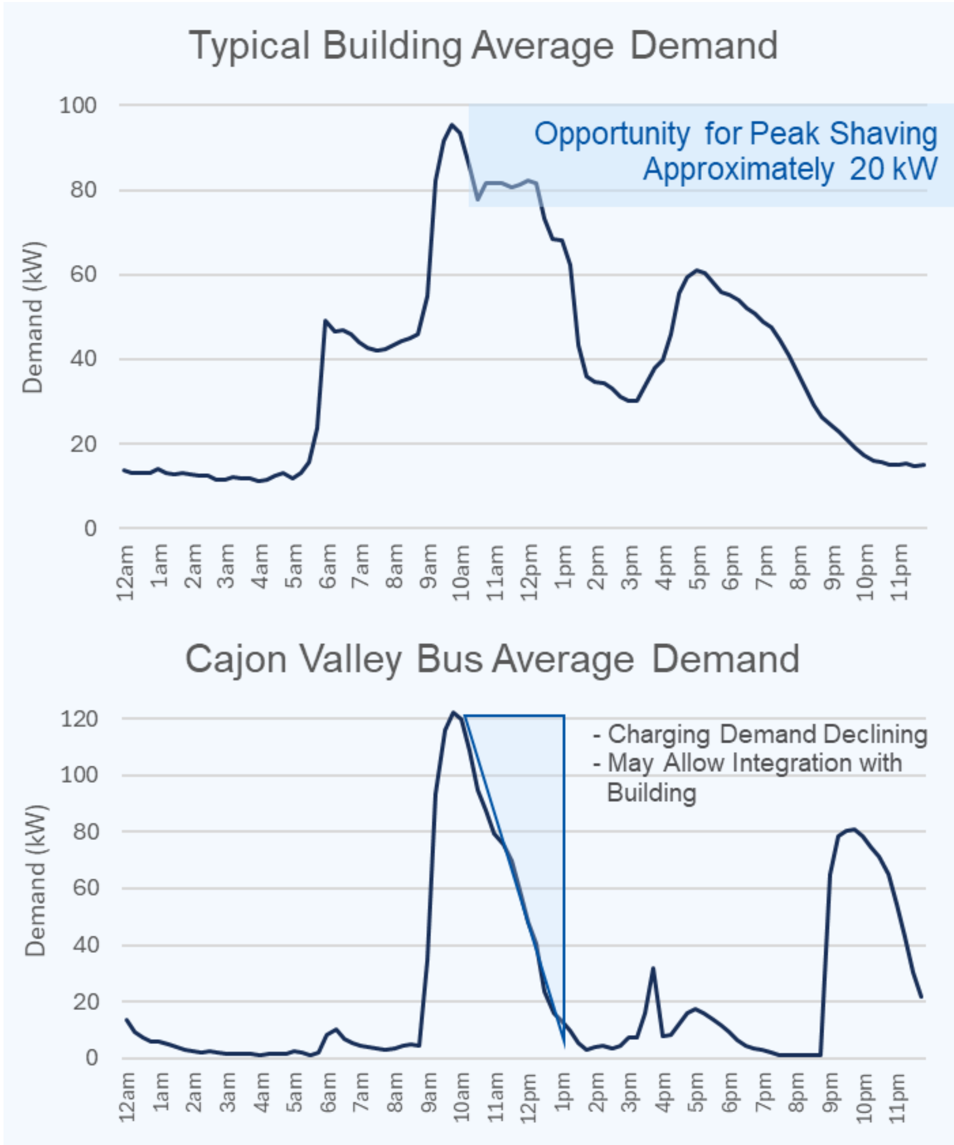
The peak shaving analysis considered billing the bus charging energy consumption with the preexisting building account (as was done in the first year) or using a sub-meter for separate billing. This building regularly has a relatively short spike from 9 a.m. until 10:30 a.m. of approximately 20 kW. Bus charging reaches a maximum demand for a short period and rapidly drops over the next four hours when buses reach a high enough state of charge that their ability to accept power diminishes. Approximately four hours remain after this maximum to shift charging around. The financial modeling analysis was based on two hours of discharge daily for 20 business days per month to achieve a 20-kW reduction in demand for the building account. This is equivalent to 40 kWh and within the typical capacity a bus has when it returns to base. If all six chargers had available buses to draw upon, this would be a small proportion of the remaining capacity of the battery (7 kWh of the 130-kWh capacity). Results indicate the account could save $600 a month, or $7,200 per year using peak shaving, with the amount of energy the buses have to discharge estimated at 800 kWh per month, or approximately $0.75 per kilowatt-hour. While the compensation rate is only 35% of ELRP, it can be used year-round instead of the limited event frequency of ELRP.

Table 162 summarizes the assumptions and results for the three financial modeling scenarios and Figure 257 compares the building and bus charging load curves.

Table 162. V2G Financial Modeling Scenario Assumptions and Results

Scenario / Parameter	Value	Unit
Average Remaining Bus Battery Capacity After Daily Driving Complete (per bus)	57%	%
Average Remaining Bus Battery Capacity After Daily Driving Complete (per bus)	74	kWh
Maximum Bus Battery Capacity Available	130	kWh
ELRP		
Annual ELRP Events	10	Events
ELRP Compensation per Kilowatt-hour	$2.00	$/kWh
Value per Bus Annually (Based on Average Remaining Bus Battery Capacity)	$1,482	$/bus/year
Value per Bus for ELRP Annually (Based on Maximum Bus Battery Capacity)	$2,600	$/bus/year
Net Metering		
Annual Peak Weekdays	260	Days/year
Net Metering Compensation per Kilowatt-hour	$0.15	$/kWh
Annual Compensation per Bus for Daily Net Metering (Based on Average Remaining Bus Battery Capacity)	$2,890	$/bus/year
Annual Compensation per Bus for Daily Net Metering (Based on Maximum Bus Battery Capacity)	$5,070	$/bus/year
Net Metering Value Compared to (Based on Maximum Bus Battery Capacity)	195%	%
Peak Shaving		
Peak Shaving Demand, kW	20	kW
Peak Shaving Hours per Day	2	Hours/day
Weekdays per Month	20	Days/month
Monthly Energy Discharge	800	kWh/month
Non-Coincident Demand Rate	$30	$/kW
Monthly Peak Shaving Value (for Utility Account)	$600	$/month
Monthly Peak Shaving Value per Kilowatt-hour	$0.75	$/kWh
Annual Peak Shaving Value	$7,200	$/year

Figure 257. V2G Pilot Building and Bus Charging Load Curves



Highlights

- The financial potential for this fleet to participate in ELRP events may be $1,500 to over $2,500 per bus per year. This is dependent on several variables including vehicle availability and battery capacity and reliable hardware and software interconnection.
- Net metering could yield almost double the annual value of the ELRP per bus at $2,000 to $5,000.
- Peak shaving building demand at a rate of 20 kW could result in approximately $7,500 of customer's utility bill savings.

V2G Market Research

During EY2023, the Evaluation Team also conducted research into other California statewide V2G activities. This section provides a summary of the Evaluation Team's research.

- SDG&E is developing a V2G-specific tariff. SDG&E hasn't received approval for the tariff As of July 2023 and the tariff would require customers to opt out of the ELRP.
- PG&E offering incentive rates for their vehicle-to-everything (V2X) pilot programs, including V2X residential, commercial, and microgrid programs.[144]
- SCE is working on a V2G electric school bus commercialization project at Rialto Unified School District with Blue Bird and Nuvve.[145] The project's objective is to create a value proposition for electric school buses based on competitive TCO, enable V2G and vehicle-to-building (V2B) income-generating grid integration, and advance technological maturity of medium-duty electric drive components. In the 2021 report, progress had been made on charger interconnection and initial V2G economic modeling results were presented. An updated progress report will likely be available in 2024.
- In early 2024, the Oakland Unified School District announced their plan to transition to 72 electric school buses with bidirectional charging infrastructure.
- In March 2024 the CEC awarded a $3 million grant for the installation of twenty-one 125 kW bidirectional chargers with at least 20 electric buses at several school districts in California.

Highlight

- The CEC and other California utilities are exploring V2G pilots and V2G-specific rates, but progress is pending.

6.3.3. Lessons Learned

The team identified two lessons learned, which may be applied to other similar efforts.

V2G financial benefits from the site's perspective could be increased by offering V2G-specific rates and utilizing energy generation and battery storage outside of emergency load reduction program (ELRP) events and potentially for on-site load reduction.

The total electric energy generation for the V2G Pilot during 2022 and 2023 was only 2,850 kWh, with most of the generation occurring during ELRP months (July, August, and September). The site host received $2 per kilowatt-hour for electricity that was fed back to the electric grid. There is opportunity

144 PG&E. *Vehicle-to-Everything (V2X) pilot program.* Accessed May 2024. https://www.pge.com/en/clean-energy/electric-vehicles/getting-started-with-electric-vehicles/vehicle-to-everything-v2x-pilot-programs.html

145 Energy.gov. *V2G Electric School Bus Commercialization Project.* Accessed May 2024. https://www.energy.gov/sites/default/files/2021-06/elt095_moore_2021_o_5-14_416pm_LR_TM.pdf

for sites to reduce their operating costs by expanding their generation beyond the limited ELRP event periods to support on-site load reduction.

V2G is still a nascent technology, and additional third-party evaluations and data collection efforts are needed to understand and resolve the issues associated with it.

Grid, hardware, and software interconnection issues were a consistent challenge for this Pilot and delayed steady-state operation until mid-2023. Data challenges—including inconsistent data sets between the chargers, vehicles, and fleet records as well as poor NSP EV charging session data quality—hindered the Team's ability to obtain a comprehensive understanding of the single V2G Pilot site's operation. The evaluation of this site is complete with this report. Given that the data challenges and evaluation findings could be unique to this site, The Evaluation Team was unable to offer overarching conclusions about the Pilot.

> **Recommendation**: Future V2G projects should prioritize interoperability of buses, chargers, and battery software during the project planning phase to enable successful bus operation from the start.
>
> **Recommendation**: While this Pilot evaluation is complete, additional third-party evaluations of other V2G projects are needed to assess the challenges and opportunities of different V2G use cases to reduce operational costs (e.g., maximizing energy export, maximizing behind-the-meter load management, participation in CAISO grid services). The Evaluation Team recommends that similar data points be collected for future V2G pilots, including AMI, NSP EV charging session, and telematics data and that Utilities consider installing generation and consumption check meters for each charging station to more accurately monitor V2G operation.

7. Liberty Utilities Transportation Electrification Programs

7.1. EV Bus Infrastructure Program

7.1.1. Overview

This overview provides a detailed description of the Liberty EV Bus Infrastructure program; summaries of the implementation process, performance metrics (site status), materials (outreach), and budget; and a timeline of major milestones. Following the overview are detailed findings, highlights, and lessons learned. This is the final report for Liberty's EV Bus Infrastructure program.

Program Description

In October 2018, CPUC Decision 18-09-034[146] authorized Liberty Utilities to complete a transit electrification site for the Tahoe Transit District (TTD). The initial plan included two Proterra (Rhombus) 60 kW DCFC chargers for three Proterra buses at Lake Tahoe Community College (LTCC), where the buses could charge overnight. The site was originally budgeted at $223,000 based on Liberty's estimates, but Liberty later expanded the site scope based on the customer's updated charging specifications. The updated scope included two additional 500 kW overhead fast chargers (pantographs) at LTCC and the associated infrastructure to support over 1 MW of new load.

Liberty did not provide incentives or grants for equipment or vehicles. Instead, the Utility provided distribution upgrades totaling $876,272 to support TTD in its fleet electrification efforts. TTD received Congestion Mitigation and Air Quality funds, which, paired with California's Transportation Development Credits and Proposition 1B (transportation bond measure), fully funded the cost of two Proterra battery electric buses. TTD also received a Low Emission-No Emission Section 5339(c) grant, which fully funded the purchase of a third Proterra bus.

Liberty remained committed to supporting the site through completion as the site scope expanded to include the following equipment:

- Traditional Utility-side upgrades including a significant line extension to bridge the long distance between the distribution supply and the transformer
- A new transformer and 3,000 ampere switchgear

Implementation

Per the approved 2018 Decision, Liberty worked directly with LTCC to design and support site construction, which was completed in 2022.

Program Materials Summary

This section highlights findings from the Evaluation Team's review of program material and ME&O activities conducted by Liberty in 2023 and applies to both its EV Bus Infrastructure program and its

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[146] September 27, 2018. *Decision 18-09-034: Decision on the Priority Review and Standard Review Transportation Electrification Projects*. https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M231/K030/231030113.PDF

Schools and Park Pilots. Liberty participated in a Tahoe community event in September of 2023 to promote EVs and the new Lake Tahoe Community College (LTCC) chargers. The event, called Lake Tahoe Electric Transportation Forum, gathered over 120 EV stakeholders, ranging from government office representatives to regional transportation staff. Figure 258 presents two photos from the community event.

Figure 258. Photos from the Lake Tahoe Electric Transportation Forum

The forum was designed to engage stakeholders who might not have been aware of the site and to foster meaningful discussion about the future of TE in the Lake Tahoe region with increasing local interest in EVs. The event was received positively by passionate stakeholders, who described the forum as a "hybrid between an energy trade show and spiritual retreat," according to RedRock Studio Events coverage.

Program Performance

Figure 259. Liberty EV Bus Infrastructure Program TTD's Proterra Electric Bus Charging at LTCC

The TTD's site at LTCC was completed with activation of the two 450 kW ABB pantograph chargers in 2022 (see Figure 259). The TTD electric buses entered into revenue service in July of 2022.

In 2021, Liberty completed the installation process and all distribution upgrades, which concluded Liberty's role in setting up the infrastructure for the project. Two 60 kW Proterra DCFCs were activated in 2021. TTD's plan was to charge the three electric buses overnight on the DCFCs located at the LTCC bus stop and to use the pantographs (also installed at the LTCC bus stop) between runs. There are two bus shelters at the stop and a shed behind the bus stop that houses the charging equipment. The Utility has offered to provide operational support including planning for and scheduling charging cycles. Liberty is also working with TTD on separate applications for new charger services for other locations in its service territory. Additional projects are expected to apply under the new EV Infrastructure Rule.[147]

Until July 2022, the three Proterra transit buses had been used only for training purposes and were not in revenue service. Also notably, due to supply chain challenges, Proterra changed the specification from 500 kW pantograph chargers to 450 kW pantograph chargers.

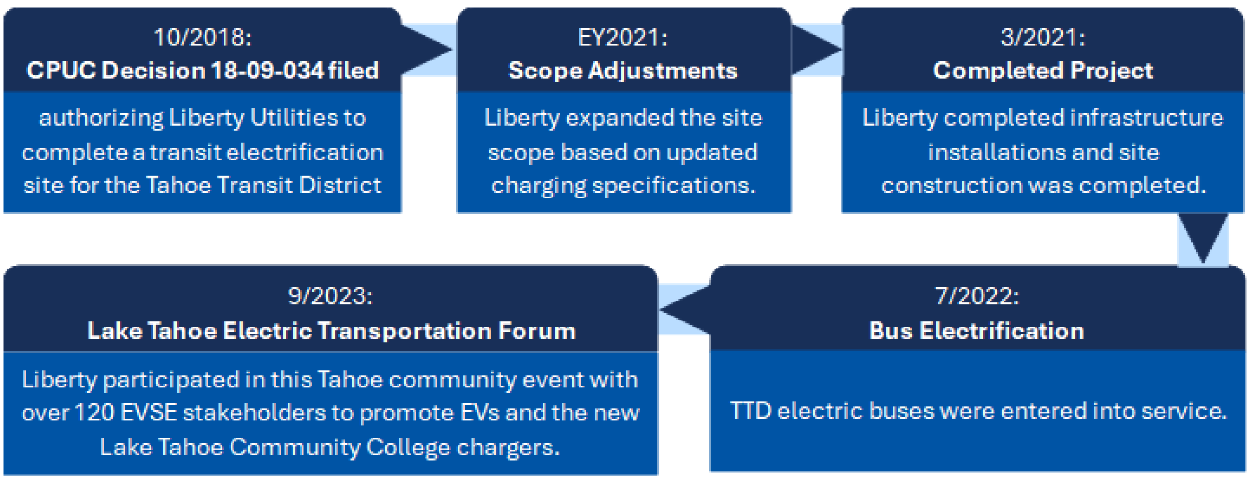
Budget Summary

Liberty did not spend any additional funding in 2023; the Utility investment to support TTD in its fleet electrification efforts was $876,272.

Timeline

There were no additional milestones in 2023. Figure 260 shows all major milestones since the program's inception.

Figure 260. Liberty EV Bus Infrastructure Program Key Milestones Timeline



7.1.2. Findings

This section provides findings from analyses of the site visits, grid impacts, petroleum displacement, GHG and criteria pollutant reductions, and health impacts as well as from interviews with Utility staff.

Table 163 summarizes key impact parameters for EY2023 as well as for the program to date. Annual estimates of impacts are provided for metrics calculated as part of the impact evaluation.

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147 Liberty Utilities (Calpeco Electric) LLC. December 6, 2021. "Rule 24 Electric Vehicle Infrastructure." https://california.libertyutilities.com/uploads/CalPeco%20Tariffs/CalPeco%20Rule%2024.pdf

Table 163. Liberty EV Bus Infrastructure Program Impacts Summary

Impact Parameter	EY2023 Actual	PTD Actual
Population of Activated Sites	1	1
Sites included in analysis (#)	1	1
Charging Ports Installed (#)	4	4
EVs Supported (#)	3	3
Electric Energy Consumption (MWh)	98,708	222,063
Petroleum Displacement (GGE)	10,457	23,524
GHG Emissions Reduction (MT GHG)[a]	77	168
PM_{10} Reduction (kg)	0.02	0.05
$PM_{2.5}$ Reduction (kg)	0.02	0.05
ROG Reduction (kg)	2.58	5.8
CO Reduction (kg)	2,064	4,642

[a] GHGs include CO_2, CH_4, and N_2O multiplied by their respective GWP as defined by IPCC AR5 (see *Appendix A* for more details).

Site Visit

The Evaluation Team visited the EV Bus Infrastructure program site at LTCC to document the physical build out and meet with Utility and transit district staff. The successful deployment took years of collaboration between Liberty, TTD, and college staff, and the Team wanted their feedback to better understand the process.

The site improvements go beyond a simple bus stop with EV charging. The site is a multimodal mobility hub. The roof structure supporting the pantograph chargers covers the waiting area for bus passengers as well as a skateboard rack, bike racks, and bike repair tools. A video display can show bus route information or campus announcements. These extra amenities were funded by the college, not by the Utility or TTD. The stone, timber, and metal structure matches the architecture of the college and fits well within the Tahoe landscape, as shown in Figure 261.

Figure 261. Liberty EV Bus Infrastructure Program LTCC Mobility Hub with Pantograph EV Chargers

The site serves multiple bus routes. The pantographs, shown in Figure 262, offer high-power (450 kW) charging for buses during in-route layovers.

The site also features two 60 kW DCFC chargers with CCS dispensers that could charge buses overnight. TTD does not currently have EVs that would use these chargers other than the three Proterra electric buses.

Figure 262. Liberty EV Bus Infrastructure Program Detailed View of Pantograph Mechanism and Protective Cover

Charger access is limited to authorized vehicles based on the ISO 15118 communication standard, and other EV fleets cannot use them unless they reach an agreement with TTD and LTCC. The high-power pantograph chargers required new Utility service, which in turn required connecting to a circuit more than a quarter mile away. This new service supports all the bus charging and auxiliary loads at the LTCC e-mobility hub. The new service could also support future installation of L2 charging for campus visitors with the addition of a step-down transformer.

The bus stop shelter and additional wall materials hide most of the electric equipment. The transformer and switchgear are housed behind one of the two bus shelters, while the DC power cabinets are located behind the other shelter. The electrical equipment, shown below in Figure 263 is painted brown/green to minimize visual impact and possibly provide additional weather protection.

Figure 263. Liberty EV Bus Infrastructure Program Transformer and Switchgear (left) and DC Power Cabinets (right) for Electric Bus Charging at LTCC

The steel gates to the enclosure were designed to achieve a natural rusty patina, but the Evaluation Team noted that some vinyl labels were peeling and certain nuts and screw heads showed some signs of corrosion. Liberty staff reported that the structure was designed to fully shelter the charging equipment, but the equipment the Utility installed did not match the original plans.

The Evaluation Team met with TTD staff to learn about the project's successes and challenges. TTD received multiple sources of funding to pay for the buses and the chargers, including from the Federal Transit Administration, Caltrans Low Carbon Transit Operations Program (LCTOP), and State Prop 1B. The fleet also monetizes its LCFS credits to help offset the cost of ongoing operation. TTD had strong initial support for the site from its board of directors who continued to support it through delays in both infrastructure completion and bus delivery. Among the causes of these delays were COVID-19 pandemic–related supply chain issues, seasonal restrictions on construction in the Tahoe basin, and local wildfires.

The charging system has functioned as designed, and the electric buses perform well on their assigned routes, with sufficient range to complete daily assignments with frequent use of the high-powered chargers. Unfortunately, various issues with the electric buses have prevented TTD from using these vehicles on longer routes or adjusting charging schedules to take advantage of the long range that these buses provide.

TTD highlighted that starting in the spring of 2023, at least one bus was out of service at all times pending repairs. At the time of the site visit, none of the three electric buses were operational. Most repairs were not related to the electric drivetrain but addressed issues with ancillary components such as air suspension components or a windshield wiper motor. One bus was observed with signs of cracking in structural fiberglass body components, which raises concerns about its long-term durability. Because of the bankruptcy and dissolution of the vehicle manufacturer, spare parts have been unavailable to fix some of these problems.

The site was designed to serve more vehicles, including full-size buses and smaller cutaway-type shuttles; however, TTD has no further EV deployments planned in the near future because of the issues with the current vehicles. Figure 264 shows one of the two installed CCS dispensers. There is also a stub out to add a third CCS dispenser when needed to serve more EVs.

Figure 264. Liberty EV Bus Infrastructure Program CCS Dispenser at LTCC

Due to the various issues with the electric buses, TTD has not yet assessed the operational cost of electric buses compared with conventional buses to assess potential cost savings. TTD still plans to eventually electrify its entire fleet, including buses serving commuter routes. This will require EV charging infrastructure at additional sites and consideration of backup power sources and potential electric bus use in emergency evacuations. These factors were not considered as part of this initial deployment; however, lessons learned from this deployment will support future electrification planning.

Highlights

- The site was designed to blend with the surrounding environment, and the bus shelters integrate amenities such as an information screen and bike parking.
- Two 450 kW pantographs and two 60 kW DCFC ports can charge electric buses in-route and overnight. More than a megawatt of charging capacity has been installed with sufficient capacity for an additional DCFC dispenser and future addition of L2 charging ports.
- The chargers have worked well at providing multiple short charges through the service day.
- Mechanical problems and a lack of spare parts due to the manufacturer’s bankruptcy have significantly limited the use of electric buses in the second half of 2023.

Grid Impacts

This section describes grid impacts for the TTD site, which was the sole Liberty EV Bus Infrastructure program site, based on an analysis of energy consumed from site activation through the end of 2023.

Data Sources

The primary data source used for the analyses detailed in this section is the energy usage–related data provided in regular 15-minute intervals from the Utility meter. Other data sources include customer bills, LCFS program information, and charging session–specific data provided by the NSP. There are several important differences between Utility meter data and NSP data. While Utility meter data includes only energy usage, NSP data includes session start and stop time, the duration of a vehicle’s connection to a charging port, the duration a vehicle is actively pulling power, and the specific port used for a session. Utility meters track standing loads (such as those the EVSE uses for communications, cooling, active power converters, solenoids, and screens), which NSPs typically cannot do. In instances where Utility meter data is missing from the dataset, the Evaluation Team uses NSP data to fill the gaps.

Summary of Grid Impacts

Table 164 presents the estimated grid impacts for the EV Bus Infrastructure program.

Table 164. Liberty EV Bus Infrastructure Program Grid Impacts

Impact Parameter	2023 Actual	PTD Actual	10-Year Projection
Operational Sites	1	1	1
Installed Charging Capacity, kW	1,020	1,020	1,020
Electric Energy Consumption, MWh	98.5	222	1,038
On-Peak (4 p.m. to 9 p.m.) MWh (percentage of total)	21.9 (22%)	51.0 (23%)	N/A
Maximum Demand, kW (date and time)	580 (3/8/23: 9 p.m.)	580 (3/8/23: 9 p.m.)	N/A
Maximum On-Peak Demand, kW (date and time)	423 (2/23/23: 8:45 p.m.)	547 (7/7/22: 6:45 p.m.)	N/A

Site Startup

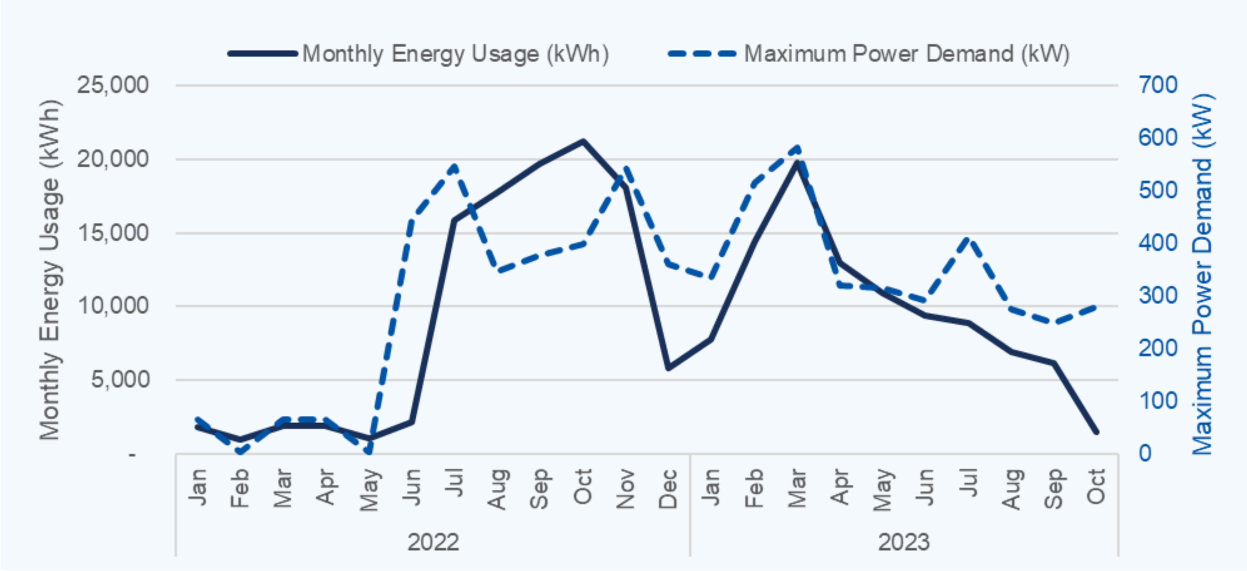
As with many projects, the pandemic had an effect on initial procurement and site preparation. The utility meter for the Liberty EV Bus Infrastructure project at the Tahoe Transportation District was set in March of 2021; however, significant usage at the site did not begin until July of 2022 (16 months later). Through April of 2022, operations were limited, with fewer than twenty days of charging, which appear to have used an overnight charger limited to 60 kW. Historical snowfall impacted Liberty's meter reading ability in late 2022 through early 2023, resulting in a data gap of approximately seven weeks. The data record supplied by Liberty runs from July of 2022 through October 9, 2023. From project inception through the end of the data record, chargers dispensed more than 12.5 MWh in 8 of 15 months, which illustrates the demand and consumption trends associated with the full use of TTD's buses.

Toward the end of the data record, TTD's electric bus manufacturer filed for Chapter 11 bankruptcy, ultimately selling its assets to other companies. In months leading up to the manufacturer's dissolution, bus reliability and manufacturer service support had been limited; the manufacturer's announcement and restructuring subsequently raised further questions about the reliability of its vehicles' service and support moving forward. Due to the difficulties obtaining bus service when issues arise, TTD has noted that at least one bus has been out of service at any given time for most of 2023, reflected by a steady decline in monthly consumption from March 2023.

Energy Trends

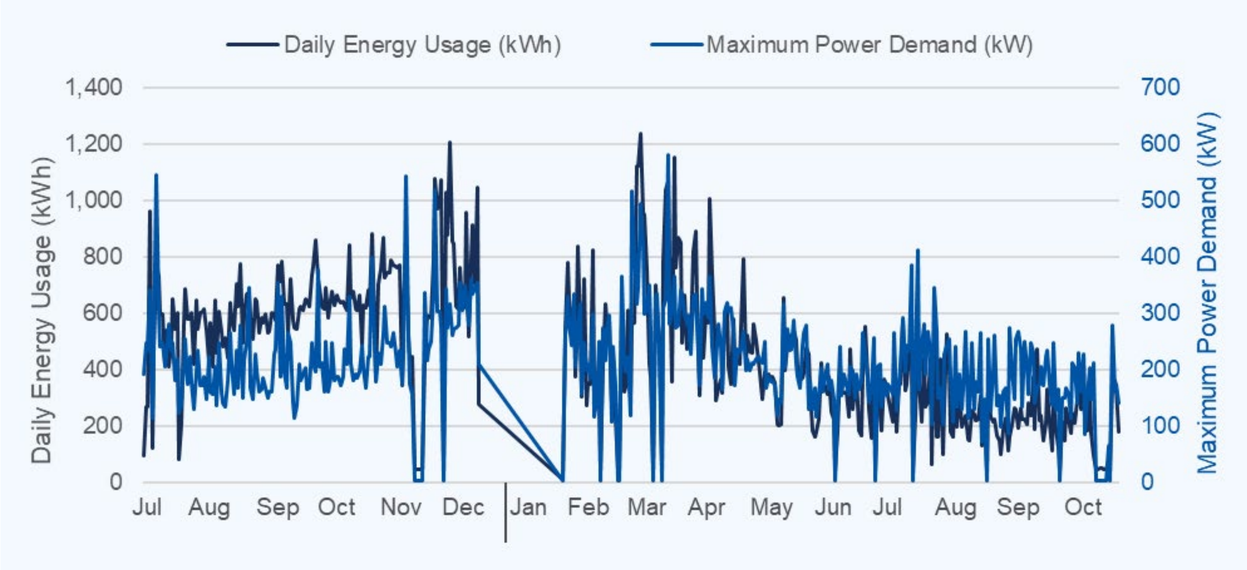
As shown in Figure 265, the average monthly usage from July through November of 2022 was between 16 MWh and 21 MWh. The aforementioned bus problems reduced charger usage from approximately 20 MWh in March of 2023 to 1.5 MWh in October 2023, after which no further data was received.

Figure 265. Liberty EV Bus Infrastructure Program Monthly Energy Usage and Demand



TTD's site involved the installation of two 450 kW pantograph chargers and two 60 kW DCFCs, for a total capacity of just over 1 MW. As Figure 266 shows, the average daily maximum demand in 2023 stabilized at a lower level after a gradual upward trend in 2022, with demand hovering around 250 kW after a small uptick in maximum demand through the winter months. A drop-out occurred in the data between December 7, 2022 and January 19, 2023 due to snowfall impacting the Utility's ability to read meters during this period.

Figure 266. Liberty EV Bus Infrastructure Program Maximum Daily Demand (July 2022 to October 2023)



The site's daily usage averaged around 650 kWh, ranged from 500 kWh to 1,200 kWh, and was very similar between weekdays and weekends. Demand reached 400 kW on several days and was over

500 kW on a few days. TTD's highest demand day since operations began was recorded in March of 2023, at just under 600 kW of demand. In 2023, the site experienced a significant decline in both daily energy and maximum daily demand starting in April of 2023. As noted previously, this apparent decrease in usage corresponds closely with the fleet's reported issues with its electric buses.

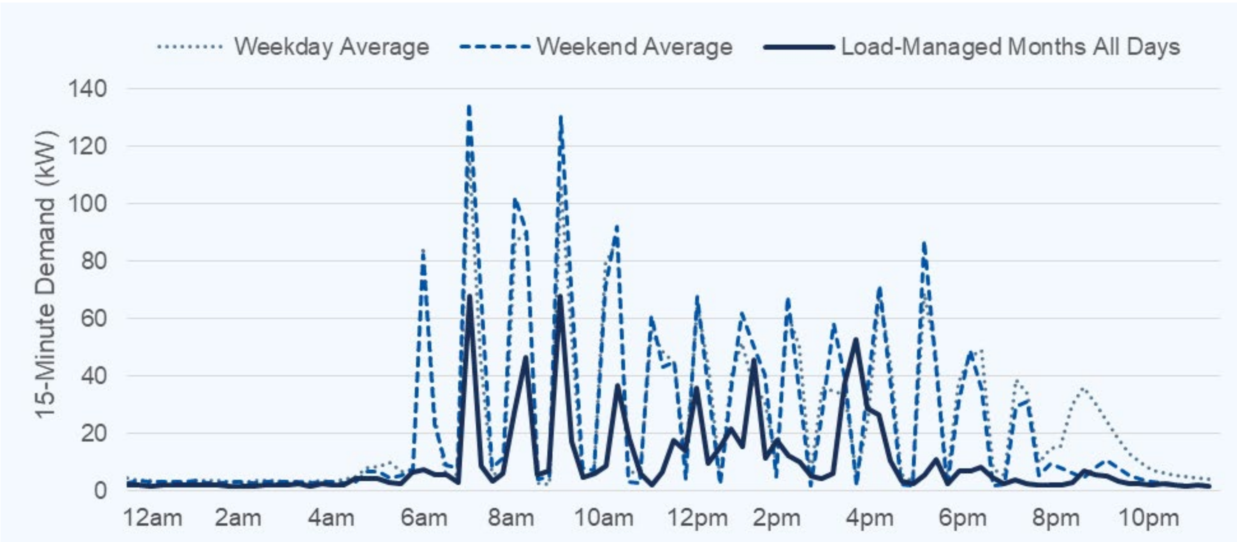
The average monthly energy consumption during the period of highest-cost energy (between 4 p.m. and 9 p.m.) ranged from 20% to 25%, as shown in Figure 267. While this is the common time period for most California IOUs' highest cost energy, Liberty's A-1 rate is actually from 5 p.m. to 10 p.m. in summer and from 10 a.m. to 10 p.m. in winter. Figure 267 remains a decent proxy for summer. Especially in the winter, taking advantage of overnight charging could help move a significant amount of energy into lower-cost time periods.

Figure 267. Liberty EV Bus Infrastructure Program Monthly Energy Use between 4 p.m. and 9 p.m. (July 2022 through October 2023)

Four of the last five months of data show that TTD consumed less than 20% of its monthly energy during the 4 p.m. to 9 p.m. time period—slightly less than the average 22% of monthly energy consumed during the 4 p.m. to 9 p.m. period in the preceding 10 months. This decrease may be associated with the fleet adjusting its charging behavior in anticipation of new rates. Liberty was able to coordinate with TTD about the imminent availability of new EV-TOU rates and the associated cost savings that would be possible through charging at lower cost times. TTD has so far relied on training its staff to avoid charging the vehicles during high-cost periods. For reference, energy consumed at times outside of the 4 p.m. to 9 p.m. period is significantly less expensive: summer rates are 25% lower, and winter rates are almost 75% lower.

Average weekday and weekend load curves for months in which energy consumption was over 12.5 MWh are shown below in Figure 268. For comparison, an average load curve for the period after TTD began load management is also shown as the Load-Managed Months All Days line.

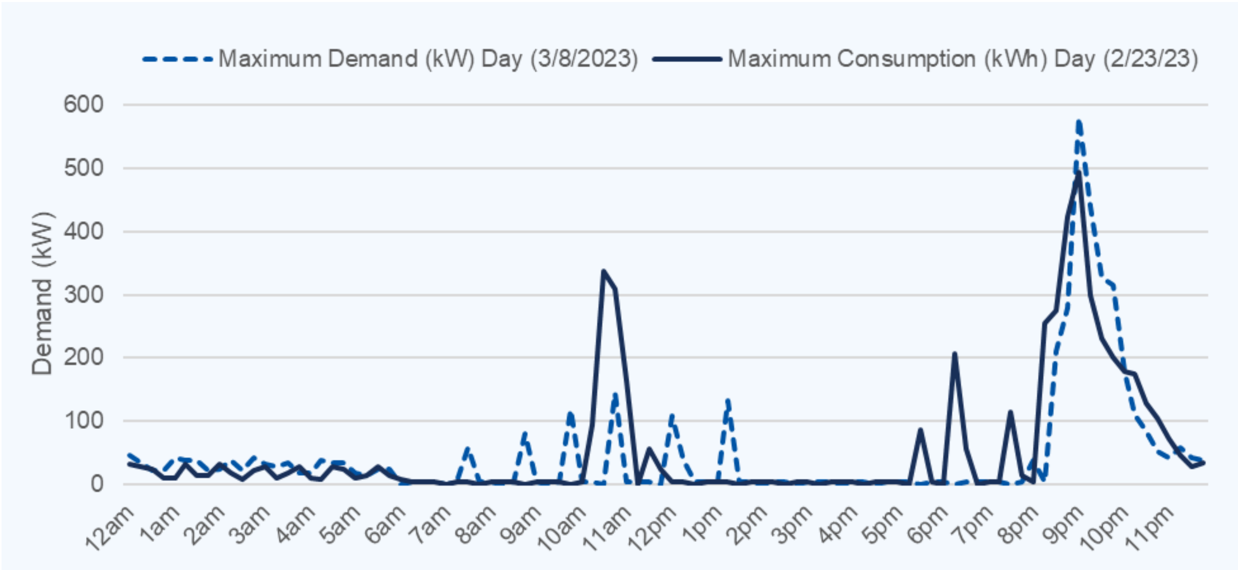
Figure 268. Liberty EV Bus Infrastructure Program Average Daily Load for Months with Energy Consumption over 12.5 MWh



Daily charging often begins by 6 a.m. and concludes by 10 p.m., following a steady pattern of opportunity charging approximately once every hour (likely as the bus completes the route and returns to the LTCC bus stop). On average, load management appears to limit these opportunity charging spikes to around 70 kW, which is a significant reduction of approximately 60 kW from previously observed weekend and weekday peaks during high-activity months.

Comparative load curves for the days representing the highest daily demand (581 kW on March 8, 2023) and highest daily consumption (1.24 MWh on February 23, 2023) are shown below in Figure 269.

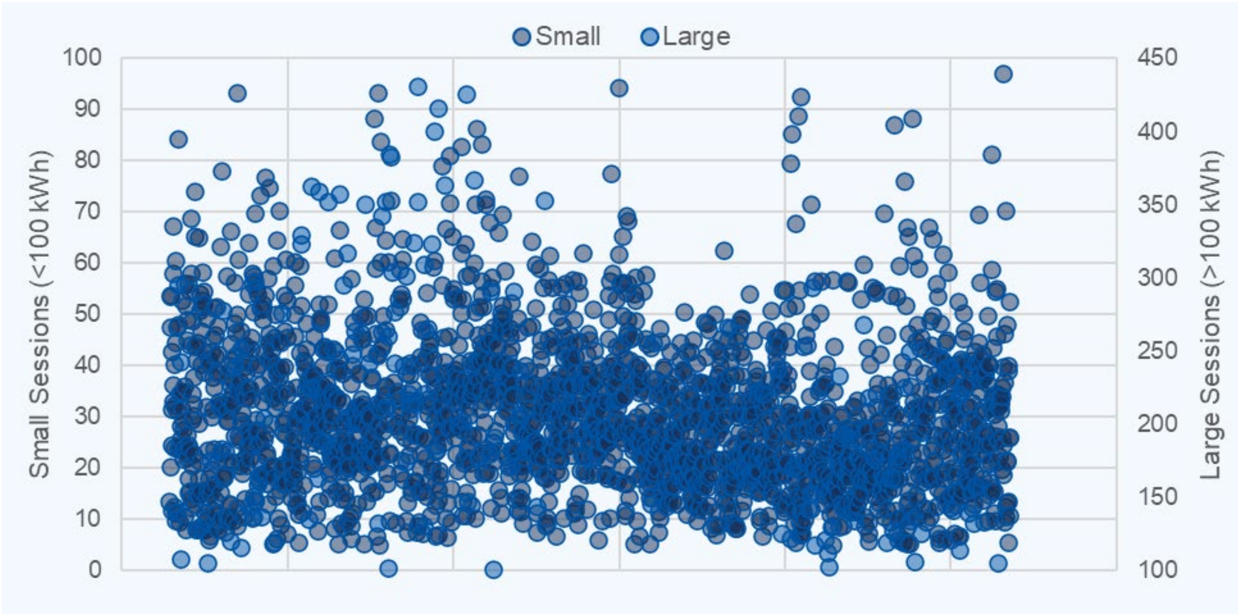
Figure 269. Liberty EV Bus Infrastructure Program Load Curves for Highest Demand and Consumption Days



The days of maximum demand and consumption in Figure 269 occurred prior to the site engaging in load management. In both Figure 268 and Figure 269, charging generally appears to peak and drop off quickly, as opposed to slowly tapering off; this is likely due to the short dwell time (averaging 25 minutes) between circuits, which indicates that charging is generally halted by connector removal before the vehicle is fully charged or that the charger begins to slow its charging power as the vehicle approaches full charge.

TTD started using load management at the LTCC site in June of 2023. The Evaluation Team typically assesses charging flexibility based on how long a vehicle is connected to a charging port in excess of receiving a full charge. Given that the TTD site currently engages in short opportunity charging sessions between circuits and that the vehicles are generally charging from session initiation to session termination, this methodology does not provide a clear picture of how much additional load management is possible. Figure 270, presents an alternative approach to gauging flexibility by categorizing charging sessions as “small” or “large,” based on whether the session was more than or less than 100 kWh. The figure illustrates the general reduction in magnitude and tighter clustering of charging sessions over time (left to right). The large sessions axis starts at 100 kWh.

Figure 270. Liberty EV Bus Infrastructure Program Charging Session Analysis



The x-axis in Figure 270 is graphed by session ID number, so the graph can be read chronologically from left to right. Small sessions account for 95% of charging sessions—in other words, 95% of charging sessions dispense 20% or less of the rated electric bus battery capacity of 450 kWh. Recent large sessions have more commonly dispensed under 250 kWh with a near-total decrease in the number of sessions above 300 kWh. On average, small sessions dispense 30 kWh, or approximately 7% of usable battery capacity. The fleet historically averages four of these small charging sessions from 4 p.m. through 9 p.m. for almost the equivalent of 30% of battery capacity using the highest-cost energy.

Analysis of 30 months of billing data for the site shows that the average cost of energy is $0.22 per kilowatt-hour. The TTD site is on the TOU A-1 EV rate schedule[148], benefitting from a demand charge holiday granted by AL 125[149]. In 2023, Liberty received approval for commercial EV TOU rate schedules; as a result the LTCC site will move from A-1 to A-3 Commercial EV Rate.

[148] Liberty Utilities (Calpeco Electric) LLC. January 5, 2022. "Schedule No. A-1 TOU EV Small General Service." https://california.libertyutilities.com/uploads/CalPeco%20Tariffs/Schedule%20No.%20A-1%20TOU%20EV%20Small%20General%20Service.pdf

[149] Liberty Utilities (Calpeco Electric) LLC. October 1, 2019. "Advice Letter No 125-E-A (U 933-E)." https://california.libertyutilities.com/uploads/CalPeco%20ALs/AL%20125-E-A%20A1%20DCFC%20Rate.pdf,

Highlights

- Liberty's TTD transit bus site was activated in 2022 and consumed up to 20 MWh of energy monthly until March of 2023 when the fleet started experiencing vehicle reliability issues.
- Vehicle reliability and manufacturer warranty support remain significant challenges to maximizing the potential of TTD bus fleet electrification.
- Charging sessions average 30 kWh (hourly opportunity charging while between route runs), which is a small percentage of the battery capacity.
- The site exhibits regular hourly charges of around 100 kW for approximately 15 minutes during weekends and weekdays between 6 a.m. and 8 p.m. Current operations do not utilize chargers between 10 p.m. and 6 a.m.
- The maximum daily demand is consistently around 200 kW (20% of installed capacity) but has occasionally exceeded 500 kW.
- Between 20% and 25% of the energy use at this site occurs between 4 p.m. and 9 p.m. resulting in average billing costs of $0.22 per kilowatt-hour.
- In the second half of 2023, TTD adopted load management resulting in less than 20% of consumption during the high-cost time period.

Petroleum Displacement, Greenhouse Gas and Criteria Pollutants

The Evaluation Team estimated program-induced petroleum displacement and emissions reductions related to the EV Bus Infrastructure Program using three key pieces of information: electricity used for vehicle charging, EV annual miles traveled, and annual counterfactual vehicle fuel consumption. From this information we estimated the reduction in equivalent gallons of petroleum as a result of the program. Table 165 presents the petroleum displacement resulting from the site in 2023, the program to date, and a 10-year projected total.

Table 165. Liberty EV Bus Infrastructure Program Petroleum Displacement Summary

	Usage				Petroleum Displacement (DGE)		
	2023 Actual[a] (kWh)	PTD Actual[b] (kWh)	2023 Actual (Miles)	PTD Actual (Miles)	2023 Actual	PTD Actual	10-Year Projection
Total	98,708	222,063	41,832	94,108	10,457	23,524	109,914

[a] "2023 Actual" represents the data for the calendar year 2023.

[b] "PTD Actual" represents the data from the site activation.

The Evaluation Team calculated reduced emissions from displaced fossil fuel use from ICE vehicles that were not in service as a result of the program. The Team first developed one ICE counterfactual, then calculated the emissions associated with these vehicles under conditions that otherwise matched the EVs to provide a baseline. Although EVs have no tailpipe emissions, the fossil-fuel power plants that supply electricity to the vehicle chargers still release some GHGs and criteria pollutants.

Table 166 presents the GHG emissions reductions resulting from the EV Bus infrastructure program in 2023 and the program to date and a 10-year projected total. Overall, the program to date resulted in reductions of 168 MT of GHG emissions. This represents an 82% reduction relative to the counterfactual.

Table 166. Liberty EV Bus Infrastructure Program GHG Reduction Summary

	Usage				GHG Reduction (MT CO2e)		
	2023 Actual[a] (kWh)	PTD Actual[b] (kWh)	2023 Actual (Miles)	PTD Actual (Miles)	2023 Actual	PTD Actual	10-Year Projection
Total	98,708	222,063	41,832	94,108	77	168	810

[a] "2023 Actual" represents the data from all activated sites from program inception for the calendar year 2023.
[b] "PTD Actual" represents the data from all activated sites from program inception for all program years.

Overall, of the local emissions, the program had the highest impact in reducing CO, resulting in an estimated reduction of 4,642 kg program to date (see Table 167).

Table 167. Liberty EV Bus Infrastructure Program Local Emissions Reductions

	NOx (kg)	PM_{10} (kg)	$PM_{2.5}$ (kg)	ROG (kg)	CO (kg)
2023 Actual[a]	4.53	0.02	0.02	2.58	2,064
PTD Actual[b]	10.2	0.05	0.04	5.80	4,642
10-Year Projection	48.1	0.23	0.22	27.08	21,664

[a] "2023 Actual" represents the data from all activated sites from program inception for the calendar year 2023.
[b] "PTD Actual" represents the data from all activated sites from program inception for all program years.

Estimated particulate matter reductions are small, as modern conventional transit buses equipped with particulate filters tend to have very low tailpipe emissions. NOx and ROG, which contribute to smog, show moderate levels of reduction. Because most power generation comes from outside the Tahoe basin, emissions from electricity-generating activities undertaken by the utility are not included in the above totals.

Highlights

- Liberty EV Bus Infrastructure Program achieved a PTD impact of more than 23,000 gallons of petroleum displaced.
- The program has resulted in an 82% reduction of GHG to date.
- Across the local emissions, the program had the highest impact in reducing CO, resulting in an estimated reduction of more than 4,500 kg to date.

Health Impacts

The Evaluation Team calculated public health impacts (benefits and costs) of reductions in criteria pollutants from vehicle electrification. Pollutants included in the analysis are primary $PM_{2.5}$ and precursors of secondary $PM_{2.5}$, including NO_x, SO_2, NH_3, and VOCs. This analysis only considered tailpipe emissions reductions, rather than the full lifecycle emissions (power plant emissions). We used the U.S. EPA's COBRA to evaluate the health benefits associated with the emissions reductions.

The total value of the health benefits associated with the emissions reductions is small, between $1,087 and $1,406. Table 168 shows the cumulative health benefits in California associated with the emissions reductions realized by the electrification of Liberty's single site.

Table 168. Liberty EV Bus Infrastructure Health Benefits

Health Endpoint	Change in Incidence (Annual Cases)		Monetary Value (Annual, 2023 Dollars)	
	Low	High	Low	High
Mortality	< 0.000	< 0.000	$1,046	$1,365
Avoided Medical Care				
Nonfatal Heart Attacks	< 0.000	< 0.000	$1	$1
Infant Mortality	< 0.000	< 0.000	$2	$2
Hospital Admits, All Respiratory	< 0.000	< 0.000	< $0	< $0
Hospital Admits, Cardiovascular	< 0.000	< 0.000	< $0	< $0
Acute Bronchitis	< 0.000	< 0.000	$4	$4
Instances of Stroke	< 0.000	< 0.000	< $0	< $0
Instances of Lung Cancer	< 0.000	< 0.000	< $0	< $0
Emergency Room Visits, Asthma	< 0.000	< 0.000	< $0	< $0
Asthma Exacerbation	0.785	0.785	$30	$30
Lost Productivity				
Minor Restricted Activity Days	< 0.000	< 0.000	$2	$2
Work Loss Days	< 0.000	< 0.000	$1	$1
Total Health Effects	–	–	**$1,087**	**$1,406**

Highlight

- The annual monetary health benefits from Liberty sites range from a low estimate of $1,087 to a high estimate of $1,406.

Utility Staff Insights

In addition to monthly check-in calls with Liberty point of contact to discuss the status of the program, the Evaluation Team also conducted a close-out interview in February 2024 to review challenges and successes through 2023. Reflecting on the program, Liberty staff identified two key challenges:

- **Inflexibility of Program Design.** The utility originally scoped the program as a single project with specific design requirements. However, by the time Decision 18-09-034 approved the program, the initial site design needed significant revisions due to several factors, such as changing customer charging needs; limited equipment availability; and staff turnover at TTD, LTCC, Liberty, and permitting Authorities Having Jurisdiction (AHJ) over the course of the implementation. Because the Decision detailed the initial scope of the project, it was difficult for staff to revise the site design without contradicting the regulatory requirements. To work around these conflicts and satisfy the customer requirements, Liberty staff provided funding beyond what the Decision granted.
- **Equipment Malfunctions.** Though the charging infrastructure supplied through the program has been in place and functional for over a year, the site has not used the chargers to their fullest extent because of ongoing electric bus issues and delays in the manufacturer's response. These

complications also delayed TTD and LTCC's ability to evaluate whether the current electric fleet meets their operational needs and effectively plan for additional fleet electrification.

Despite these challenges, the EV Bus Infrastructure program's site not only was successful, but it also strengthened Liberty's relationship with key customers TTD and LTCC:

- **Relationship Building.** Liberty collaborated closely with TTD and LTCC from inception through site construction. Balancing the needs of all three organizations helped Liberty staff develop a better understanding of how to serve customers with dynamic needs (such as route changes depending on the season) for complex EV infrastructure projects. After the Pilot, Liberty staff noted that its relationships with these customers have grown; for example, LTCC staff now seek Liberty's advice on operating their new systems. Further, despite challenges with equipment and program implementation, LTCC and TTD have expressed interest in further electrification and innovative projects with Liberty.

Highlights

- Inflexibility in the approved program design ultimately led to Liberty staff providing extra funding so the participant could complete the project as intended.
- Though the charging infrastructure has been in place for over a year, the site has not used the chargers to their fullest extent, due to ongoing electric bus issues and delays in manufacturer's response.
- Navigating these program challenges helped Liberty staff better understand how to serve customers with dynamic needs for complex EV infrastructure projects.

7.1.3. Lessons Learned

The Evaluation Team identified some lessons learned. These lessons, presented below with key supporting findings and recommendations, may be applied to future similar efforts.

Liberty Utilities EV Bus Infrastructure program required strong partnerships between stakeholders and represents a highly visible investment in TE and multimodal transportation.

The new bus charging hub at Lake Tahoe Community College was the result of a long collaborative relationship between staff from the college, TTD, and Liberty Utilities. The complex site took longer and cost more than originally planned by the Utility, but resulted in a highly visible station serving electric buses and offering other passenger amenities. The shelter structures support the overhead pantograph chargers, protect passengers, and screen the visual impact of charging equipment. The project was designed to accommodate more buses than are currently operating, including overnight charging using conventional plug-in charging.

The EV Bus Infrastructure program site helps to displace petroleum and reduce GHG and local emissions; however, these impacts have been limited by inconsistent bus operation.

The TTD site accounted for over 10,000 gallons of petroleum reduced in EY2023; with 110,000 gallons estimated over a 10-year period. The site also reduced GHG by 77 MT, with an estimated 10-year reduction of 810 MT. The site has estimated monetary health benefits from the project ranging from $1,087 to $1,406. All of these impacts were limited by reliability issues with the vehicles. With the bus vendor entering bankruptcy, spare parts and service has been greatly delayed, reducing the amount of electric bus service offered.

7.2. Schools and Parks Pilots

7.2.1. Overview

This overview provides a detailed description of the Liberty Schools and Parks Pilots; summarizes the Pilot implementation process, materials review, performance metrics, and budget; and provides a timeline of major milestones. Following the overview are detailed findings, highlights, and lessons learned.

Pilot Description

Schools Pilot: Through its Schools Pilot, Liberty aims to increase access to available charging at schools and educational facilities throughout its service territory. Liberty provides charging infrastructure to support electric school buses and light-duty charging for parents, teachers, and students. At the time of Decision 19-11-017, Liberty had identified 17 potential sites, with 15 at K–12 schools, one at LTCC, and one (a bus barn) for the Lake Tahoe School District. There are no DAC requirements for the Liberty Pilots, as there are no CES 4.0–defined DACs in the service territory.[150] Per Decision 19-11-017, Liberty plans to install 56 L2 charging ports and two DCFCs across all sites. Liberty's ownership model for all charging stations in the Schools Pilot covers the cost of EVSE, network software, transformers, permitting, electrical work, and trenching. Liberty also installs safety bollards and snow melt and lighting equipment, where appropriate.

Schools Pilot Targets

- 56 L2 and 2 DCFC charging stations
- 17 schools

Schools Pilot Design Goal

Empower schools to offer public charging to staff, students, parents, and the greater community.

Parks Pilot: Because the Tahoe region is a destination for many nonresidents, Liberty staff designed the Parks Pilot to increase access to available charging at state parks throughout its service territory for park staff fleet vehicles and visitor vehicles. Prior to Decision 19-11-017, Liberty staff worked with parks staff to determine the most attractive sites for EVSE by considering the needs of the parks and their proximity to town and regional centers, retail centers, beaches, recreation areas, education facilities, and large marinas. Through the Pilot, Liberty plans to install five dual-pedestal charging stations, each with two charging ports, at three California park locations. Similar to the Schools Pilot, Liberty's ownership model for all charging stations covers the cost of EVSE, networking software, transformers, permitting, electrical work, and trenching.

Parks Pilot Targets

Five dual-pedestal charging stations with two charging ports each at three sites.

Parks Pilot Design Goal

Encourage state parks and beaches to charge their own EV fleets and offer charging to staff and patrons with LDVs.

[150] The bus barn for Lake Tahoe School District is included in the Schools Pilot as a part of Liberty's goal to replace 50% of the district's diesel bus fleet (as of 2019) with electric school buses.

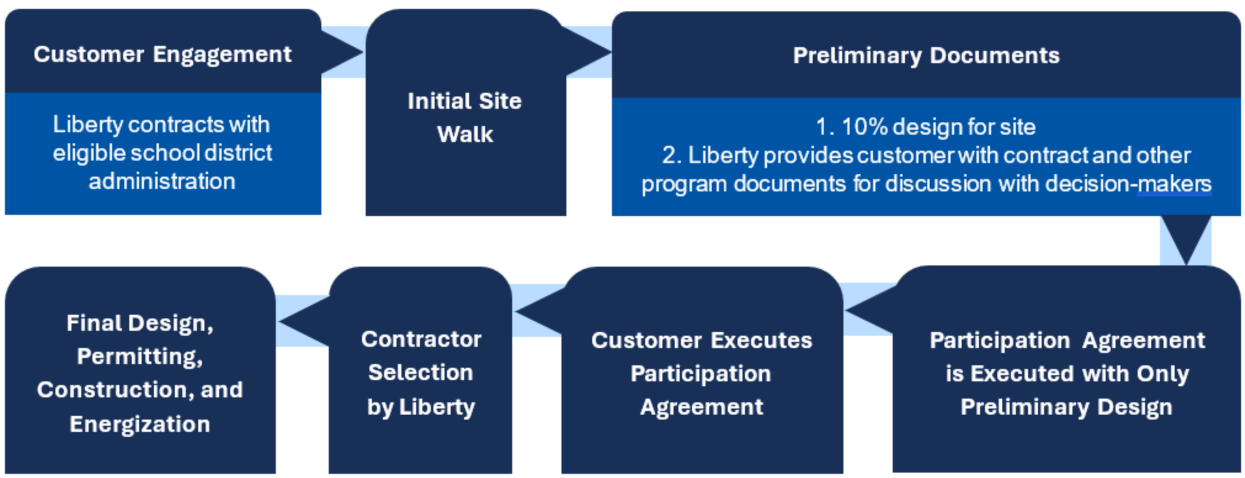
Liberty designed both Pilots to help meet the perceived growing demand for EV charging from residents and visitors to the Lake Tahoe region. Through these Pilots, Liberty will increase the share of EV miles traveled in the Tahoe region, which supports the community's move toward its sustainability and environmental improvement objectives, including reducing GHG and criteria air pollutant emissions.

Implementation

Liberty staff began site recruitment in 2019 in preparation for Decision 19-11-017 by directly engaging with potential sites prior to filing. In 2021 and 2022 staff focused their efforts on trying to gain interest from schools and parks. Liberty completed one final wave of recruitment in 2023 by reaching back out to all nonparticipating schools before considering recruitment complete.

Figure 271 describes Liberty's implementation process for both the Schools and Parks Pilots.

Figure 271. Schools and Parks Pilots Implementation Process



Program Materials Summary

See the overview of the shared outreach conducted in 2023 in Section 7.1.1.

Program Performance Metrics

Although, in 2023 Liberty did complete one School Pilot site, it was not activated in this evaluation period. Liberty did not secure any Park Pilot sites in 2023.

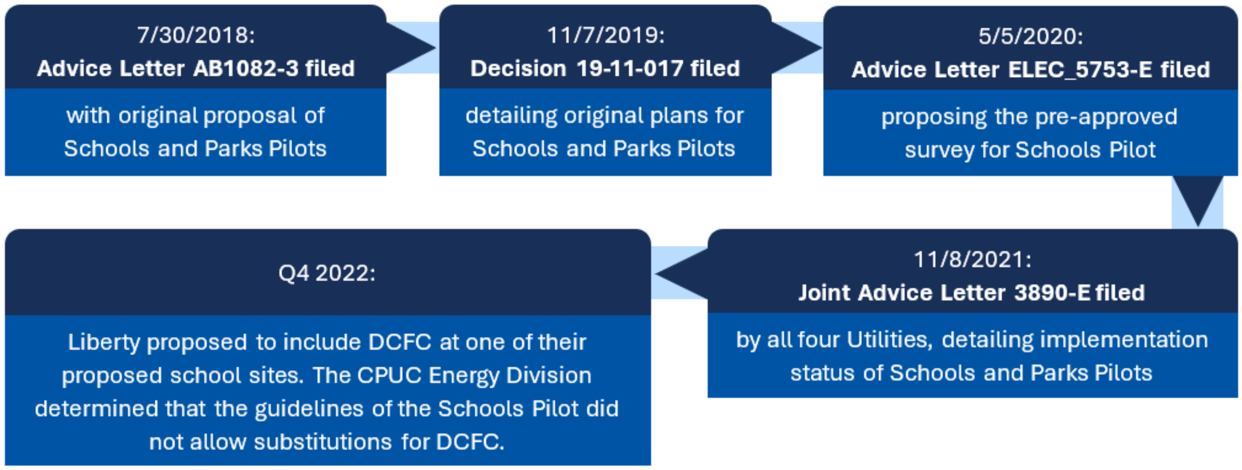
Budget Summary

Through 2023, Liberty spent $19,135 of $3.9 million on the Schools Pilot and has spent none of the approved $0.78 million Parks Pilot funds.

Timeline

Since the beginning of the Pilots Liberty has filed three Advice Letters: one pertaining to the Schools Pilot and two to both Schools and Parks Pilots. Though there were no additional milestones in 2023, Figure 272 shows all major milestones since the Pilots' inceptions.

Figure 272. Liberty Schools and Parks Pilots Key Milestones



7.2.2. Findings

As discussed in the *Overview* section, neither Liberty Pilot had any activated and operational sites in 2023. As a result, the Cadmus team did not complete any visual site visits in 2023 and plans to complete the first round of impacts assessment—including incremental EV adoptions, grid impacts, petroleum displacement, GHG and criteria pollutant reductions, and health impacts—as part of the 2024 evaluation report. The subsections below provide limited insights based on Utility staff interviews.

Utility Staff Insights

In addition to monthly check-in calls with Liberty staff to discuss the status of the Schools and Parks Pilots, the Cadmus team conducted a close-out interview with staff in February 2024 to review overall Pilot challenges and successes in 2023. The following sections present these challenges and successes organized by Pilot.

Schools Pilot

Although all schools in Liberty's service territory are eligible for the Pilot, Liberty has secured only one school for the Pilot to date. In 2021, 2022, and continuing into 2023, Liberty staff reported struggling with a lack of interest from schools in the prescriptive Pilot design, specifically citing a higher degree of interest in bus charging than light-duty charging, more interest in DCFC than L2 charging, and a number of safety concerns:

- **Lack of Interest in the Pilot.** When Liberty staff first started engaging schools, school staff were overburdened with urgent concerns caused by the COVID-19 pandemic and could not focus on participating in the Pilot. However, even as concerns about COVID-19 slowly faded, ultimately no longer posed a barrier starting in 2022, and continued to decrease in importance during 2023, Liberty staff reported a continued lack of interest in the Schools Pilot.
- **Interest in Buses.** Starting in 2022 and continuing into 2023, many schools in Liberty's territory were more interested in receiving bus charging than charging for light-duty vehicles. Liberty started construction on their first school site in late 2023 to serve school buses with L2 chargers.

- **Preference for DCFC Charging.** As first noted in 2022, Liberty staff continued to hear in 2023 that schools were most interested in DCFC over L2 charging. In 2022, Liberty's request to expand the Pilot to fund DCFC chargers was rejected by the CPUC.
- **Safety Concerns and Liability.** In previous evaluation years, most K–12 schools in Liberty's territory expressed concern over the Pilot's original design intention of keeping the light-duty charging accessible to the public during or after school hours, despite the flexibility in accessibility allowed within the Pilot design that would allow schools to opt for private chargers. In 2023, while coordinating with the schools that were still interested despite this concern, Liberty discovered that school staff had other safety concerns such as ADA requirements, snow removal, and liability for charger damage or misuse. Furthermore, because the schools in Liberty's territory are public schools, these concerns not only surfaced during discussions with school staff, but also sparked debate at public meetings in which the EV chargers were discussed.

Though most schools in Liberty's territory are currently not interested in participating in the Schools Pilot, Liberty staff continue to remain optimistic about the future of TE within schools, and reflected on the long-term positive customer relationships:

- **Fostering Positive, Long-Term Relationships with Schools Customers.** Though Liberty may not see much participation in the Pilot, through its implementation, Liberty staff have connected with customers outside of typical utility-customer exchanges. In 2023, Liberty staff shared that schools have re-engaged with them as interest in on-site EV charging grows (despite the Pilot-specific barriers noted above). Liberty staff believe that while this re-engagement might not result in more sites in the Pilot, it demonstrates Liberty's ability to transparently prioritize customer needs over program promotion results for customers that are eager to electrify and work with Liberty when given the opportunity.

Parks Pilot

Liberty had initially intended to sign on to a collective Utility MPA with the DPR in 2021. However, in 2022, the Utilities separated their negotiations to ensure that all legal team requirements could be met. Liberty was ultimately not able to sign a MPA in 2023. Liberty staff noted challenges with state-level negotiations and some concern about timing for the Pilot once an agreement is signed:

- **Waiting for Other Final Agreements.** Although Liberty was engaged in some state-level discussions with DPR in 2023, ultimately Liberty is looking to leverage the acceptable terms that DPR establishes with the other Utilities. Liberty anticipates that by leveraging other MPAs as a starting point, its own negotiations with DPR will be much more efficient and cost-effective.
- **Pilot Design and Timeline.** While Liberty staff is hopeful that they will be able to sign a MPA by the end of 2024, given the additional coordination that will be necessary at the site level, Liberty staff has potential concerns about the two-year time period allowed for the Pilot if the clock starts after the master agreement is signed.

Liberty staff expressed that even if Liberty is not able to complete an MPA, just building the relationship with DPR has been a success of trying to implement the Pilot:

- **State-Level Coordination for Electrification.** Though it has been difficult to secure a MPA at the state level for this Pilot, through implementing it, Liberty staff have engaged with DPR staff in ways they had not previously. Regardless of what activity is completed through the Parks Pilot, building these relationships will benefit any future state-level electrification or utility-based coordination with DPR.

Highlights

- **Schools:** Schools continue to be concerned about access to school property in regard to public charging as well as ADA requirements, snow removal, and liability for charger damage or misuse.
- **Schools:** Although these concerns have resulted in a lack of interest in the Schools Pilot, these schools are interested in EVs, in particular DCFC over L2 charging.
- **Schools:** Liberty's continued engagement with schools despite no participation has led to positive relationships which may support long-term electrification when schools are ready.
- **Parks:** To mitigate the cross-jurisdiction coordination challenge, Liberty hopes to leverage the acceptable terms of the MPA that DPR establishes with the other Utilities in 2024.

7.2.3. Lessons Learned

The Evaluation Team identified a number of lessons learned. These lessons, presented below with key supporting findings and recommendations, may be applied to other similar efforts.

Schools Pilot

Although the highly prescriptive Pilot design has not attracted many participants, schools appear to be interested in TE and view Liberty as a trusted resource.

Liberty's Schools Pilot serves a specific, targeted market sector with the clear intention of increasing public charging in the Lake Tahoe area. However, from the beginning Liberty staff have encountered barriers unique to K–12 schools that have delayed Pilot activity. Specifically, schools continue to have concerns about access to school property for public charging, ADA requirements, snow removal, and liability for charger damage or misuse. Although these concerns have prevented schools from moving forward with the Schools Pilot, the schools are interested in EVs and EV charging, particularly DCFC over L2 chargers. However, without CPUC approval to add DCFC to the programs, Liberty was only able to secure one K-12 school site using L2 charging for School Busses.

Parks Pilot

Cross-jurisdiction coordination remains a challenge to implementing the Parks Pilot.

The original plan for the Parks Pilot in 2021 was for all Utilities to enter into a collective participation agreement with the DPR. Throughout the joint negotiations Liberty staff followed the path set forward by the other Utilities. In 2022, when the Utilities decided to pursue independent agreements with the DPR, Liberty staff began to cultivate a relationship and engage with the state office of the DPR. With the Utilities making process in 2023 on MPAs at the state level, Liberty hopes to leverage the acceptable terms of the MPA that the DPR establishes with the other Utilities in 2024.

Appendix A. Methodology

This section describes the evaluation methodologies for the MDHD programs, Public Charging programs (AB 1082 [Schools Pilot], AB 1083 [Parks Pilot], and EV Fast Charge program), and V2G programs, including data collection and analysis activities. The Evaluation Team collected primary or secondary data (data collection) and transformed that data to produce findings (analysis). Some methodologies are identical across programs, while others are specific to a given program.

Table 169 lists the evaluation activities conducted for each program for EY2023. The individual program chapters discuss the evaluation activities, methodology, and findings.

Table 169. EY2023 Data Collection and Analyses, by Program

Type of Data Collection and Analysis	Program									
	Liberty		PG&E			SCE		SDG&E		
	MDHD	Schools and Parks Pilots	MDHD	Schools and Parks Pilots	EV Fast Charge	MDHD	Schools and Parks Pilots	MDHD	Schools and Parks Pilots	V2G
Data Collection										
Program Data and Materials	x	x	x	x	x	x	x	x	x	x
AMI/EVSP Data			x		x	x	x	x	x	x
Site Visits			x	x	x	x	x	x	x	
Site Costs			x	x	x	x	x	x	x	x
Interviews	x	x	x	x	x	x	x	x	x	x
Surveys			x			x		x		x
Delphi Panel			x			x		x		
Analysis										
EV Adoption					x		x		x	
Grid Impacts			x		x	x	x	x	x	x
Counterfactual Development	x	x	x	x	x	x	x	x	x	x
Petroleum Displacement			x		x	x	x	x	x	x
GHG and Criteria Pollutant Reductions			x		x	x	x	x	x	x
Health Impacts			x		x	x	x	x	x	
Site Costs			x		x	x		x	x	
Site Visit Findings			x		x	x	x	x	x	
Co-Benefits and Co-Costs			x			x		x		
Interviews and/or Survey Findings	x	x	x	x	x	x	x	x	x	x
Market Effects			x			x		x		

The Evaluation Team developed an evaluation methodology for the data collection and analysis to address three research objectives:

- **Research Objective 1.** Determine whether TE investments accelerated widespread TE, reduced petroleum dependence, helped meet air quality standards, reduced GHG emissions, and achieved the goals of the Charge Ahead California Initiative.[151]
- **Research Objective 2.** Determine whether TE investments maximized benefits (including co-benefits) and minimized costs (including co-costs) and the extent to which the costs and benefits accrued to DACs.
- **Research Objective 3.** Maximize lessons learned from analyzing data collected during program implementation.

The scope of activities was aimed at addressing the specific characteristics of each program evaluated at an appropriate level of rigor and to report findings at a meaningful level of detail. The evaluation activities conducted for each program were largely influenced by the number of sites in the participant population for that program and within the market sector.

The Evaluation Team reviewed program participation and adjusted the sampling methodology, scope, and timeline of activities to maximize efficiency. This report provides impact and process evaluation findings that were derived by attempting a census approach to gather site-level inputs from AMI and EVSP data, site visits, or surveys from activated sites. For activities that involved a more granular approach to data collection, where program or market sector participation levels were insufficient to allow reporting at any meaningful level of detail, the Evaluation Team updated the scope and timeline of activities to be reported as part of the next evaluation cycle.

Sites in Evaluation Report

Throughout this report, we use the following terminology to describe participating sites or sites included in the evaluation effort:

- **Utility Construction Completed:** Sites where the Utility has completed its scope (TTM, TTM and BTM, and turnkey installation)
- **Activated:** Sites with charging stations installed and available for use
- **Operational:** Sites for which AMI and/or EVSP energy usage data have been received from the Utility or EVSP
- **Closed Out:** Sites where financial documentation has been finalized by the Utility and rebates for the installed chargers have been paid

[151] Environment California. December 17, 2021. "Charge Ahead California Budget Request 2022." https://environmentcalifornia.org/programs/cae/charge-ahead-california

Medium-Duty Heavy-Duty Programs Evaluation Methodology

This section outlines the data collection and analysis methodologies for the MDHD programs.

Data Collection Methodology

To assess the MDHD programs the Evaluation Team collected program performance metrics, program materials, AMI and EVSE data, and site visit data and conducted surveys and interviews.

Program Performance Metrics

Data on program performance metrics included information about program applications such as count of charging ports, number of EVs procured, site status (inside a DAC or outside a DAC), time in each program phase, and site costs, where available. These data support an understanding of program performance, such as the median number of days sites spent in different program phases, the percentage of applicants from different market sectors, and program spending.

The Evaluation Team collected and securely transferred this data between the Utilities' secure SharePoint sites or other secure file transfer systems and our own Microsoft Azure cloud-based environments. We completed this transfer monthly for most data, with some variation in timing among PG&E, SCE, and SDG&E. Once we received data from each Utility, we moved it to the Evaluation Team data warehouse for secure storage and retrieval.

Program Materials

To understand how the programs are operating and communicating with customers, the Evaluation Team reviewed available program-related materials, such as Decisions, Advice Letters, and Program Advisory Committee (PAC) presentations. We reviewed the changes in program design and implementation and the legal and regulatory environments that impact the programs, including site and vehicle requirements, outreach and onboarding approaches, and required materials from participating fleets. The program material review is important to establish a foundational understanding of program design, to track changes in design over time and to understand implementation progress.

Table 170 shows a list of the types of data (for both program performance metrics and program materials) the Evaluation Team reviewed.

Table 170. Medium-Duty Heavy-Duty Program Materials Reviewed

Program Materials Reviewed
• **PAC presentations** • **Program data such as number and type of EVSE installed, and VAPs** • **Regulatory documents such as Decisions and Advice Letters** • **Public reports such as the Joint IOU EV Load Research and Charging Infrastructure Cost Report** • **Utility websites:**   ▪ **EV Fleet Charging Guidebook**

Program Materials Reviewed
▪ **Calculators and tools** ▪ **Programs and handbooks** ▪ **Application and application preparation and information documents** ▪ **Fact sheets and case studies** ▪ **Vehicle availability lists and approved EVSE product list** ▪ **Funding information** ▪ **OEM information**
• **Marketing materials:** ▪ **Emails and email collateral** ▪ **Webinars**
• **Program documents:** ▪ **Agreements and contracts** ▪ **Technical requirements** ▪ **Registration forms**
• **Utility information:** ▪ **EV rate schedules** ▪ **EVSE maps** ▪ **DAC maps**

AMI/EVSP Data

The Evaluation Team used AMI data to estimate charger usage, a key input for subsequent analyses and estimations of program impacts such as impacts to the grid, petroleum displacement, emissions reductions through EV adoption, and associated health impacts.[152] The Evaluation Team collected and securely transferred all AMI data between the Utilities and Microsoft Azure cloud-based environments. The Team used Azure Databricks to transform and standardize the data, which we then imported into an SQL server data warehouse. We performed these transfers monthly, with some variation in timing among the Utilities. Once we received this data, we input it into the Cadmus data warehouse for secure storage and retrieval and aggregated it for subsequent calculations and analysis. Time-stamped energy consumption data were recorded in 15-minute intervals.

A second critical data source was EVSE data provided by participating EVSPs. The electric Utilities developed a process for screening and approving EVSPs based in part on their ability to provide essential monthly charging data of EVSE sessions, intervals, stations, and ports.

[152] Liberty Utilities does not have AMI so the Team collected regular meter data instead.

Together, AMI and EVSE data provided the basis for analyzing at a granular level program performance such as customers' ability to shift loads to off-peak times in response to time-varying rates. The Evaluation Team used data from EVSPs to examine port utilization, which is based on the time a vehicle is parked at a charging station and consuming energy. Port utilization rates can be expected to rise as programs mature and consumers and fleets acquire more vehicles.

The Evaluation Team worked to obtain complete AMI and EVSE data for every charging session from the Utilities and EVSPs. In some limited cases where AMI data were not available from the Utility, the Team worked with the Utility to obtain these data and incorporate them into future analyses. In some cases where AMI data were not available, either a customer provided a submetered dataset or the Team synthesized data from existing EVSE data.

Synthesized Data

Some AMI data were missing or hourly distributions were unavailable for brief periods of time for a limited number of sites across the Utilities. Consequently, the Evaluation Team generated representative AMI data for these sites based on available EVSP data through a synthesis process using a conversion factor of the ratio between EVSP data and AMI data. We derived specific conversion factors for each site by evaluating the ratio of total kilowatt-hours delivered as reported by EVSPs, which in most cases existed for the same site at a different time period, or for similar charging stations and vehicles. The resulting factors ranged from 0.59 to 0.99 for EVSP data to AMI data. In the rare case in which there was no specific match, the Team used a standard factor of 0.85 to account for electricity losses between the meter and the EVSE.

Annualized Data

The Team considered all operational sites for annualization.[153] In the EY2021 annual evaluation, we annualized all sites with greater than six months of usage data and considered annualizing sites with between three and six months of usage data depending on observed usage patterns. For both EY2022 and EY2023, the Evaluation Team annualized all sites to provide a more complete picture of the entire program to date and the impacts of the existing program performance over a full 10-year life. Our experience has shown that sites that have an abbreviated period of performance (less than six months) will inherently have lower utilization than fully developed sites. As a result, annualized sites with an operational time of six months or less will underrepresent the full 10-year impact; however, excluding those sites would create an even greater underrepresentation.

The Team annualized each site by creating a representative 12-month operation period, which could be projected into the future until the site reaches its 10-year life. We determined the 10-year life by evaluating when the operational use of the EVSE would begin and projecting forward 10 years from that point. For sites that had more than 12 months of operating data without a significant increase in use in the past 12 months, we used the most recent 12 months as an annual profile. For sites with less than 12

[153] The Evaluation Team annualized electricity usage data for sites with operational AMI data (data indicating that EVs were actively being charged). We extrapolated partial year site electricity usage data out to a full year to make site-to-site and year-over-year comparisons.

months of fully developed usage data, we removed months of data before the point at which the site reached 75% of the maximum monthly use and replaced that data with a synthesis of all months of data following 75% of the maximum utilization.

Site Visits

Site visits are an important part of the data collection process as they provide an on-the-ground view of the sites and access to stakeholders such as fleet and facility managers who may be included in surveys and in-depth interviews. Site visits help answer questions related to the integration of infrastructure- and vehicle-focused programs. They also allow us to confirm what vehicles and charging hardware were delivered and are in operation and how routes, utilization, and duty-cycles impact performance and electricity demand.

During the site visits, the Team collected qualitative and quantitative information that provided us with an understanding of fleet composition and operations. We compared this data against Utility-provided information for individual sites. The Team collected the make, model, and number of EVs on site and information about types of conventional vehicles or equipment replaced, charging equipment, charge management capabilities, electrical infrastructure, future vehicle/equipment replacement plans (including future vehicle adoption), and public funding sources, and interest in on-site solar and/or storage at the site. The Team held meetings on the premises with facility managers and other personnel to learn about the particulars of each site. At sites where the site host was able to answer and the fleets had more than three months of operational experience, the Team asked questions about satisfaction with the Utility program, charging infrastructure, and EVs. We also asked about any co-benefits or co-costs the site host experienced or anticipated. Additionally, we inquired about the availability of telematics or fleet usage records to characterize site operations. The Team used this process for each visit, asking the same questions and starting the same conversations. After each site visit, we entered data into an in-house web-based tool for site visit data collection to compile notes and photos for aggregate analysis.

Site Costs

The Evaluation Team collected site-level costs from the Utilities via their annual SB 350 report.

Deep Dives

The Evaluation Team engaged with six participants (two each in PG&E, SCE, and SDG&E territories) for deep dive assessments. Our deep dives included detailed examinations of site usage metrics and assessments of vehicle and charging performance, user experience with EVs and EVSE, and site characteristics. The deep dives allow the Team to gather insights based on projects that appear to provide significant learnings for stakeholders. This data collection provided a secondary, more in-depth conversation between the Evaluation Team and site host than occurred during site visits. The Team asked site-specific questions about vehicle operations, reliability, and behavior based around observed utility and session data.

We identified potential sites for deep dives from the previous year's evaluated MDHD sites and selected them based on several criteria. Sites of interest included those with significant demand, consumption, or installed charging capacity; a demonstrated ability to expand EV infrastructure; the presence of load management; unique vehicles or charging equipment; a large fleet size; and a fleet manager who was willing to participate.

We asked site hosts who had agreed to participate in the deep dive process to share additional site data and to discuss their experiences with the electrification process and operation of EVs. We also asked these site hosts to administer a survey to their vehicle operators to gauge feedback on EV and charger performance during normal operations.

Interviews, Surveys, and Expert Opinions

Interviews

This section describes the approach, data sources, and analyses performed for the EY2023 Utility interviews. The Team conducted Utility staff interviews (SCE, PG&E, SDG&E, and Liberty) to provide insight into program design and implementation and context to analysis outputs and findings. As listed below, the Team interviewed all Utility program managers to cover a variety of topics about their respective programs.

The Team developed interview guides outlining key topic areas and questions for discussion to ensure that we covered each topic area during the phone interview:

- Status updates and changes from EY2022 (and before)
- Program design
- Key milestones
- Key barriers to implementation and solutions
- Preliminary areas of success and lessons learned

The Evaluation Team tailored each interview guide based on information previously provided by the Utilities to ensure an effective use of time. A group of various Evaluation Team members conducted the interviews to ensure coverage across all relevant evaluation areas.

The Team reviewed verbatim notes taken during each interview as the basis of our analysis. We integrated those findings throughout the report, informing many sections including program overviews, materials reviews, and Utility interview analysis findings.

Surveys

The Evaluation Team surveyed fleet managers of activated sites that participated in the program who had complete contact information. The purpose of the survey was to gather information about several topics:

- Identify factors that facilitated successful fleet electrification and lessons learned
- Explore the benefits and costs of transportation electrification for fleets
- Assess the experience of fleet managers with the program and infrastructure
- Gauge market impacts and trends and identify market barriers

- Assess program attribution

The Evaluation Team conducted the survey via an online survey platform, Qualtrics, and delivered the survey link via email to the site hosts through the contact information provided by PG&E, SCE, SDG&E, and Liberty. To encourage participation, the Evaluation Team sent several follow-up emails to contacts, made phone calls to nonrespondents when phone numbers were provided, and followed up with additional contacts through contact information collected from site visits. Additionally, the Evaluation Team offered each respondent a $50 gift card for completing the survey.[154] For EY2023, the Evaluation Team developed a sample frame based on available contact information and attempted to reach all sites in the sample frame.

The Evaluation Team also surveyed site hosts who withdrew from the PG&E, SCE, or SDG&E program (known as withdrawn fleet managers).[155] During the sample selection process, the Evaluation Team worked with the PG&E, SCE, or SDG&E program managers to ensure that the survey was sent only to sites that were eligible for and withdrew from the program—not to sites that applied but were not eligible. Surveying only eligible sites strengthened the insights gathered through these surveys and allowed the Team to focus on the reasons for withdrawal that PG&E, SCE, or SDG&E might be able to address.

The survey covered many topic areas, several of which were similar to the fleet manager survey:

- Identify the factors that facilitate successful fleet electrification and lessons learned
- Explore the benefits and costs of transportation electrification for fleets
- Gauge market impacts and trends and identify market barriers
- Understand the reasons for withdrawing from the program

For EY2023, the Evaluation Team attempted to reach a census of sites that withdrew from the PG&E EV Fleet, SCE CRT, and SDG&E PYDFF programs. We invited withdrawn fleet managers to complete the survey via email and sent them several follow-up emails. To encourage participation, the Evaluation Team offered a $50 gift card to respondents who completed a survey.[156] Additionally, the SCE account managers conducted outreach to withdrawn sites via email to help increase the response rate.

Delphi Panels

To support the estimation of market effects, the Evaluation Team conducted Delphi panels to develop baseline electrification adoption curves.

A Delphi panel is a method developed to reach a group consensus by aligning the range of opinions from a panel of subject matter experts. Certain components are particular to Delphi panels including the use of a group of anonymous experts with opinions collected through a series of two or three sequential,

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[154] We did not offer this gift card to public agency sites in SCE's service territory.

[155] The Liberty MDHD program includes only one site, and there were no withdrawn sites.

[156] We did not offer this gift card to public agency sites in SCE's service territory.

structured questionnaires. Opinions from the first round are summarized and provided to the experts for the second round so they can re-evaluate their original responses. Panelists can either agree with the overall opinion or provide evidence or argument for their own opinion. The rounds continue until a majority consensus is reached. The Delphi method is particularly useful in cases with limited data. A panel moderator controls and manages interactions among the experts, with communication typically conducted remotely.

The Evaluation Team conducted two Delphi panels for the EY2023 report: one on the regional and long-haul truck market and one on the school market. The school bus panel followed up on a previous Delphi panel conducted in EY2021. For both panels, we recruited experts within each respective vehicle market to develop a consensus forecast of the market baseline for electrification in California through 2030.

The Evaluation Team conducted the two panels concurrently and recruited eight market experts for each panel (16 panelists total) in January and February 2024, and they provided two rounds of structured feedback in March 2024. The Evaluation Team provides all panelists with the same background information, such as projections of vehicles under the ACT and ACF regulations. In the first round, we asked the panel of experts to provide a forecast of the electric market share for their respective vehicle market assuming no intervention by the Utilities along with a rationale for the shape of their forecast. The Evaluation Team aggregated the first-round results, calculated the median forecast,[157] and shared the anonymized market predictions with the panel in the second round. The experts then reviewed all forecasts and had the opportunity to either agree with the median estimate or submit a new estimate. This process typically continues until convergence occurs (when over half of panelists agree).The school bus panel achieved convergence in the second round.

The Evaluation Team recruited experts from different organizations to provide input. The composition of the panels is shown in Table 171. As every expert and organization carries its own biases, it was crucial for the Delphi panels to feature individuals from a variety of backgrounds. We also required that experts on the panel have a background in and recent experience (in the last two years) with their respective vehicle market or transportation electrification policy in California and no conflicts of interest (financial or otherwise) that would impact their objectivity. We did not permit more than one expert from the same organization to participate in the panels.

Table 171. Delphi Panelist Composition

Panelists	Academia	Nonprofit	Manufacturer	Industry	Third-Party Evaluator	Regulator
Regional and Long-haul Truck	2	3	1	1	0	0
School Bus	2	3	1	0	1	1

[157] Although Delphi panels typically use an average of experts' responses, for this study we employed the median to mitigate the impact of outlier responses.

Truck Choice Model

The Evaluation Team employed the UC Davis TCM to establish a baseline for ZEV truck adoption and thereby enable assessment of the NTG impacts of the Utility MDHD programs. The TCM is a multinomial logistic model that predicts vehicle choice by fuel type and vehicle application via a generalized cost equation. The model has been used extensively in recent years to better understand how California policies and programs impact fleet operator purchase decisions of alternative fueled MHDVs. We used the TCM to predict the likelihood that each fleet would adopt MDHD EVs in its next procurement in the absence of the Utility programs.

The model draws on multiple inputs including vehicle purchase price, maintenance costs, fuel costs, non-monetary costs (such as aversion to new and uncertain technologies and lower availability of fuel infrastructure), and incentives or subsidies. UC Davis has compiled the information for model inputs over several years. Additional data specific to this analysis includes Utilities' MDHD program data, specifically the rebates and incentives provided for EVSE installation. The Utilities report these data directly as part of the SRP evaluation and as part of their SB 350 reporting. The Evaluation Team adhered to guidance provided by the Utilities regarding which data were reliable enough to be used for model inputs. The Evaluation Team applied data from the completed projects to estimate the average TTM and BTM utility investment or incentive.

Analysis Methodology

The following subsections provide an overview of the analyses for the MDHD bundle. These analyses include determining the characteristics of counterfactual vehicles[158] and assessing grid impacts, petroleum displacement, GHG and criteria pollutant reductions, and health impacts. The Evaluation Team also estimated the TCO and addressed research objectives using data collected from site visits, Utility interviews, and surveys. As discussed below, we conducted additional calculations for the petroleum displacement, emissions reductions, and health impact analyses to consider these impacts on DACs in particular.

Grid Impacts

The Team estimated electric grid impacts for MDHD on-road and off-road vehicles that consumed electricity from charging stations installed through the MDHD programs. The following subsections describe the approach, data sources, and analyses performed to estimate grid impacts.

The Team collected, cleaned, compiled, and analyzed site-level, granular (15-minute interval) Utility AMI (meter) data and EVSP data. For the analysis we used the primary and secondary data sources shown in Table 172.

[158] Counterfactual data are used to establish a counterfactual fuel economy (miles per gallon) and vehicle emissions factors to estimate petroleum displacement, emissions reductions, and health impacts.

Table 172. MDHD Grid Impacts Data Inputs

Category	Source
Primary Data	Utility AMI data, charging session data from EVSPs, site details (capacity of various Utility and charging equipment), site visits, and surveys
Secondary Data	Time-varying Utility rates in effect at sites, historical CAISO data (demand, supply sources, renewable curtailments), and load management plans

We uploaded AMI and EVSP data to the data warehouse and calculated results using the internal Power BI dashboard. Foundational program analysis included total electricity consumption (kilowatt-hours) for MDHD vehicles (on-road and off-road), and new demand (kilowatts) added to the grid. The Team established trends based on the proportion of electricity usage during the highest cost period (defined as 4 p.m. to 9 p.m. daily) versus other time periods. We calculated load factors based on usage and determined utilization rates based on the installed capacity for each site.

The Evaluation Team assessed daily and weekly charging behaviors and captured patterns that accounted for differences in weekday and weekend operations. We used load curves by vehicle category to identify trends of operating versus charging. Effectively doing this required filtering out data from periods when vehicles were not in full operation, had ongoing technical problems, or were not fully integrated with the EVSE or other equipment.

We used CAISO data on electricity supply at different times combined with AMI meter data and EVSE charging session information to compare EV program load curves with overall system demand. The 24-hour load curves provided key insights into how the grid was impacted by each program.

The Evaluation Team assessed charging flexibility to determine the extent to which managed charging could increase benefits, such as by lowering electricity prices paid (based on time-of-use rates), reducing emissions (from charging when lower-emissions resources were powering the grid), and having the least impact to the grid (minimal new demand). Although the grid impacts analysis included data for all operational sites, the Team annualized AMI data to support analyses that included forecasts such as for petroleum displacement and GHG and criteria pollutant emissions reductions. Through the annualization of AMI data the Team identified the region of stable operation and leveraged this data to generate a statistically representative full year of operation.

Load Shifting Analysis Methodology

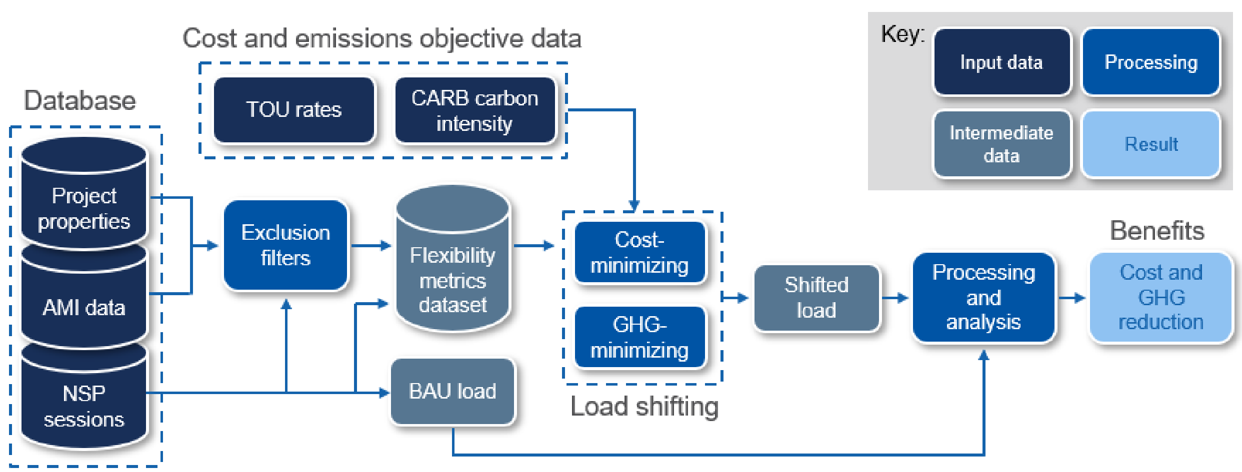
Historical electricity usage data shows that sites participating in the Utility transportation electrification programs consume a substantial fraction of their daily electricity consumption during the high-cost peak period (4 p.m. to 9 p.m.) and underutilize lower-cost off-peak and super off-peak periods for charging—despite often being plugged into chargers during these periods—incurring higher than necessary electricity consumption costs. This is particularly true for electric school bus fleets, which travel short distances during the day and spend a long time each day parked, allowing for considerable flexibility for charging. Off-peak charging periods tend to coincide with a lower average carbon intensity for grid electricity, suggesting the potential to reduce both costs and GHG emissions by load shifting charging sessions.

Implementing load management software/controls that prioritize charging during off-peak periods allows these sites to substantially reduce charging costs, lower carbon emissions, and support grid reliability by helping to rebalance the overall grid demand.

The Evaluation Team analyzed consumption data from EY2023 provided by program participants and developed an optimization routine to reallocate charging energy consumption to lower-cost or lower-emissions times of day, taking into account each participant's flexibility to shift the charging load. This section outlines the approach used to quantify the potential cost and GHG emissions impacts of load shifting for the MDHD transportation electrification programs. The results of this analysis are provided in the Load Shifting Analysis section of each of the respective Utility program sections.

Figure 273 provides a high-level summary of the analysis approach, including preparing data, applying exclusion filters, performing the load shifting optimization routine, processing the data, and analyzing the results.

Figure 273. Data Preparation and Load Shifting Analysis Process Diagram



Load Shifting Data Preparation

To model load shifting, the Evaluation Team used data from NSPs and from AMI provided by the Utilities for each site in the evaluation. NSP data include information about the charging sessions as recorded by the charger or NSP software, and AMI data contain the site energy consumption as measured at the utility meter in 15-minute intervals.

Operations Data Extraction

The Evaluation Team cleaned and stored NSP and AMI data across available sites in a set of Microsoft Power BI database tables. For the load shifting analysis, we downloaded these tables (titled FACT_NSP_Session and FACT_PMO_AMI) in full from the Power BI tool as comma-separated value (.csv) files. Table 173 lists the operations data the Team used for the analysis.

Table 173. Description of NSP and AMI source data tables

Table Name	Description	Fields Used	Used For
FACT_NSP_Session	Data capturing information about each charging session recorded by NSPs	• LocationID • PortID • SessionID • SessionStartDateTime • SessionEndDateTime • ChargeKWH • ChargeMaxDemandKW • VehicleMake • VehicleModel	• Determining analysis dates for each project • Filtering and removing passenger cars • Determining each port's maximum power capacity • Conducting load shifting analysis
FACT_PMO_AMI	Data capturing energy consumption in 15-minute intervals as captured by site-level AMI	• application_id • interval_datetime • usage_kwh	• Filtering analysis dates for each project

Operations Data Filtering and Cleaning

The Evaluation Team carefully reviewed the source data and applied a set of date filters to the available NSP and AMI data tables to exclude data outside of EY2023. For each project, we defined the load shifting analysis date range using the start and end dates of data availability for both NSP and AMI. The analysis date range began on the first date for which both NSP and AMI data were available and ended on the final date for which both NSP and AMI data were available. This ensured sufficient alignment in the data sources to include the site in the analysis.

The Evaluation Team applied an additional set of filters to NSP data:

- To focus the analysis on MDHD vehicles as narrowly as possible, the Evaluation Team manually inspected the unique values of VehicleMake and VehicleModel in the NSP data. From those unique values, the Evaluation Team made an exclusion list of 111 passenger cars and filtered all known passenger car sessions from the analysis dataset. We did not remove from the dataset NSP sessions that did not include data for vehicle make or model.
- NSP sessions with a total energy consumption (ChargeKWH) equal to zero were excluded.
- NSP sessions with a start timestamp (SessionStartDateTime) equal to the end timestamp (SessionEndDateTime) were excluded.
- NSP sessions with a missing value for LocationID or failing certain other quality control checks (incorrect charge duration, incorrect demand values, or irreparable errors in the raw data) were excluded.

Some NSP sessions follow the charging port's prior session with no time gap in between. These successive zero-gap sessions do not appear to leave time for a new vehicle to be plugged into the port, and thus are likely reflecting the same vehicle continuing its prior charging session. To simplify the following analysis steps, we combined each sequence of one or more zero-gap sessions into a single session, with a shared session identifier and computed the combined session's total energy (ChargeKWH) and maximum power level (ChargeMaxDemandKW) across underlying sub-sessions.

Load Shifting Optimization Approach

After preparing the source data, the Evaluation Team developed a load shifting optimization routine to minimize electricity consumption costs by reallocating daily charging energy from peak periods to lower-cost off-peak periods within the same 24-hour day. Charging energy can be shifted only to intervals when the NSP session data indicate connected vehicles and additional, or unused, charging capacity. The Evaluation Team compared the resulting cost-optimized (or shifted) charging loads to the observed daily BAU charging loads to evaluate the cost-reduction and resulting emissions reduction potential of load shifting. This subsection describes how the Team structured the load shifting optimization potential analysis.

Charging Port Power Capacity Estimation

The maximum potential power output of shifted load at each charging port is determined not only by the nameplate power capacity of the charging infrastructure, but also by the charge acceptance characteristics of the connected vehicle(s) that are using the charger in any given time period. To infer a realistic potential maximum power output of each charging port, the Evaluation Team analyzed historical NSP data at each port and took the following steps to calculate each port's potential power output:

1. The Team used the total energy output (taken from the ChargeKWH field) and the total time duration (taken from the SessionStartDateTime and SessionEndDateTime fields) for each session at each port to compute an average power output per session. If the session's maximum power demand (ChargeMaxDemandKW) recorded in the NSP data table was higher than the computed average, we used that recorded value.
2. For each port, and for each calendar month of EY2023, the Team computed the monthly 80th percentile value of average power output across all sessions that month. The resulting 80th percentile average power output defined each port's monthly potential power output.

The resulting potential power output metric is intended to capture not only the technology of each charger, but also any limits arising from the charge acceptance characteristics of specific vehicles using the port or other operating concerns that may vary over time.

Flexibility Metrics Dataset Creation

The Evaluation Team combined information across NSP sessions for each site into a flexibility metrics dataset, which includes the following variables for each 15-minute interval within each project's analysis date range:

- Observed (BAU) project-level energy demand from the AMI and NSP tables. NSP demand is summed across NSP sessions belonging to the site that overlap with the interval. To allocate each NSP session's energy across intervals, we assume a constant charge rate for the duration of the session.
- Total unique ports that were connected in each interval.
- Total unique sessions that were connected in each interval.

- Hours of overlapping charge sessions in the interval summed across connected ports. For example, if only one port has a connected vehicle for the full 15-minute interval, there would be a total of 0.25 overlapping session-hours in that interval. On the other hand, if four ports are connected for the full duration of a 15-minute interval, the site would have 1.0 overlapping session-hours in that 15-minute interval.
- Maximum potential energy demand within the 15-minute interval. This value represents the sum of the estimated charging power capacity of each of a site's ports multiplied by the port's overlapping session-hours in the 15-minute interval.

The resulting flexibility metrics dataset forms the basis for the load shifting optimization.

Cost and Emissions Data Preparation

The Evaluation Team prepared a dataset of TOU rates for each participating Utility from publicly available data regarding Utility rates. We converted each set of rates from TOU bins into sub-hourly time series (15-minute intervals) of electricity rates per kilowatt-hour to match the resolution of the AMI data 15-minute intervals. We made two simplifying assumptions to our cost measures:

- Only the volumetric component of costs (unit cost per kilowatt-hour of delivered energy in each TOU period) are included in this analysis. The analysis assumes that each site will not choose a charging strategy that increases its peak power demand above business-as-usual levels.
- We assume all PG&E projects fall into the BEV-1 rate category with peak demand below 100 kW, and all SCE projects fall into the TOU-EV-8 (20 kW to 500 kW) category. This simplifying assumption was informed by the available NSP data for EY2023.

GHG emissions carbon intensity values (ton of CO2-equivalent emissions per kilowatt-hour of delivered energy [ton-CO_2e/kWh]) were taken from CARB's 2023 hourly carbon intensity estimates by quarter of year and hour of day and down-sampled to 15-minute intervals. These estimates represent estimated average emissions factors (including renewable generation) for grid electricity in California.

Load Shifting Optimization Model

For each project, the flexibility metrics dataset is merged on unit (volumetric) TOU energy costs and emissions factors using the time interval and the project's Utility as keys for merging data. This results in a table with both charging potential (maximum potential energy demand in each 15-minute interval) and objective values for optimization (costs or emissions).

The resulting table is input into an optimization model that minimizes total energy costs. Load is shifted to lowest-cost times of day, based on the volumetric (TOU) component of each Utility's rate structure. Each interval's carbon intensity is used to break ties between intervals with identical energy costs. As a final tiebreaker for hours with identical energy costs and carbon intensities, the hour with higher unshifted (BAU) energy demand observed in the NSP data is preferred. In both versions of the optimization, the following constraints apply for each project:

- *Preservation of total demand*: within each 24-hour (midnight-to-midnight) period, total kilowatt-hours of shifted energy demand must be equal to the total kilowatt-hours of energy demand observed in the NSP data.
- *Maximum demand per interval*: within each 15-minute time interval, total kilowatt-hours of shifted energy demand may not be greater than the estimated maximum potential energy demand for the charger(s) at each site (using the calculation steps described above).

This optimization results in a dataset of shifted loads in the form of 15-minute shifted interval data. These results are summarized in total across each site (i.e., percentage reduction in costs equals total BAU cost in comparison to total optimized cost, summed across days). This summarization approach tends to reduce the impact of low-demand days, such as summer days and weekend days for school buses and prioritizes the impact of high-energy days. As such, it is weighted in a similar manner as the volumetric component of each project's energy bill.

Counterfactual Development

The Evaluation Team identified the market sectors in each Utility program and the counterfactual vehicle and fuel type that corresponded with each market sector. A counterfactual vehicle is the vehicle type that the fleet would have used in the absence of the program.

Rather than assess the composition of each legacy fleet (conventional ICE vehicles displaced by the program), we established a generic counterfactual vehicle type. In total, the Evaluation Team used 18 counterfactual vehicles defined by weight class and fuel type. The Team assigned all sites an initial counterfactual vehicle type based on Utility program applications. We then refined this information based on additional vehicle information included as part of participants' VAPs submitted to Utilities.

Each counterfactual vehicle type had a corresponding fuel economy (miles per gallon) for on-road vehicles or fuel consumption (gallons per hour) for off-road equipment as well as emissions factors (GHG and criteria pollutants). We also determined the electricity consumption rate used by the corresponding EV (in kilowatt-hours per mile for on-road vehicles and kilowatt-hours per hour for off-road equipment).

To characterize the counterfactual vehicles, the Evaluation Team processed Emissions Factors (EMFAC) data for on-road vehicles and Off-Road Inventory Online (ORION) data for off-road vehicles as default sources for efficiency and emissions. We input these tables into the Cadmus data warehouse. For cases in which electricity consumption rates were not available for a particular vehicle or equipment type, we used supplemental data sources to determine an appropriate rate. Table 174 shows the primary and secondary data inputs.

Table 174. MDHD Counterfactual Data Inputs

Category	Source
Primary Program Data	Utility VAPs, site visits, fleet manager surveys, and OEM interviews
Secondary Data	California Air Resources Board (CARB) EMFAC and ORION (default source for efficiency and emissions), Priority Review Projects fleet data (from the final report),[a] other demonstration reports (from CARB, CEC, and the National Renewable Energy Laboratory), MDHD vehicle registration data as available, Department of Motor Vehicles Motive Power Report, and California Department of Motor Vehicles Motive Fuels Report

[a] Energetics Incorporated. April 2021. California Investor-Owned Utility Transportation Electrification Priority Review Projects: Final Evaluation Report. https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/sb-350-te/california-te-prp-final-evaluation-report-presentation.pdf

The final output is a lookup table that maps all the relevant market sectors to each of the CPUC-defined market sectors and its associated counterfactual vehicle type (such as electric Type C school bus and diesel Type C school bus).

Petroleum Displacement

For this analysis, the Evaluation Team estimated the reductions in counterfactual vehicle fuels compared with the electricity usage attributable to the MDHD programs. Expected fuel types and typical end uses included diesel (such as trucks and school bus), CNG (such as transit and shuttle bus), propane (such as forklifts), and gasoline (such as trucks and vans). Based on the *Counterfactual Development* analysis, we presented all displaced fuel as petroleum-based in DGE units.

To conduct the petroleum displacement analysis, the Team converted the electricity used from EVs (based on Utility-provided AMI data) to petroleum displaced using an electricity consumption rate to calculate the EV miles traveled or equipment hours of use. We used the same number of EV miles or hours for the counterfactual ICE vehicle that would have been used in the absence of the MDHD programs. To calculate the petroleum displacement in gallons per site, we divided the ICE vehicle miles or hours by the counterfactual on-road vehicle's fuel economy (miles per gallon) or multiplied by the off-road equipment's fuel consumption (gallons per hour). We then converted the amounts of petroleum displaced to DGEs for ease of comparison. Then the Team calculated the petroleum displaced by each MDHD program by Utility, in DACs, and by market sector.

Data inputs included Utility program data (market sector and vehicle type), data from site visits and fleet manager surveys, historical counterfactual vehicle fuel consumption, EMFAC and ORION databases, Utility AMI data, and EVSE charging session data. Table 175 shows the data collection categories and sources.

Table 175. MDHD Petroleum Displacement Data Collection

Category	Source
Primary Data	(1) Utility program data (on vehicle types, quantities, and other details) (2) Utility electric AMI data (in 15-minute intervals) (3) EVSE charging session data (4) Site visit and survey data for site-specific inputs • EV fleet make/model • Daily/annual vehicle utilization (miles) and schedules • EV charging schedules • Counterfactual fleet fuel type and average fuel economy/historical fuel usage • Estimated annual idling hours per vehicle
Secondary Data	EV and counterfactual ICE fuel efficiency (from counterfactual EMFAC lookup table and other sources)

For this analysis the Team leveraged the Cadmus data warehouse and counterfactual lookup tables, Power BI dashboard, and other sources and outputs from the *Grid Impacts* analysis. AMI data are the basis for these calculations. Table 176 shows the analysis steps.

Table 176. MDHD Petroleum Displacement Analytical Steps

Step	Description
Identify counterfactuals and secondary data	For each vehicle type, identify gallons per mile or gallons per hour and kilowatt-hours per mile efficiency from: • MDHD counterfactuals • EMFAC/ORION for both EV and ICE real-world efficiencies
Identify EV energy consumption	Identify annual kilowatt-hours consumed by EVSE at each site from grid impacts analysis
Account for charging losses	Use 15% loss from grid to vehicle battery for vehicle charging, assume no loss for electric truck refrigeration units
Calculate vehicle miles or hours (for off-road applications)	Calculate EV miles or hours based on kilowatt-hours consumed and vehicle efficiency
Estimate petroleum displacement	Estimate petroleum displacement based on ICE vehicle miles or hours and efficiency, converted to a DGE

GHG and Criteria Pollutant Impacts

The MDHD programs are expected to reduce the amount of GHGs and criteria pollutants emitted as EVs replace fossil-fuel-powered on-road and off-road MDHD vehicles. This section describes the approach, data sources, and analyses we performed to estimate these reductions.

The Evaluation Team first calculated GHG and criteria pollutant emissions reductions from the petroleum displaced by the EVs incented through the programs.[159] The GHG emissions estimates included CO_2, N_2O, and CH_4. The criteria pollutant reductions we analyzed included $PM_{2.5}$ and PM_{10}, CO,

[159] The Evaluation Team counted tailpipe emissions for the counterfactual vehicles and electricity grid emissions for EVs. We did not consider upstream emissions for the counterfactual vehicles (such as petroleum refining). Additionally, we did not include emissions from brakes and tires for the counterfactual vehicles and EVs.

NO_x, and oxides of sulfur (SO_x). Additionally, the Team estimated reductions of ROGs, which are not criteria pollutants but contribute to the formation of ground-level ozone, which is a criteria pollutant.

Next, the Team examined the increase in emissions attributed to the electricity used by the EVs. We calculated the emissions from EV electricity use by examining the emissions profile of the grid at the time of charging using the published CAISO grid mix at five-minute intervals. Since the electric grid emissions profile varies substantially by time-of-day and season, we estimated reductions using actual 8,760-hour load curves based on Utility AMI meter data.

The difference between the counterfactual vehicles' petroleum emissions and the EVs' electricity emissions was the net reduction in emissions for the more global-scale pollutants (GHG, NO_x, and SO_x). For criteria pollutants with localized health effects such as CO, PM, and ROG, the emissions are presented as an absolute reduction from the counterfactual.

The Evaluation Team used the GHG and criteria pollutant inputs shown in Table 177 regarding electricity usage, resource mix, emissions, vehicle types, and petroleum displaced.

Table 177. GHG and Criteria Pollutant Data Inputs

Category	Unit	Source
Site-level AMI data in 15-minute intervals	kWh	Utility AMI (~1 month delay between measurement and reporting)
Overall electricity demand by five-minute interval	MW	CAISO demand (real time)
CO_2 grid emissions by five-minute interval	MT	CAISO emissions (real time)
Resource mix by interval	% by generator fuel	CAISO supply (real time)
NO_x, SO_x, CH_4, and N_2O emission rates	g/kWh	EPA eGRID (2022)
CO_2 emission rate	kg/kWh	EPA eGRID (2022)
CO_2-equivalent emission rate	kg/kWh	EPA eGRID (2022) as derived from emission rates above
Vehicle tailpipe emissions (CO_2, CH_4, N_2O, CO, NO_x, PM_{10}, $PM_{2.5}$, SO_x, and ROG) by vehicle and fuel	g/mile	CARB EMFAC (2021 v.1.0.2)
Vehicle type (vehicle classification code for linkage to emission tables)	standard category	Evaluation Team analysis in *Petroleum Displacement* section
Petroleum use by month	unit measure for fuel type	Evaluation Team analysis in *Petroleum Displacement* section
Petroleum fuel type	fuel type	Evaluation Team analysis in *Petroleum Displacement* section
Petroleum fuel energy content	MMBtu/unit	U.S. DOE AFDC

The analysis comprised four steps. The Team used the CAISO application programming interface, the EMFAC dataset, and the U.S. EPA's eGRID data to perform this work:

- **Counterfactual emissions:** We determined emissions from counterfactual vehicle fuel usage using EMFAC emissions data for specific displaced fuels in (g/mile) along with the determined miles driven from the petroleum displacement methodology.
- **Electricity emissions:** We used CAISO five-minute demand and resource mix data reported by zone to establish an emissions record for each pollutant. We averaged five-minute interval emissions

data, applied this to each 15-minute AMI interval, and applied the CAISO-specific emissions factors for that resource provided by the U.S. EPA's eGRID dataset.

- **GHG calculation:** We used the United Nations IPCC GWPs for CO_2 equivalence (CO_2e) on a 100-year timeframe based on the IPCC AR5. We used GWP-100 factors of 28 for CH_4 and 265 for N_2O. Equation 1 presents the GHG calculation based on CO_2e:

Equation 1. GHG Calculation

$$CO_2e = CO_2 + 28 * CH_4 + 265 * N_2O$$

- **GHG and criteria emissions reductions:** The overall reduction in GHGs, NO_x, and SO_x was net of annual emissions from the displaced counterfactual fossil fuel equipment and the electricity consumed by the adopted electric equipment. The overall reduction in $PM_{2.5}$, PM_{10}, CO, and ROG was represented by the annual emissions from the counterfactual vehicle, as these pollutants present localized effects on populations rather than the more globalized effects of the other pollutants. The Team calculated these emissions reductions for sites both inside and outside DACs.

For the prediction of future emissions savings, it is expected that the California Utility grid will further reduce power plant emissions in future years in alignment with the CPUC IRP process. The Evaluation Team determined the hourly mix of electricity in future years from the most recent IRP RESOLVE models available and applied the changing mix for future years out to 10 years of operation for each site. We treated the emissions factors for these resources as static using the most recent U.S. EPA eGRID dataset for CAISO resources.

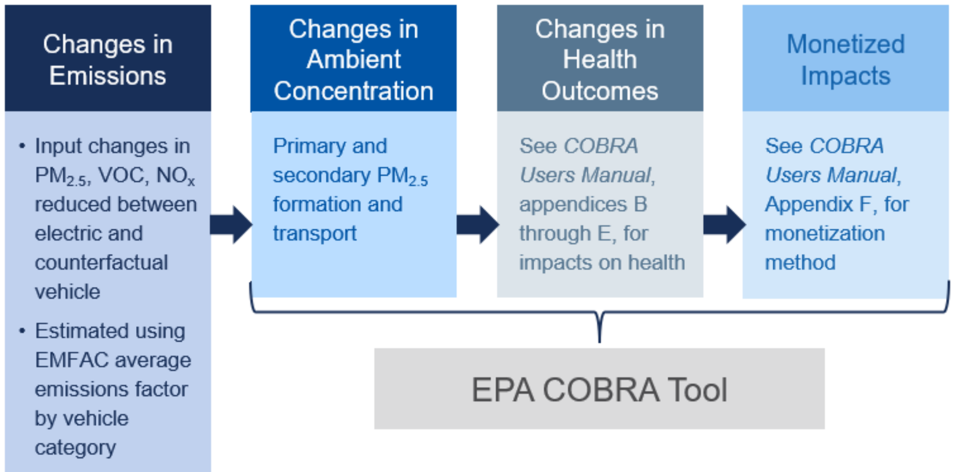
Health Impacts

As EVs replace traditional ICE vehicles, petroleum-based fuels are displaced. These displacements reduce GHG and air pollutant emissions, which may lead to health benefits in regions where EVs are adopted. To understand the effects of the programs on air pollution and related health benefits, the Team estimated the monetized value of health benefits of each individual Utility-funded site by running the emissions reductions through the U.S. EPA's COBRA. As part of this analysis, we also examined the impact on DACs. For Liberty, PG&E, and SCE, DACs are identified in the California Communities Environmental Health Screening Tool, CalEnviroScreen, developed by California's Office of Environmental Health Hazard Assessment. SDG&E uses a service territory definition of DAC.[160] This section describes the approach, data sources, and analyses performed to estimate health impacts associated with the MDHD programs.

The Evaluation Team used a four-stage methodology shown in Figure 274.

[160] As per Advice Letter 2876-E, SDG&E found that only 27 census tracts in its territory were considered DACs using the top quartile in the CalEnviroScreen statewide definition. However, the service territory definition is broader and produced a calculated 180 DAC census tracts in SDG&E service territory.

Figure 274. Four-Step Process for Estimating Health Impacts by Census Tract



Step 1: Changes in Emissions. These estimates are annualized emission reductions by site for EY2023 in tons for $PM_{2.5}$, VOCs, and NO_x. The Evaluation Team aggregated emission reductions by county and used those as inputs into the U.S. EPA COBRA, which uses several fields:

- **Sector** – Highway vehicles or off-highway sector
- **Subsector #1** – Diesel for most vehicle applications
- **Subsector #2** – Subsector of highway or non-road
- **Discount rate** – 3% assumed, which reflects the interest rate consumers might earn on government-backed securities

Using the COBRA desktop application, the Evaluation Team uploaded the annual reductions in emissions for $PM_{2.5}$, VOCs, and NO_x, and the tool output estimates as shown in Table 178. In this analysis VOCs are assumed to be the same as ROGs, which are the output from EMFAC.

Table 178. Mapping of Vehicle Types to Sector and Subsectors

Vehicle Type	Sector	Subsector #1 (Counterfactual Fuel Type)	Subsector #2 (Counterfactual Fuel Type)	Discount Rate
LDV (at public charging sites)	Highway vehicle	Gasoline fuel	Light duty	3%
Airport GSE	Off-Highway	Non-road diesel	Airport service	3%
Cargo handling equipment	Off-Highway	Non-road diesel	Industrial	3%
Forklift	Off-Highway	Non-road diesel	Industrial	3%
Heavy-duty vehicle	Highway vehicle	Diesel fuel	Heavy duty	3%
Medium-duty vehicle	Highway vehicle	Diesel fuel	Heavy duty	3%
Other heavy-duty vehicle	Highway vehicle	Diesel fuel	Heavy duty	3%
Port cargo truck	Highway vehicle	Diesel fuel	Heavy duty	3%
School bus	Highway vehicle	Diesel fuel	Heavy duty	3%
TRU	Highway vehicle	Diesel fuel	Heavy duty	3%
TSE	Highway vehicle	Diesel fuel	Heavy duty	3%
Transit bus	Highway vehicle	CNG	Heavy duty	3%

Step 2: Changes in Ambient Concentration. The U.S. EPA COBRA has a feature that uses the reductions in emissions to estimate the change in ambient concentration. The tool also accounts for transport and transformation of the pollutants (for example, into ozone).

Step 3: Changes in Health Outcomes. The U.S. EPA COBRA uses epidemiological models to estimate the health impacts of these emission changes at the county level. COBRA's estimates reflect the current scientific thinking on the relationship between particulate matter and human health, as well as the economic valuation of these health effects. In particular, the U.S. EPA draws from the Integrated Science Assessment for Particulate Matter.[161] Additionally, the U.S. EPA's methodology for characterizing health impacts has been reviewed by two National Academy of Sciences panels and multiple U.S. EPA Science Advisory Boards. Because the health impacts of air pollution and approaches to value these impacts are areas of active research, the selection of studies used in COBRA may evolve over time, as new evidence and studies emerge. More information is available in the online COBRA documentation.[162] Note that COBRA estimates health impacts for all 3,033 counties in the United States (because of the transport of the pollutants).

Step 4: Monetized Impacts. The U.S. EPA COBRA estimates the economic value (in 2017 USD) of the change in health impacts from the emissions changes at the county level. These values are converted to current year dollars using a multiplier.[163] Economic value is estimated differently depending on the health impacts (such as by estimating avoided lost wages, avoided medical costs, the amount people are willing to pay to avoid a negative health impact [such as a respiratory symptoms], or the value of statistical lives [VSL] approach, which uses value-of-life studies to determine a monetary value of preventing premature mortality). COBRA reports both a low impact and a high impact, representing uncertainties in the estimates. The low estimate represents results based on an evaluation of mortality impacts of $PM_{2.5}$ by the American Cancer Society.[164] The high estimate represents results based on the Harvard Six Cities mortality study.[165] Rather than average the results of these studies, the U.S. EPA's standard practice has been to report the estimated change in mortality separately as low and high values.

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162 U.S. Environmental Protection Agency. Last updated November 1, 2022. "Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool COBRA." https://www.epa.gov/cobra/users-manual-co-benefits-risk-assessment-cobra-screening-model

163 U.S. Bureau of Labor Statistics. 2023. "CPI Inflation Calculator." https://www.bls.gov/data/inflation_calculator.htm

164 Krewski, Daniel et al. May 2009. "Extended Follow-Up and Spatial Analysis of the American Cancer Society Study Linking Particulate Air Pollution and Mortality." *Res Rep Health Effects Institute* (140): 5–114. https://pubmed.ncbi.nlm.nih.gov/19627030/

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Site Costs

The Evaluation Team used site-level cost data provided by the Utilities to compile summary statistics of TTM and BTM costs. The costs included in the analyses include:

- **TTM**: Costs are taken straight from the SB 350 data provided by the Utilities.
- **Ratepayer BTM**: Costs are either the Utility-sponsored costs to construct utility-owned infrastructure BTM or the incentive/rebate amount paid by the Utility for customer-owned infrastructure.
- **All-in BTM**: Costs are either the Utility-sponsored costs to construct Utility-owned infrastructure BTM or are estimated using the following equation:
  - **>50 kW EVSE**: BTM cost ($/installed kW) = 4,650 * (installed capacity in kW) ^ (-0.414)
  - **<50 kW EVSE**: BTM cost ($/installed kW) = 30,666 * (installed capacity in kW) ^ (-0.652)
- **Ratepayer EVSE**: Reflects the EVSE rebate amount from the Utility.
- **All-in EVSE**: Reflects the full cost of the EVSE equipment and installation. For simplicity, the Evaluation Team assumes L2 ports cost $3,000 per port and DCFC ports cost $45,000 per port.

Other notes and assumptions using in the cost calculations include:

- The port counts used in the cost-per-port calculations reflect the number of ports reported by site visits. If a site visit did not occur, we used the port counts reported by the Utility.
- The vehicle counts used in the cost-per-vehicle calculations are from the VAP.
- The installed capacity values used in the cost-per-kilowatt calculations are the site capacities observed at the site visit. If a site visit did not occur, we used the port counts reported by the Utility.

Site Visits

The Team visited program sites that were activated during EY2023 to provide quantitative and qualitative infrastructure insights. This section describes the approach, data sources, and analyses performed for these site visits.

The Team used detailed notes and photos taken during each site visit as well as data provided by the Utilities. After each site visit, the Team compiled the notes and photos and entered data into the Arkenstone data collection platform. Arkenstone is the custom data management platform developed by Cadmus that houses site visit data. We used these data to support grid impacts and petroleum displacement analyses, because these analyses rely on site-specific energy consumption, which can be impacted by the reliability of charging systems for EVs and by the change in energy consumption from integrating EVs into a fleet’s operation.

The Team then analyzed the data to document several types of quantitative and qualitative insights:

- Confirm the number and type of conventional vehicle and fuel types to support counterfactual analysis adjustments in future evaluation years.

- Confirm the installed charging hardware and whether an EVSP (charging station network provider) is being used, as well as the number and type of EVs delivered compared to the vehicle and EVSE acquisition plans provided by Utilities as part of the program data. The results indicate:
    - Total installed charging capacity (kW)
    - Expandability, which may be indicated by the size of transformers, details of service panels (amperage and space for circuit breakers), pre-installed conduit, available parking area, and other vehicle types used by fleets.
  - Visually identify variables leading toward final design and construction decisions (such as whether transformers are new, upgraded, or pre-existing) with the support of on-site hosts or Utility staff for interpreting site cost under TCO analysis.
  - Confirm co-funding for vehicles and charging infrastructure that helps address ratepayer cost benefits.
  - Explore lessons learned, challenges, and operability (EVs and or charging hardware) such as software, hardware, staffing, and passenger loads that support the site utilization rates.
  - Compare site visit findings to Utility PMO (vehicle/EVSE acquisition plans) and PAC meetings.

Co-Benefits and Co-Costs

The Evaluation Team collected information on co-benefits and co-costs for fleet managers through fleet manager surveys and interviews and fleet driver surveys. For the fleet manager surveys specifically, the Team asked both closed- and open-ended questions to understand which co-benefits and co-costs fleet managers experienced. The survey was designed to build upon data the Team collected in the previous year by using the results to expand the number of co-benefits and co-costs evaluated and retaining a similar survey structure year over year. Given that some fleets have been operating for a short time, the Evaluation Team took a qualitative approach to assessing co-benefits and co-costs, asking respondents to provide a relative rating of size (significant benefits, some benefits, or no benefits). Additionally, the Team worded these questions to focus on what respondents *expected,* not what they experienced, because many of the co-benefits are felt by drivers and the local communities and not by the fleet managers specifically. To supplement survey responses, we incorporated relevant data from the site visits. Although we did not formally ask about co-benefits and co-costs during site visits, the Evaluation Team was able to obtain anecdotal information from site representatives.

Deep Dives

Analysis for deep dives included synthesis of multiple data sources such as site visits, surveys, interviews, and project documentation for selected sites.

- **Fleet Manager Interviews:** The Team interviewed fleet managers via phone in the fall. We focused the interview questions on EV and charger performance and satisfaction and the vehicle acquisition process. During each interview, we also requested data from fleet managers on historical fuel and mileage logs, vehicle telematics data, and historical maintenance costs.
- **Driver Surveys:** The Team distributed driver surveys after discussing logistics with the fleet manager during the interview. At two surveyed sites, we administered paper surveys per the request of the

fleet managers, who distributed the surveys to drivers. The surveys covered the driver experience, benefits of electrification, and operational impacts.

- **Operational Analysis Presentation**: If requested by the fleet manager, the Evaluation Team scheduled a one-hour virtual meeting with each deep dive participating fleet to present the results of the analysis (based on at least the past 12 months of operational data).
- **Activities**: Sites with a significant change in operations may require an extended deep dive analysis for another year (such as sites that added a significant number of vehicles or implemented load management strategies). The Team asked these fleet managers to participate in a brief follow-up phone interview in EY2023 to enable an iterative dialogue.

Net Impacts

MDHD Fleet Manager Self-Report NTG Methodology

The Evaluation Team's approach for MDHD program enhanced self-report NTG analysis relied partly on data obtained via surveys with key site decision-makers such as program participating fleet managers. The Team estimated freeridership and spillover ratios for each program to determine program-specific self-report NTG ratios using the following calculation:

NTG Ratio = 1 – Freeridership Ratio + Participant Spillover Ratio

Freeridership is the percentage of participants who report they would have adopted the MDHD EVs even in the absence of the MDHD make-ready program. Participant spillover in the MDHD fleet sector is the increase in participants' EV adoption (beyond direct participation in the program) that the Team can attribute to their experience participating in the MDHD program.

For the MDHD fleet manager self-report freeridership analysis, the Team assessed three aspects:

- **Acceleration from the program:** The extent to which the make-ready and infrastructure savings motivated fleet managers to purchase MDHD EVs sooner than they had originally intended before learning about the MDHD program.
- Awareness of the program: The extent to which fleet managers were aware of the program at the time they decided to implement their TE project.
- **Influence from the program:** The degree of influence the program had on fleet managers' purchases.

For the MDHD fleet manager participant spillover analysis, the Team assessed three aspects:

- **Additional electrification after program participation:** The extent to which fleet managers continued electrifying their fleet after participating in the MDHD make-ready program without additional incentives from the MDHD program.
- Use of outside funding: The extent to which participating fleet managers received financial support from any other organization for their additional fleet electrification projects.
- **Influence from the program:** The degree of influence MDHD program participation had on fleet managers' decisions to continue electrifying their fleet without Utility program support.

Self-report information was a core component of analyzing the net effects directly attributable to MDHD programs. The Team used the CPUC nonresidential customer self-report NTG framework as the basis for developing the MDHD fleet manager NTG methodology approach.[166] The nonresidential NTG methodology that has been in use since the 2006-2008 energy efficiency program evaluation cycle addresses the unique needs of nonresidential customer projects developed through energy efficiency programs offered by the four California Utilities and third-party implementers. This method relies exclusively on the standardized self-report approach to estimate site and domain-level NTG ratios, because other available approaches and research designs are generally not feasible.

The Evaluation Team developed the MDHD self-report approach NTG methodology in accordance with the relevant EM&V guidelines, including the California Energy Efficiency Evaluation Protocols (April 2006) and the most recent updates to the nonresidential NTG framework that incorporated an alternative to a legacy program PAI scoring component (PAI-1 score) of the core NTG calculation.[167] For the purposes of this MDHD self-report approach NTG methodology, the Evaluation Team has adopted the alternative scoring structure documented in the referenced evaluation reports – the PAI-1A[168] score – to replace the legacy PAI-1 score.

Recognizing the varying degrees of site complexity and the underlying decision processes, the CPUC framework includes three levels of detail – all built around the same core questions but incorporating additional sources and higher levels of review as the size and complexity of projects increase. Table 179 presents the potential data sources for use in each of the three levels of NTG analysis.[169]

Table 179. NTG Rigor and Data Sources

NTG Rigor	Program Files [a]	Decision-Maker Survey	Vendor/Dealer Survey	Secondary Research Findings
Basic NTG	X	X	X	
Standard NTG	X	X	X	
Standard NTG – Very Large	X	X	X	X

[a] Program files for MDHD make-ready projects can contain data on equipment costs, expected savings, funding sources and amounts, and decision-maker and vendor contact information.

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166 California Public Utilities Commission, Energy Division. February 20, 2015. *Methodological Framework for Using the Self-Report Approach to Estimating Net-to-Gross Ratios for Nonresidential Customers.*

167 Quantum Energy Analytics and DNV-GL. March 26, 2021. *Final Impact Evaluation: NonResidential Lighting Sector Program Year 2019*. Appendix A. Prepared for California Public Utilities Commission. https://www.calmac.org/publications/PY2019_NonresLgtImpact_FinalRpt.pdf
Itron, ERS, and Tierra Resource Consultants. March 31, 2020. *PY2018 Small/Medium Commercial (SMB) Sector ESPI Impact Evaluation: Final Report.* Prepared for California Public Utilities Commission. https://pda.energydataweb.com/api/view/2361/2018_Small_Medium_Com_ESPI_Evaluation_Final_with_Appendices.pdf

168 PAI-1A is the PAI-1 alternative.

169 Participant fleet manager surveys were the primary source of the SRA NTG ratio in EY2022. When available, the Team incorporated information from other data sources in the final determination of a project's NTG ratio.

Decision-maker (fleet manager) surveys are a key source of attribution data under all three levels of NTG rigor. The Team used three separate sets of questions to assess three components of the core NTG ratio, placing each score on a 0.0–1.0 scale as an alternate way to characterize Utility program influence.

- **Program attribution index 1A (PAI-1A) score** captures the type of TE investment participating fleet managers would most likely have procured if the Utility program had not been available, yielding a score between 0.0 and 1.0.
- **Program attribution index 2 (PAI-2) score** reflects the extent to which participating fleet managers perceived the Utility program (rebates, recommendation, training, or other program intervention) as important relative to non-program factors in their decisions to implement the TE projects they eventually completed. The Team determined this score by asking fleet managers to assign importance values (using a 0.0–10 scale) to both the program and the most important non-program influences, so that the two values totaled 10. The Team divided the Utility program's score (0.0–10) by 10 to calculate the score for the project (0.0–1.0). We halved the score for fleet managers who said they had already made their decision to procure the specific program-qualifying TE project before they learned about the program.
- **Program attribution index 3 (PAI-3) score** captures the likelihood (on a 0.0–10 scale) that fleet managers would have taken the same various actions (or might take them in the future) even in the absence of the Utility program (the counterfactual). The Team calculated the project's score by subtracting from 10 the likelihood rating of procuring the exact same program-qualifying TE project, and dividing by 10 (yielding a project score 0.0–1.0).

Core NTG Ratio Scoring

The Team calculated the resulting self-report approach core NTG ratio for a project, prior to accounting for participant spillover, as the average of the PAI-1A, PAI-2, and PAI-3 values. The freeridership ratio for a project was equal to one minus the core self-report approach NTG value.

Participant Spillover Calculation

To measure participant spillover, the Evaluation Team asked fleet managers if they chose to electrify more of their fleet even without additional incentives from the MDHD Utility fleet electrification program, due to their earlier participation in the MDHD program. We then asked follow-up questions about the type and number of EVs that fleet managers purchased without support from the MDHD Utility fleet electrification program. The Team asked fleet managers if they received financial support from any other organization for any of the EV types they reported purchasing after participating in the MDHD program. If they had, we asked what specific organizations had provided that financial support and what amount of financial support they had received. An electrification project is not considered participant spillover attributable to the MDHD program if a participating fleet manager received financial support from an organization for the additional fleet electrification activity.

The Evaluation Team asked participating fleet managers how important their participation in the MDHD Utility fleet electrification program was to their decision to electrify more of their fleet without MDHD program support. A participant spillover electrification project is one for which the fleet manager rated the importance of their MDHD program participation as 8, 9, or 10 on a 10-point scale, where 0 meant *not at all important* and 10 meant *extremely important*. An electrification project that received a rating of 8, 9, or 10 and did not receive financial support from another organization was eligible to have the full amount of estimated spillover benefits attributed to the MDHD Utility program.

The Team assigned benefits values to spillover projects based on evaluated gross program benefits. A participating fleet manager's project participant spillover ratio equaled the sum of fleet manager-reported additional spillover benefits, divided by the total gross program benefits achieved by the MDHD project:

$$Participant\ Spillover\ Ratio = \frac{\sum Spillover\ Benefits\ Reported\ by\ Fleet\ Manager}{\sum MDHD\ Program\ Benefits\ Reported\ by\ Fleet\ Manager}$$

Final Self-Report Approach NTG Ratio

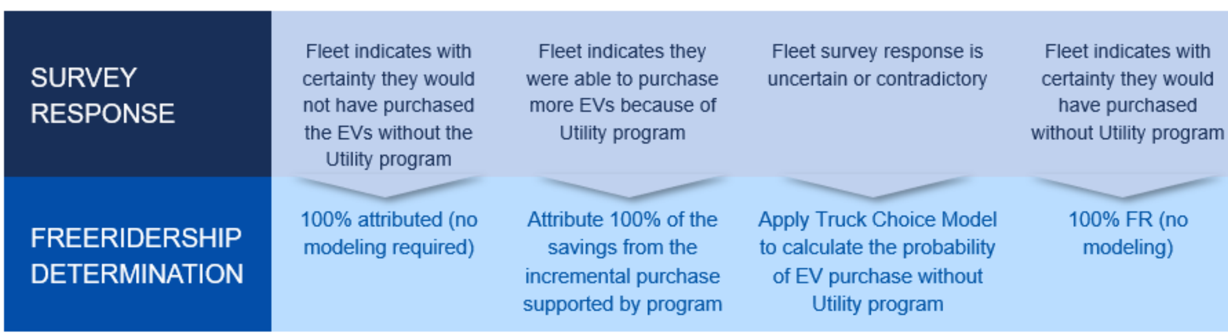
The Team separately estimated freeridership and spillover rates for each surveyed project to determine the final project-specific self-report approach NTG ratios using the following calculation:

NTG Ratio = 1 – Freeridership Ratio + Participant Spillover Ratio

Self-Report Approach NTG Integration with TCM to Determine Final NTG Ratio

The Evaluation Team determined the final NTG ratio for a MDHD project by applying the self-report approach NTG ratio or by applying the UC Davis TCM. Figure 275 illustrates the situations in which we used the self-report approach NTG ratio.

Figure 275. Freeridership Determination for MDHD Projects



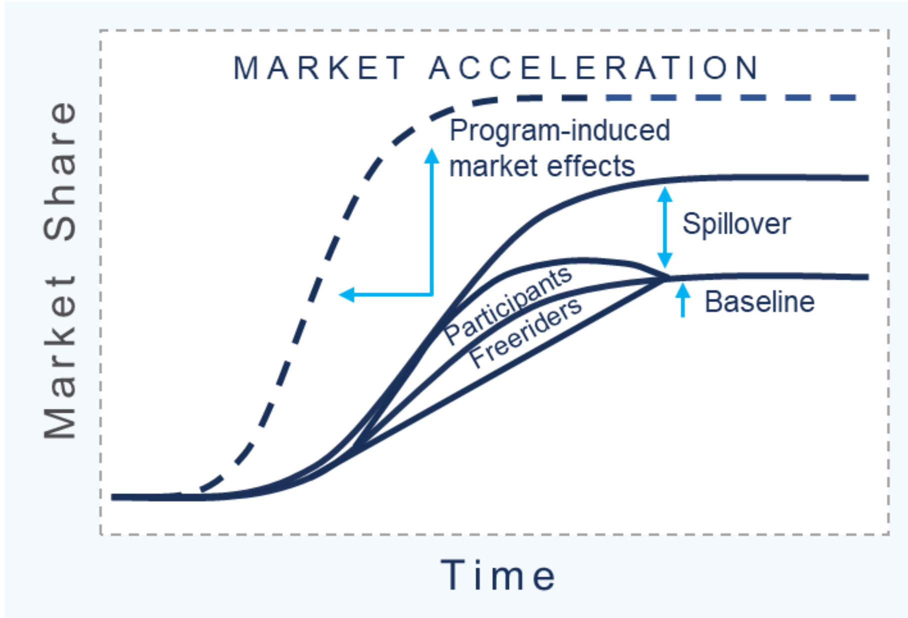
Market Effects: Electrification Market Share Baselines

Measuring market effects informs Research Objective 1: "whether transportation electrification (TE) investments accelerated widespread TE."

Market effects include changes in market structure or market participant behavior in the form of increased adoption of clean energy products, services, or practices as a result of market interventions (such as program incentives and training events). In the context of the MDHD programs, effects in the MDHD market consist of EV adoption by fleets that did not directly participate in the programs. Figure 276 illustrates how market effects capture the difference between actual adoption (dotted line) and the combination of naturally occurring baseline market adoption and direct program participation.

Market effects shift the adoption curve upwards and to the left, indicating faster and higher levels of EV adoption compared with the baseline scenario where no Utility market interventions occurred.

Figure 276. Market Effects: Acceleration and Transformation



Estimating market effects requires knowing the actual adoption rate, program participant net impacts, and naturally occurring baseline market adoption. Ideally, measurement of the naturally occurring baseline occurs prior to significant program activity because the baseline represents adoption in a scenario without Utility market intervention.

Market Share Electrification Naturally Occurring Baseline

The Evaluation Team conducted two Delphi panels, two rounds each, with market experts in various market sectors to develop a consensus forecast of the market share baseline for the electrification for those sectors in California through 2030. The baseline assumes no market interventions by the electric Utilities. The sectors for the EY23 report were Regional and Long-Haul Trucks and School Buses.

The panelists provided their inputs through an online survey, which the Evaluation Team programmed to capture electrified market share in 2024, 2026, 2028, and 2030. The online survey allowed the panelists to see their forecasted adoption curve generated in real time and adjust their responses dynamically.

In the first round, we asked experts to provide a forecast of their respective market sector's market share assuming no Utility interventions, along with a rationale for the shape of their forecast. The Evaluation Team aggregated the first-round results, calculated the median forecast, and shared the anonymized market predictions with the panel in the second round. The experts reviewed all forecasts and could either agree with the median estimate or submit a new estimate. This process typically continues until convergence occurs, meaning more than half of panelists agree. In this case, both panels reached convergence in the second round.

While the main purpose of these Delphi panels was to develop a consensus market baseline forecast, the panelists' written rationales contained valuable qualitative information. We consolidated this information into a summary of factors panelists believe will accelerate or impede electrification in California.

The panelists considered the impact of the ACT, with some forecasting trajectories below the ACT requirements (suggesting either incomplete compliance or compliance through alternative technologies) and some forecasting trajectories consistent with full compliance.

Truck Choice Model

The UC Davis TCM is structured as a nested multinomial logit model in a Microsoft Excel spreadsheet. The model represents a discrete choice formulation that includes a number of important factors that will influence individual decision-makers' preferences among a suite of vehicle technology options. These factors include private economic costs, such as vehicle purchase price, maintenance and fuel costs, non-monetary costs (such as aversion to new and uncertain technologies and lower availability of fuel infrastructure), and incentives or subsidies. The choice formulation assumes a variation in the utility of trucks for decision-makers.

The Team disaggregated trucks into several categories that encompass specific vehicle types and use patterns. We then segmented these truck categories into risk groups that have different factors impacting truck purchases. The Team applied the discrete choice model to each of these risk groups to generate the market shares for each vehicle technology.

The model calculates a total generalized cost, which is the numerical summation of both monetary and non-monetary factors: capital cost, fuel cost, green public relations, uncertainty, incentives, refueling inconvenience, maintenance cost, carbon tax, and model availability. For monetary factors, the model calculates the cost in U.S. dollars. The model quantifies non-monetary factors by certain functions and subsequently expresses those in U.S. dollars. For each truck type (such as short haul delivery, medium-duty delivery, transit bus, and school bus) the model calculated the generalized cost for each technology type (diesel, natural gas, hybrid, fuel cell, battery electric, gasoline). Using these generalized costs, the model calculated the market shares.

The model has been used extensively in recent years to better understand how California policies and programs impact fleet operator purchase decisions of alternative fueled MDHD vehicles. Using the TCM, the Evaluation Team predicted the likelihood that each fleet would adopt MDHD EVs in its next procurement in the absence of the Utility program.

The Evaluation Team developed a version of the TCM with a focus on the market sectors most heavily represented in the Utilities' programs. We incorporated actual program cost data including Utility rebates and incentives. The model produced three trajectories for each market sector: adoption with no Utility investment, adoption with Utility investment only in the TTM infrastructure (as required by AB841), and adoption with the full suite of Utility programs, rebates, and incentives.

Process Evaluation

The following subsections discuss the process evaluation for MDHD surveys and interviews.

Surveys

The Evaluation Team used survey data regarding fleet motivations for participating in Utility electrification programs, fleet motivations for withdrawing from the program, fleets' experience with the process, barriers to electrification, costs and benefits, and operational constraints.

To gather the survey data, the Evaluation Team invited respondents to complete surveys via email. The Team developed two surveys: one for managers of participating fleets and one for managers of fleets that had withdrawn from the program. We designed the survey questions to align with the evaluation objectives and focused the questions on understanding fleets' experience with the program.

Seventeen fleet managers responded to the fleet manager survey and two responded to the fleet withdrawal survey. The Evaluation Team compiled survey data to produce and interpret graphical analysis of the survey responses.

The Evaluation Team analyzed the fleet manager and fleet withdrawal surveys primarily at the Utility stratum. For select questions and when sample size allowed, we further stratified the sample by DAC status and vehicle type to provide additional insights to the analysis. The Team created graphical data representations to interpret survey data, draw conclusions about fleets' experiences, and identify trends in fleets' experiences with electrification. In future evaluation years, the Evaluation Team expects a larger sample size, which will allow for a more robust analysis among different strata. Due to the small sample sizes, the Evaluation Team did not apply any significance testing to EY2023 survey data.

Interviews

The Team also conducted in-depth interviews with the four participating Utilities to gather qualitative insights regarding Utility experience with the program process, barriers to electrification, program design, costs and benefits, and operational constraints. We used this interview data to provide context to information from other sources, such as PAC presentations.

The Team synthesized Utilities' responses to in-depth interview questions to draw conclusions about the topics covered in the interview. We analyzed each Utility's responses separately but used a nearly consistent set of questions across Utilities.

We synthesized the vendor (EVSP) responses to highlight general concerns across all of the Utility programs (such as delays due to supply chain constraints). We included such findings in the report sections corresponding to SCE, SDG&E, and PG&E. Most vendor comments applied to the programs of all three of these Utilities, so the corresponding report sections are generally similar. Where vendors singled out specific Utility programs in their comments, we only included such comments in that Utility's section of this report. Liberty's program was distinct with a single EVSP vendor who did not provide EVSP services under the other programs.

Public Charging (Schools, Parks, and EV Fast Charge) Evaluation Methodology

This section outlines the data collection and analysis for the Public Charging program evaluation.

Data Collection Methodology

The following subsections discuss data collection for the Public Charging program evaluation, including program data, materials, AMI and EVSE data, site visits, and Utility interviews.

Program Performance Metrics

Program data provides essential insights into program performance. The Evaluation Team collected and securely transferred Utility data between the Microsoft Azure cloud-based environments and a secure SharePoint site. The Team sought to transfer data monthly, with some variation in timing among PG&E, SCE, and SDG&E.[170] Once we received data from these Utilities, we moved it to the Cadmus data warehouse for secure storage, retrieval, and analysis. The Evaluation Team then unified the data imported from each Utility to provide a single resource output to adhere to SB 350 reporting.

These data included program application status and timing, as well as details such as the number of ports by type/level, site status by DAC, program, application phase timing, and number of applications operational and activated.

Program Materials

The Evaluation Team reviewed available EY2023 program-related material such as marketing education and outreach documentation, Advice Letters, the *Joint IOU EV Load Research and Charging Infrastructure Cost Report*, and PAC presentations. The annual program material review is important to maintain an understanding of each program, including program changes and implementation progress.

Table 180 shows a list of the material types the Evaluation Team reviewed by Utility in EY2023.

Table 180. Public Charging Materials Reviewed

Utility	Program Materials Provided
Liberty	No new materials for EY2023
PG&E	(Schools and Parks Pilots and EV Fast Charge) PAC presentations (Schools and Parks Pilots and EV Fast Charge) Regulatory documents (the Advice Letter) (Schools and Parks Pilots and EV Fast Charge) Joint IOU EV Load Research and Charging Infrastructure Cost Report (Schools and Parks Pilots only) Marketing materials (Schools and Parks Pilots only) School curriculum
SCE	Regulatory documents (the Advice Letter) Joint IOU EV Load Research and Charging Infrastructure Cost Report PAC presentations Marketing materials
SDG&E	PAC presentations Joint IOU EV Load Research and Charging Infrastructure Cost Report Marketing materials

170 Liberty provided no site data for EY2022 (as no public charging sites were completed).

AMI/EVSP

The Evaluation Team used AMI data to estimate charger usage, a key input for subsequent analyses and estimations of program impacts such as impacts to the grid, petroleum displaced, emissions reduced by EV adoption, and associated health impacts. The Team collected and securely transferred AMI data between the Utilities and Microsoft Azure cloud-based environments. We used Azure Databricks to transform and standardize the data, which we then imported into an SQL server data warehouse. We performed these transfers monthly, with some variation in timing among the Utilities. Once we received the data, we input it into our data warehouse for secure storage and retrieval and aggregated it for subsequent calculations and analysis. Time-stamped energy consumption data were in 15-minute intervals.

A second critical data source was EVSE data provided by participating EVSPs. The electric Utilities developed a process for screening and approving EVSPs based in part on their ability to provide essential charging data of EVSE sessions, intervals, stations, and ports monthly.

Together, AMI and EVSE data provided the basis for analyzing program performance at a granular level. The Team used data from EVSPs to examine port utilization, which is based on the time a vehicle is parked at a charging station and consuming energy. Port utilization rates can be expected to rise as the program matures, consumers and fleets acquire more vehicles, and the effects of the COVID-19 pandemic begin to subside.

The Evaluation Team worked to acquire complete AMI and EVSE data for every charging session from the Utilities and EVSPs. In some limited cases where AMI data were not available from the Utility, the Team worked with the Utility to obtain these data and incorporate them into future analyses. In other cases where AMI data were not available, either the Utility provided a customer submetered dataset or the Team synthesized data from existing EVSE data.

Synthesized Data

Where some complete AMI data were missing or where AMI data were missing for some periods of times, the Evaluation Team generated representative AMI data for these sites based on available EVSP data through a synthesis process using a conversion factor of the ratio between EVSP data and AMI data. Specifically, we derived conversion factors for each site by evaluating the ratio of total kilowatt-hours delivered as reported by EVSPs, which in most cases existed for the same project at a different time period or existed for similar charging stations and vehicles. For the rare case where there was no specific match, the Team used a standard factor of 0.85 to account for electricity losses between the meter and the EVSE.

Annualized Data

The Evaluation Team considered all operational sites for annualization.[171] In the EY2021 annual evaluation, we annualized all sites with greater than six months of usage data and considered annualizing sites with between three and six months of usage data depending on observed usage patterns. For both EY2022 and EY2023, the Evaluation Team annualized all sites to provide a more complete picture of the entire For EY2023, to provide a more complete picture of the entire program to date and the impacts of the existing program performance over a full 10-year life. We have found that sites with an abbreviated period of performance (less than six months) inherently have lower utilization than fully developed sites. As a result, annualized sites with an operational time of six months or less will underrepresent their full 10-year impact; however, excluding those sites would lead to a greater underrepresentation.

We annualized site data by separating a representative 12-month operation period, which can be projected into the future until the site reaches its 10-year life. Next, we determined the 10-year life by evaluating when the operational use of the EVSE would begin and projecting forward 10 years from that point in time. For sites with more than 12 months of fully developed utilization, the Team used the most recent 12 months. For sites with less than 12 months of fully developed utilization, we removed the months of data that did not yet reach 75% of the maximum monthly use, then replaced that data with a synthesis of all months of data following 75% of the maximum utilization.

Site Visits

Site visits to program charging stations are an important data collection element, as they provide an on-the-ground view of installed sites. For EY2023, the Public Charging site visits brought supplemental qualitative insights, especially regarding lessons learned (such as why some sites may have higher usage than others). The Team attempted a census of visits to activated sites for EY2023.

Interviews

In-depth interviews provide critical insight on the original intent, actual implementation, and success of the Pilots and programs and allow us to assess their potential to scale up. For EY2023, we conducted close-out interviews with core staff overseeing the public charging programs[172] across the four Utilities. We developed interview guides outlining key topic areas and questions for discussion to ensure that we covered each topic area during the phone interview. Topics included staff roles and responsibilities, program design and implementation, and areas of challenge and success.

Analysis Methodology

This section provides an overview of the analyses of the Public Charging bundle, including estimating EV adoption and grid impacts; developing the vehicle counterfactual; determining petroleum displacement,

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171 The Evaluation Team annualized electricity usage data for sites with operational AMI data (data indicating that EVs were actively being charged). To accomplish annualization, we extrapolated partial year site electricity usage data out to a full year to make site-to-site and year-over-year comparisons.

172 This pertained specifically to the Schools Pilot, Parks Pilot, and PG&E EV Fast Charge program.

GHG and criteria pollutant reductions, and health impacts; and preparing for a TCO analysis, qualitative site visits, and Utility interview analysis. The petroleum fuel reductions, GHG and criteria pollutant reductions, and health impacts analyses assessed impacts on DACs versus non-DACs.

EV Adoption

The Team conducted an EV adoption analysis to estimate the effects of utility investments in public charging infrastructure on household ownership of EVs.[173] Recent research shows that growth in the availability of public charging networks can boost EV purchases.[174] However, the mechanism by which public charging availability affects EV purchases is not clear. Understanding this mechanism may help the Utilities and other investors in public EV charging facilities make more productive investments. This section describes the Evaluation Team's approach and data sources to estimate the impact of public charging programs on EV adoption.

The Team estimated the effect of public charging stations on EV adoption for populations neighboring public charging stations[175] with a two-stage analysis:

- Historical analysis of public EV charging impacts on vehicle ownership
- Analysis of ownership attributable to specific utility investments in public charging

In the first stage, the Team estimated the effects of access to any neighboring public charging on EV ownership.[176] The second stage involved was an attribution analysis; the Team applied the regression coefficient estimates of public charging access from the first stage to the specific utility public charging investments to estimate their impact on EV ownership (for the EV Fast Charge program, Schools Pilot, and Parks Pilot).

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173 PG&E made these investments through Utility EV pilots and programs including the PG&E EV Fast Charge program and Schools and Parks Pilots.

174 Springel, Katalin. 2021. "Network Externality and Subsidy Structure in Two-Sided Markets: Evidence from Electric Vehicle Incentives." *American Economic Journal: Economic Policy*, 13 (4): 393–432.

175 There are two main channels through which the availability of public charging networks may affect EV purchases. The first is a network effect, through which EV owners gain increased access to the public charging stations because of the stations' placement at destinations such as workplaces, commercial establishments, schools, and parks. The Evaluation Team expects the availability of EV charging equipment at convenient locations (for midday charging away from home) to increase the convenience of owning an EV (such as lessening range anxiety) and to increase the probability of EV ownership. The second channel is a neighborhood effect on the driving population living in areas neighboring the public EV charging stations. The Evaluation Team expects the availability of nearby charging infrastructure to reduce the cost of EV ownership by providing alternatives to home charging. We expect that public EV charging will have the biggest impact on residents of multifamily buildings, many of whom will have limited access to EV charging equipment, or on low-income households, who may be unable to afford home EV charging equipment. The public charging access may boost EV ownership through both channels and there may be positive interactive effects between the channels that boost the overall impact of public charging networks. The Evaluation Team focused on analyzing the second channel and will analyze the impacts for the first channel separately when data become available.

176 For the stage one analysis, the Evaluation Team focused on general public charging, not Utility-specific charging; however, for the stage two analysis, we will consider both Utility- and program-specific charging.

The Utility EV Adoption findings sections provide the end results as the estimated changes in annual EV ownership (EV registration), which are a function of changes in annual access to public EV charging stations while accounting for potential nonrandom siting of public EV charging infrastructure.

Analysis Data and Sample Selection

The Evaluation Team assembled a CBG panel dataset on annual EV ownership and access to public EV charging for calendar years 2015 through 2020 to perform the analysis. The Team assembled the panel data from free, publicly available secondary data sources on EV registrations, public EV charging infrastructure, census demographic data, and census geography (CBG and census block) shape files. Table 181 lists the data sources.

Table 181. EV Adoption Data Collection

Data Element	Description	Source	Reporting Unit
California CBG shapefiles	Polygon shapefile representing CBGs for the state of California from 2010 Census	U.S. Census Bureau: https://www.census.gov/cgi-bin/geo/shapefiles/index.php?year=2010&layergroup=Block+Groups	CBG
California census block shapefiles	Polygon shapefile representing census blocks for the state of California from the 2010 Census	U.S. Census Bureau: https://www.census.gov/geographies/mapping-files/time-series/geo/tiger-line-file.2010.html	Census block
California vehicle registration data	Data on EV ownership for California CBGs by vehicle category, fuel type, fuel technology, and number of vehicles registered at the same address for 2015 through 2020	California Air Resources Board (CARB): https://arb.ca.gov/emfac/fleet-db	CBG
EV charging stations	EV station attributes and location	National Renewable Energy Laboratory AFDC: https://developer.nrel.gov/docs/transportation/alt-fuel-stations-v1/	Fueling station
Population demographics and socioeconomic data	Decennial Census or American Community Survey data (five years) on population, housing, income, race, and ethnicity	U.S. Census Bureau: https://data.census.gov/cedsci/	Zip code tabulation area, census block, or CBG
California DACs	Data on CalEnviroScreen 4.0 scores in census tracts that the Team could use to identify DACs	California EPA Office of Environmental Health Hazard Assessment: https://oehha.ca.gov/calenviroscreen/maps-data	Census track
California cities land zoning shapefiles	Polygon shapefile representing land use for the top 20 largest cities in California where land zoning data are publicly available	Anaheim: https://main-anaheim.opendata.arcgis.com/datasets/f40f6f69179a4bccb5d4359a0e054b04_3/about Bakersfield: https://bakersfielddatalibrary-cob.opendata.arcgis.com/ Fresno: https://www.co.fresno.ca.us/departments/public-works-planning/divisions-of-public-works-and-planning/cds/gis-shapefiles	Land zone

Data Element	Description	Source	Reporting Unit
		Long Beach: https://datalb.longbeach.gov/search?q=zoning Los Angeles: https://geohub.lacity.org/datasets/lahub::zoning/about Oakland: https://data.oaklandca.gov/dataset/Zoning/q8sz-29u5 Sacramento: https://data.cityofsacramento.org/search?q=zoning San Diego: https://data.sandiego.gov/datasets/zoning/ San Francisco: https://data.sfgov.org/Geographic-Locations-and-Boundaries/Zoning-Map-Zoning-Districts/3i4a-hu95 San Jose: https://gisdata-csj.opendata.arcgis.com/datasets/CSJ::zoning-districts/about Santa Ana: https://gis-santa-ana.opendata.arcgis.com/datasets/Santa-Ana::zoning-classifications/explore?location=33.737642%2C-117.887350%2C13.14 Riverside: https://geodata-cityofriverside.opendata.arcgis.com/datasets/edd9eb97a1dd446cb30336d91bc40e8a_2/explore?location=33.945918%2C-117.401342%2C12.00 Stockton: http://www.stocktongov.com/services/gis/mapdatdat.html Chula Vista: https://chulavista-cvgis.opendata.arcgis.com/datasets/a0591cdb609548a182f35bd70a431a20/explore?location=32.631384%2C-117.021350%2C12.73 Fremont: https://fremont-ca-open-data-cofgis.hub.arcgis.com/datasets/25db2e74c6254091a6f340cf01f8f092_0/explore?location=37.529560%2C-122.012239%2C12.00 Fontana: https://data-fontanaca.opendata.arcgis.com/datasets/FontanaCA::zoning-2/explore?location=34.104611%2C-117.459495%2C11.66&showTable=true Oxnard: https://data-oxnard.opendata.arcgis.com/datasets/Oxnard::zoning/explore?location=34.173578%2C-119.184614%2C13.63	

Data Element	Description	Source	Reporting Unit
		Rancho Cucamonga: https://rcdata-regis.opendata.arcgis.com/datasets/zoning/explore?location=34.106902%2C-117.563238%2C15.16&showTable=true Elk Grove: https://gisdata.elkgrovecity.org/datasets/elkmap::city-of-elk-grove-zoning/explore?location=38.407478%2C-121.378550%2C12.52 Garden Grove: https://ggcity.org/maps/data-portal/#/osm/planning/zoning	
California utility investments in EV charging stations	EV station attributes and location	California Utilities	Fuel station

The Evaluation Team then reviewed all data for completeness and accuracy and documented any significant gaps or other issues that might affect the analysis results.

Our analysis sample includes all California CBGs, except those meeting one or more exclusion criteria:

- The CBG was in a rural area.[177]
- The CBG did not have any households.
- The CBG was new since the 2010 census.
- The CBG has outlier EV registration numbers (greater than the 99th percentile in EY2020).

After applying these sample exclusion criteria, there were 131,105 CBG-year observations remaining in the analysis sample.

Modeling of EV Ownership

The goal of the stage one analysis was to estimate the impact of public EV charging access on EV ownership. During this stage, we constructed a composite measure of CBG access to public charging as a function of the number of neighboring public EV charging stations, the geographic distance from homes to the stations, and the number of chargers (ports) at each station. Next, we performed the EV adoption analysis using annual panel data on California EV registrations at the finest spatial resolution possible (the CBG level) from 2015 through 2020. We then estimated the impacts of public charging on EV ownership using two approaches. We first conducted an OLS estimation of a panel annual regression or

177 We adopted the U.S. Census Bureau's urban-rural classification, which is based on 2010 Census population and housing unit: https://www.census.gov/programs-surveys/geography/guidance/geo-areas/urban-rural.html. Previous literature has found that the inclusion of rural areas could lead to overestimating the effect of chargers on these non-urban residents, and that limiting the study to an urban population could reduce variation in population density. See Hsu, Chih-Wei, and Kevin Fingerman. 2021. "Public Electric Vehicle Charger Access Disparities across Race and Income in California." *Transport Policy* (100): 59–67.

long differences regression of normalized EV registrations (annual registrations per 1,000 households), which assumes that the siting of public charging infrastructure was exogenous to EV registrations. The panel model included year fixed effects, CBG fixed effects, and county time trends. The Team uses CBG fixed effects and county time trends to control for, respectively, time-invariant CBG and time-varying county characteristics that could correlate with the location decisions of public charging and subsequent EV adoption. The long differences model of the change in annual EV registrations between 2015 and 2020 includes controls for income, building type, and annual EV registrations in 2015.

The Evaluation Team recognized the potential for bias in the estimates from this OLS analysis if public EV charging location decisions drew from unobservable trends in EV registrations, such as locating public charging infrastructure in areas with higher EV demand (we refer to this as the endogeneity of charging location decisions). So with the second approach, the Evaluation Team estimated the public EV charging impacts using IV-2SLS. The IV-2SLS models use the percentage of the neighboring land area zoned for public EV charging facilities (that is, land zoned for commercial use, parking, or public use, such as schools, government lands, and parks) as the instrumental variable while controlling for the income and percentage of multifamily housing units in CBGs.[178]

In stage two, the Team took a three-step approach to estimate the impact of California utility investments in public charging on EV adoption in the study period:[179]

- **Step 1:** Using the public charging access framework above, we estimated the effect of the Utility charging stations on access for California households. We calculated the change in access for each CBG.180
- **Step 2:** We used the regression model estimates to determine, for each affected CBG, the impact on EV ownership by the change in public charging access for households.
- **Step 3:** We summed the changes in ownership across CBGs to determine the total impact on EVs and to estimate the standard error.

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178 A valid instrumental variable will be strongly correlated with the location of public charging but uncorrelated with EV adoption conditional on other exogenous explanatory variables. Our approach uses the availability of nearby land zoned for public charging as a source of exogenous variation in the availability of public charging among CBGs with similar income levels and housing types. Specifically, the analysis uses the percentage of CBG land area zoned for commercial use, public use (such as schools or government buildings), or parks and beaches. As public charging infrastructure may exist only on suitably zoned land, and land zoning remains mostly unchanged over time, proximity to space zoned for commercial, public uses, or parking should correlate with the change in access to public charging between 2015 and 2020 but not correlate with EV adoption over this period.

179 The Team developed the current methodology to study the impact of public EV charging on existing EV adoption. Forecasting the impact in a future period will require a separate approach and additional data on the utility investments in public charging.

180 A full accounting of the impact of utility investments would require considering whether EV charging station developers would build more (or fewer) charging stations if the Utilities had not built charging stations. Incorporating this supply response would diminish (or increase) the effect of the Utility charging network on EV adoption.

A notable benefit of this two-stage approach to assessing EV and EVSE market acceleration is that it can apply to evaluations of other programs that also increase EV charging access, ensuring methodological consistency.

Grid Impacts

The Evaluation Team calculated the associated grid impacts for the Public Charging programs based on the consumed energy from charging stations installed through the programs and charging session data from the EVSPs. As part of this analysis, the Team examined impacts at the program and bundle levels. This section describes the approach, data sources, and analyses we performed to estimate Public Charging grid impacts.

The Team collected, cleaned, and analyzed Utility AMI data, provided at 15-minute increments, to calculate total kilowatt-hour usage, on-peak and off-peak usage, and maximum demand, which we then used to calculate load factors. The Team took a three-step approach to the analysis:

- **Step 1:** Accounted for total consumption (kilowatt-hours), the proportion of consumption during the on-peak time period, and new load on the grid (kilowatts).
- **Step 2:** Targeted issues such as stability versus growth of charging load, charging load by time of day, and charging session flexibility.
- **Step 3:** Projected the extent to which transportation energy use can be integrated with the grid at a least cost to retail consumers and ratepayers.

These data are reported by site, in aggregate, and on a daily and monthly basis.[181]

The Team used the essential primary and secondary data summarized in Table 182 for the Public Charging grid impacts analysis.

Table 182. Public Charging Grid Impacts Data Inputs

Category	Source
Primary Data	Utility AMI data, historical CAISO data (demand, supply sources, renewable curtailments), charging session data from EVSP networks
Secondary Data	Time varying Utility rates in effect at sites, EVSE (interval and charging session) data, site management details (charger capacities), site visits

We uploaded AMI and EVSP data to the data warehouse and calculated results using the internal Power BI dashboard. Foundational program analysis included total electricity consumption (kilowatt-hours) and new demand (kilowatts) added to the grid. The Team established trends based on the proportion of electricity usage during the highest cost period (defined as 4 p.m. to 9 p.m. daily) versus non-highest cost periods. We calculated load factors based on usage and utilization rates, which we based on the installed capacity for each site.

[181] The actual reported results for each Utility are reflected in a way that preserves and masks personally identifiable information.

The Team then assessed daily and weekly charging behaviors and captured patterns that account for load growth. We also examined CAISO data on fuel mix at different times of the day to estimate the extent to which EV loads contribute to system demand.

The 24-hour load curves provided key insights into how the grid is impacted by the program. Charging approaches in which EVs consume power during off-peak periods such as when solar output is high (midday) and/or demand is low (night) will become increasingly important as more EV loads are added to the grid and have a different role in each public charging program. Charging flexibility in response to price signals offers a potentially valuable tool to safeguard the grid with new EV loads coming online and to support the growth of renewable energy to provide this power.

The Evaluation Team applied the grid impact analysis to the actual AMI data for the activated sites in EY2023, and annualized AMI data to support analyses with forecasts such as the petroleum displacement and GHG and criteria pollutant emissions reductions. Through the annualization of AMI data the Team identified the region of stable operation, and leveraged this data to generate a statistically representative full year of operation.

Emissions calculations require the date and time of AMI data to be matched with the electric generation mix at the time of use. This approach necessitates normalizing emissions calculations across the whole year to capture daily, monthly, and seasonal variations in electric generation mix. Therefore, we did not annualize data from sites with two months of data or less (as we were unable to determine seasonable variability). For sites with more than two but less than four months of data, we visually inspected the datasets and used expert judgement to evaluate whether the operation was consistent enough to be annualized.

Of the activated Public Charging sites in EY2023, the Evaluation Team annualized AMI data through a four-step process:

- **Step 1: Find the maximum monthly site usage.** The Team identified the month with the maximum total usage in kilowatt-hours for the site by examining the EY2023 AMI data.
- **Step 2: Identify the start month.** The starting month for the actual data used to develop the annualized data was the one in which total usage exceeded 75% of the maximum month's usage.
- **Step 3: Create a representative weekly load curve.** Using the AMI data from the start month to the end of the year, we created an average daily load curve for each day of the week and for each 15-minute interval throughout the day.
- **Step 4: Extrapolate weekly load curve.** Using the representative weekly load curve, we extrapolated AMI data that is outside the operational period. We then matched weekday load curves for each day of the week (such as matching Monday to Monday).

Counterfactual Development

The Team conducted secondary research to inform the development of the electric LDV and conventional counterfactual for the public charging sites:

- **The electric LDV counterfactual** establishes an average EV efficiency (kilowatt-hours per mile) to convert energy dispensed at charging stations to resulting EV miles.
- **The conventional LDV counterfactual** is the average fuel economy (miles per gallon) for a representative ICE LDV on the road that the electric LDV counterfactual replaces to convert displaced counterfactual vehicle miles to gallons of petroleum displaced.

These counterfactuals are foundational to the public charging evaluation, impacting the EV adoption analysis as well as analyses of petroleum displacement, GHG and criteria pollutant emissions reductions, and grid impacts. The subsections below describe the approach, data sources, and analyses performed to develop the counterfactuals for Public Charging.

The Evaluation Team calculated the electric LDV counterfactual for EY2023 as average EV efficiency (kilowatt-hours per mile) using a weighted average for the most popular new EVs in each Utility territory. Next, the Team calculated the conventional LDV counterfactual for EY2023 as the average fuel economy (miles per gallon) for a representative LDV on the road that the electric LDV counterfactual replaces based on the comparable mix to the EVs available (currently this mix is sedans along with small and mid-size SUVs [some Rivian and Ford light-duty trucks have reached the market, but these currently represent less than 2% of the total EVs on the road], but that mix is expected to change over time). We determined that the counterfactual is a composite of all equivalent new vehicles that could have been purchased instead of an EV over the past five years.

The Evaluation Team used the secondary data presented in Table 183 to develop the electric and conventional LDV counterfactuals.

Table 183. Counterfactual Data Inputs by Category

Category	Data Inputs
Electric LDV Counterfactual	New EV sales by county: https://www.energy.ca.gov/files/zev-and-infrastructure-stats-data
	EV efficiency: www.fueleconomy.gov
Conventional LDV Counterfactual	BEV and PHEV registrations by county: https://www.energy.ca.gov/files/zev-and-infrastructure-stats-data
	Popular counterfactual vehicles sold and percentage of their sales: https://www.cncda.org/news/?category=auto-outlook
	Fuel economy: www.fueleconomy.gov

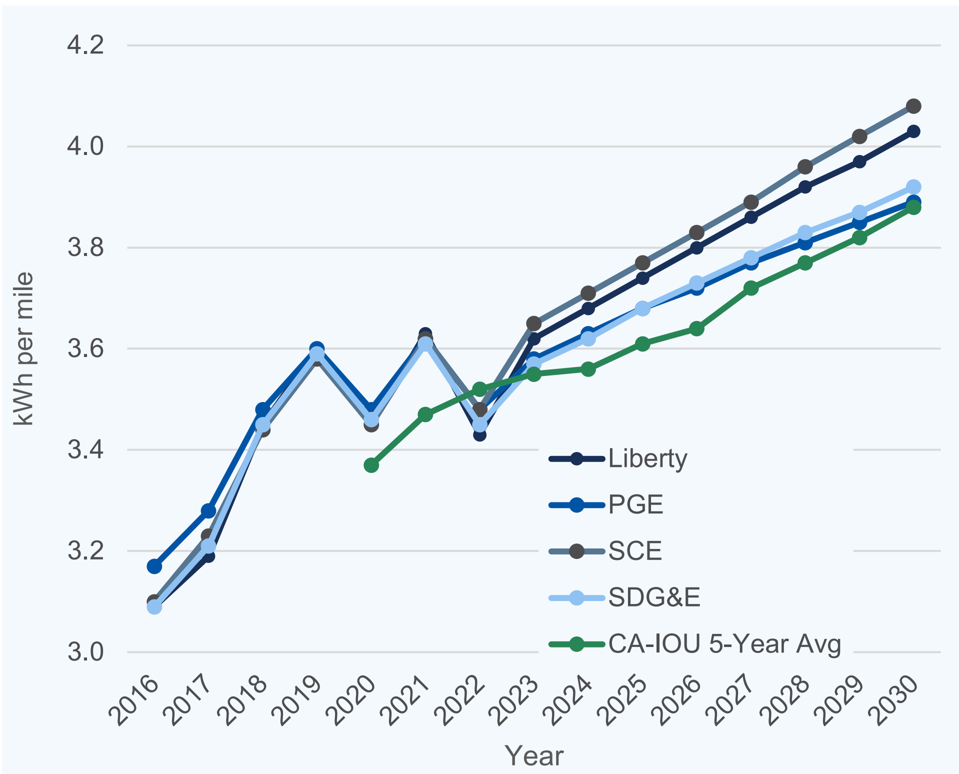
The counterfactual results from 2016 through 2022 are shown in Table 184.

Table 184. Electrical Vehicle Efficiency by Year and Utility

Year	Liberty	PG&E	SCE	SDG&E	CA Utility Average (kWh/mile)	Largest Difference	CA Utility 5-Year Average (kWh/mile)	5-Year Efficiency (kWh/mile) Average
2016	3.09	3.17	3.10	3.09	3.11	2.6%	-	-
2017	3.19	3.28	3.23	3.21	3.23	2.8%	-	-
2018	3.45	3.48	3.44	3.45	3.46	1.3%	-	-
2019	3.60	3.60	3.58	3.59	3.59	0.7%	-	-
2020	3.45	3.48	3.45	3.46	3.46	0.9%	3.37	0.297
2021	3.63	3.62	3.62	3.61	3.62	0.5%	3.47	0.288
2022	3.43	3.48	3.48	3.45	3.46	1.6%	3.52	0.284

The Team used the single most recent five-year average (accounting for the most likely mix of EVs using these stations) for all participating Utilities because the difference between Utilities (due to the different EV makeup) is not significant, as shown in Figure 277.

Figure 277. EV Efficiency Per Utility Per Year



The Team then identified the comparable vehicle type mix, shown in Figure 278, which resulted in California-wide counterfactual weighted averages for 2017 through 2022, as well as the prior five-year average (as shown in Figure 278 and Table 185).

Figure 278. EV Market Share Penetration Rates to Reach 100% BEV Sales by 2035

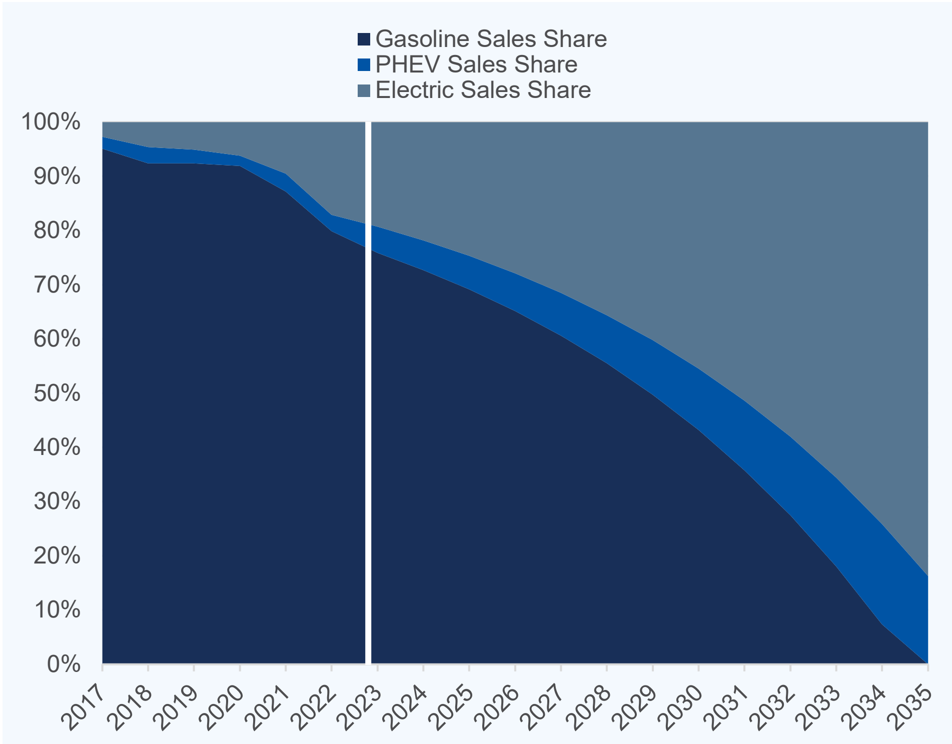


Table 185. Counterfactual Vehicle Fuel Economy by Year

Year	Gasoline	PHEV	Electric	Weighted Average	Last 5-Year Average
2017	27.00	71.83	109.38	30.21	-
2018	27.06	72.98	111.82	32.33	-
2019	26.90	72.69	117.07	32.64	-
2020	27.46	70.65	115.95	33.76	-
2021	28.13	63.06	121.75	38.18	**33.43**
2022	28.36	58.14	120.10	44.94	**36.37**

Petroleum Displacement

One goal of the Public Charging programs is to reduce the amount of petroleum fuel conventional vehicles used as they are replaced by EVs. As part of this analysis, the Team examined petroleum fuel reduction at the program and bundle levels. This section describes the approach, data sources, and analyses we performed to estimate the Public Charging–related petroleum fuel reduction.

The Team determined the reduction in gasoline equivalent gallons of petroleum compared to electric usage as a result of the Public Charging programs. To complete this analysis, we calculated annual energy consumption, EV annual miles traveled, and annual counterfactual vehicle fuel consumption, as described in the *Counterfactual Development* section above.

The Team developed a petroleum displacement tool to estimate EV miles traveled by converting electrical energy use from the EV Public Charging programs in kilowatt-hours from Utility AMI data to petroleum displaced by the use of electricity. We assumed that conventional vehicles would have been driven the same number of miles in absence of the program (the counterfactual). We then calculated the petroleum displacement in terms of the GGE using the petroleum displacement equation shown in Equation 2:

Equation 2. Petroleum Displacement Calculation

$$Gallons\_Displaced_{x,y} = \frac{Annual\ kWh_{x,y} * (1 - Charger\_Losses) * Counterfactual\_Efficency_z}{EV\_Efficiency_{x,y}}$$

The Team used the primary and secondary data presented in Table 186 for the Public Charging petroleum analysis.

Table 186. Public Charging Petroleum Displacement Data Inputs

Category	Source
Primary (critical) Data	Utility AMI data, EMFAC database, and counterfactual tables to assign linkages between sites and EMFAC Vehicle Classification Codes
Secondary Data	EVSE (interval and charging session) data

The Team conducted a range of categorical analyses (shown in Table 187) using tools that include Azure Studio (SQL statements for the resulting calculations), the counterfactual lookup table (populated by the EMFAC and other sources), and outputs from analysis described above. As noted above, Utility AMI data were the basis for much of this analysis.

Table 187. Analysis of Petroleum Displacement

Category	Analysis
Reference Counterfactuals and Secondary Data	For each vehicle type, referenced gallons per mile and kilowatt-hours per mile efficiency from: • Vehicle counterfactuals • Five-year weighted average based on California Department of Motor Vehicles vehicle registrations from CEC [a] and individual vehicle fuel economies for both EV and conventional vehicles from the U.S. EPA [b]
Determine EV Energy Consumption	Referenced annual kilowatt-hours consumed by EVSE at each site (as described in the *Grid Impacts* analysis)
Account for Charging Losses	Compared AMI data to EVSP session data
Calculate Vehicle Miles	Determined miles based on kilowatt-hours consumed using reference counterfactual
Estimate Petroleum Displacement	Estimated petroleum displacement based on conventional miles and fuel consumption factor of conventional vehicles

[a] California Energy Commission. 2023. "Light-Duty Vehicle Population in California." https://www.energy.ca.gov/data-reports/energy-almanac/zero-emission-vehicle-and-infrastructure-statistics/light-duty-vehicle

[b] U.S. Department of Energy. 2023. "Fuel Economy." https://www.fueleconomy.gov/

GHG and Criteria Pollutant Impacts

This section describes the methods and sources for calculating GHG emission reduction and criteria pollutant emissions reductions. The Public Charging programs are expected to reduce the amount of GHG and criteria pollutants emitted into the environment as EVs replace conventional ICE vehicles.

The Team calculated reduced emissions from displaced fossil fuel use from ICE vehicles that were not in service because of the Public Charging programs. We first developed an ICE counterfactual, then calculated the emissions associated with these vehicles under conditions that otherwise matched the EVs to create a baseline.

The criteria pollutants emissions reduction calculations account for NO_x, $PM_{2.5}$ and PM_{10}, carbon monoxide (CO), and SO_x. The Evaluation Team also estimated emissions reductions of ROGs, which are not criteria pollutants.

Because the electric grid emissions profile varies substantially by time of day and season, the Evaluation Team estimated reductions using actual 8760-hour load curves based on Utility meter data and calculated the annual avoided emissions implied by the gallons of fossil fuels that were displaced.

The total program and Pilot emissions impact presented for key pollutants in Table 188 are net of annual emissions from the displaced counterfactual fossil fuel equipment and the electricity consumed annually by the adopted electric equipment. Local emissions reductions are presented for the remaining pollutants. We developed GHG and criteria pollutants reduction estimates for the overall program, each Utility, and the individual DACs.

Table 188. GHG and Criteria Pollutant Data Inputs

Description	Unit	Source
Site-Level AMI Electric Data in 15-Minute Intervals	kWh	Utility AMI (~1 month delay between measurement and reporting)
Overall Electricity Demand by 5-Minute Interval	MWh	CAISO Demand (Real time)
CO_2 Grid Emission by 5-Minute Interval	MT	CAISO Emissions (Real time)
Resource Mix by Interval	% by generator fuel	CAISO Supply (Real time)
California Utility Integrated Resource Planning Clean Power System Tool	% by generator fuel	CPUC Developed Clean Power System Tool
Electricity Emission Factors by Resource (details below)	Lb/MWh [a]	EPA eGRID (2022)
NO_x Emissions Rate	grams/kWh	
SO_2 Emissions Rate	grams/kWh	
CO_2 Emissions Rate	kg/kWh	
CH_4 Emissions Rate	grams/kWh	
N_2O Emissions Rate	grams/kWh	
CO_2 Equivalent Emissions Rate	kg/kWh	
Vehicle Emissions (ROG, CO, NO_x, CO_2, PM_{10}, $PM_{2.5}$, SO_X) by Vehicle and Fuel	g/mi	CARB EMFAC (2021 v.1.0.2)
Vehicle Type (Vehicle Classification Codes or linkage to emission tables)	Standard category	Petroleum reduction methodology
Petroleum Use by Month	Unit measure	Petroleum reduction methodology
Petroleum Fuel Type	name	Petroleum reduction methodology

[a] Units provided by eGRID are in pounds per megawatt-hour and converted to grams per kilowatt-hour (and kilograms per kilowatt-hour for CO_2) for the purposes of this work.

These are multiyear programs, and several input sources are updated periodically. The Team uses newly published resources as they become available.

The Team completed the analysis in four steps using the CAISO application programming interface, the CPUC IRP RESOLVE model, the U.S. EPA's eGRID, and EMFAC:

- **Electricity emissions:** We used CAISO five-minute demand and resource mix data reported by zone to establish an emissions record for each pollutant. We averaged five-minute interval emissions data, applied this to each 15-minute AMI interval, and applied the CAISO-specific emissions factors for that resource provided by the U.S. EPA's eGRID dataset.
- Counterfactual emissions. The Team determined baseline emissions for counterfactual vehicles using EMFAC for specific displaced fuel use. We determined this value based on the application using a standard source for lower heating value energy content available within that fuel on a per unit energy (Btu) basis. This is most often measured in Btus per gallon to derive the grams per gallon and ultimately the tons per year. The factor provided by EMFAC encompasses the estimated number of cold starts and the idling operation.
- **GHG calculation.** We used the United Nations IPCC GWPs for CO_2 equivalence (CO_2e) on a 100-year timeframe based on the IPCC AR5. For EY2023, we used GWP-100 factors of 28 for CH_4 and 265 for N_2O. Equation 3 presents the GHG calculation based on CO2e:

Equation 3. GHG Calculation

$$CO_2e = CO_2 + 28 * CH_4 + 265 * N_2O$$

- **GHG and criteria emissions reductions.** The overall reduction in GHGs, NO_x, and SO_x was net of annual emissions from the displaced counterfactual fossil fuel equipment and the electricity consumed by the adopted electric equipment. The overall reduction in $PM_{2.5}$, PM_{10}, CO, and ROG was represented by the annual emissions from the counterfactual vehicle, as these pollutants present localized effects on populations unlike the more globalized effects of the other pollutants. The Team calculated these emissions reductions for sites both inside and outside DACs.

Health Impacts

As EVs replace traditional ICE vehicles, petroleum-based fuels are displaced. These displacements reduce GHG and air pollutant emissions, which may lead to health benefits in regions where EVs are adopted. To understand the effects of the public charging programs on air pollution and related health benefits, the Team estimated the monetized value of health benefits for each individual Utility-funded site by running the emissions reductions through the U.S. EPA's COBRA. As part of this analysis, we also examined the impact on DACs. For Liberty, PG&E, and SCE, DACs are identified in the California Communities Environmental Health Screening Tool, CalEnviroScreen, developed by California's Office of Environmental Health Hazard Assessment. SDG&E uses a service territory definition of DAC.[182] This section describes the approach, data sources, and analyses performed to estimate health impacts associated with the public charging programs.

The Evaluation Team used a four-stage methodology to estimate health impacts, shown in Figure 279 and described below.

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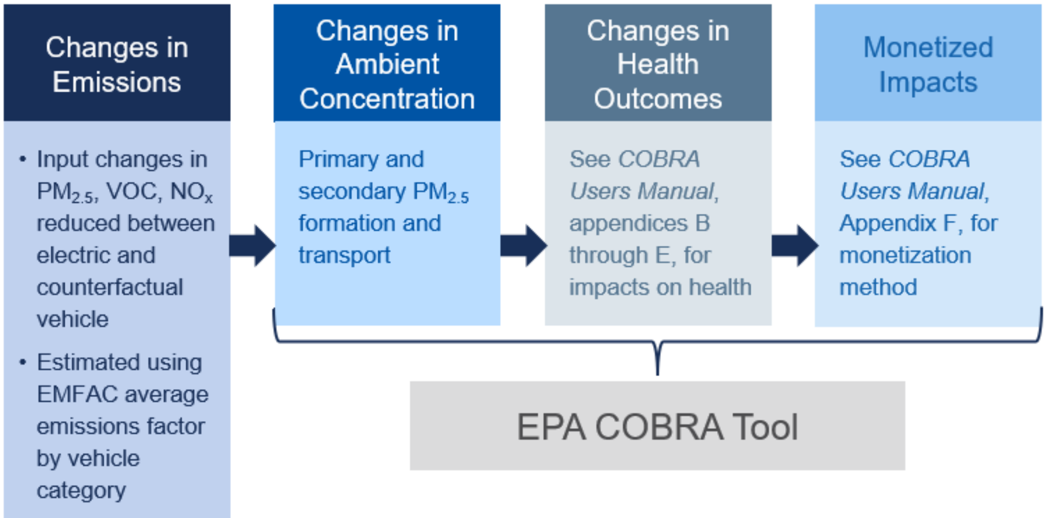
182 As per Advice Letter 2876-E, SDG&E found that only 27 census tracts in its territory were considered DACs using the top quartile in the CalEnviroScreen statewide definition. However, the service territory definition is broader and produced a calculated 180 DAC census tracts in SDG&E service territory.

Figure 279. Four-Step Process for Estimating Health Impacts by Census Tract



Step 1: Changes in Emissions. These estimates are annualized emissions reductions by project site for EY2023 in tons for $PM_{2.5}$, VOCs, and NO_x. The Evaluation Team aggregated emissions reductions by county and used those as inputs for the U.S. EPA COBRA, which uses several fields:

- **Sector** – Highway vehicles or off-highway sector
- **Subsector #1** – Diesel for most vehicle applications
- **Subsector #2** – Subsector of highway or non-road
- **Discount rate** – Three percent assumed, which reflects the interest rate consumers might earn on government-backed securities

Steps 2 through 4 are run using the COBRA desktop version. The Evaluation Team uploaded the annual reductions in emissions for $PM_{2.5}$, VOCs, and NO_x and the tool output estimates as shown in Table 189. In this analysis VOCs are assumed to be the same as ROGs, which are the output from EMFAC.

Table 189. Mapping of Vehicle Types to Sector, Subsector #1, Subsector #2

Vehicle Type	Sector	Subsector #1 (Counterfactual Fuel Type)	Subsector #2 (Counterfactual Fuel Type)	Discount Rate
LDVs (at public charging sites)	Highway vehicle	Gasoline fuel	Light-duty	3%

Step 2: Changes in Ambient Concentration. The U.S. EPA COBRA has a feature that uses the reductions in emissions to estimate the change in ambient concentration. The tool also accounts for transport and the transformation of pollutants (for example, into ozone).

Step 3: Changes in Health Outcomes. The U.S. EPA COBRA uses epidemiological models to estimate the health impacts of these emissions changes at the county level. COBRA's estimates reflect the current scientific thinking on the relationship between particulate matter and human health, as well as the economic valuation of these health effects. In particular, the U.S. EPA draws from the Integrated Science

Assessment for Particulate Matter,[183] and its methodology for characterizing health impacts has been reviewed by two National Academy of Sciences panels and multiple U.S. EPA Science Advisory Boards. Because the health impacts of air pollution and approaches to value these impacts are areas of active research, the selection of studies used in COBRA may evolve over time as new evidence and studies emerge. More information is available in the online COBRA documentation.[184] Note that COBRA estimates health impacts for all 3,033 counties in the United States (because of the transport of the pollutants).

Step 4: Monetized Impacts. The U.S. EPA COBRA estimates the economic value (in 2017 USD) of the change in health impacts from the emissions changes at the county level. These values are converted to 2023 USD using the multiplier of 1.23 (that is, $1.00 in 2017 is the same as $1.23 in 2023).[185] Economic value is estimated differently depending on health impacts (such as by estimating avoided lost wages, avoided medical costs, the amount people are willing to pay to avoid a negative health impact [such as respiratory symptoms], or the VSL approach, which uses value-of-life studies to determine a monetary value of preventing premature mortality). COBRA reports both a low impact and a high impact, representing uncertainties in the estimates. The low estimate is based on an evaluation of mortality impacts of $PM_{2.5}$ by the American Cancer Society,[186] and the high estimate is based on the Harvard Six Cities mortality study.[187] Rather than average the results of these studies, the U.S. EPA's standard practice has been to report the estimated change in mortality separately as low and high values.

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[183] U.S. Environmental Protection Agency. Last updated June 27, 2022. "Integrated Science Assessment (ISA) for Particulate Matter." https://www.epa.gov/isa/integrated-science-assessment-isa-particulate-matter

[184] U.S. Environmental Protection Agency. Last updated November 1, 2022. "Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool COBRA." https://www.epa.gov/cobra/users-manual-co-benefits-risk-assessment-cobra-screening-model

[185] U.S. Bureau of Labor Statistics. 2023. "CPI Inflation Calculator." https://www.bls.gov/data/inflation_calculator.htm

[186] Krewski, Daniel et al. May 2009. "Extended Follow-Up and Spatial Analysis of the American Cancer Society Study Linking Particulate Air Pollution and Mortality." *Res Rep Health Effects Institute* (140): 5–114. https://pubmed.ncbi.nlm.nih.gov/19627030/

[187] Lepeule, Johanna, Francine Laden, Douglas Dockery, and Joel Schwartz. March 28, 2012. "Chronic Exposure to Fine Particles and Mortality: An Extended Follow-Up of the Harvard Six Cities Study from 1974 to 2009." *Environmental Health Perspective* 120(7): 965–970. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3404667/

Site Visits

The Team conducted visual site visits for the Public Charging programs during EY2023 to provide qualitative insights on activated EV infrastructure sites. This section describes the approach, data sources, and analyses performed for the EY2023 Public Charging site visits.

The Team took a census approach in EY2023, visiting all active sites. The Team collaborated with the Utilities and site hosts, as appropriate, to access each site location and complete the EY2023 site visits. For the analysis, the Team used detailed notes and photos taken during each site visit as well as data provided by the Utilities. After each site visit, the Team compiled the notes, photos, and completed data into the Arkenstone data collection platform.

The Team then analyzed the data to document qualitative insights such as critical design elements including the number of dedicated and other parking spots parking spots within reach of charging ports, charger signages, distances from surrounding buildings to charging, optimization of the number of vehicles that can charge at one time, competition for parking (such as at convenience stores), and any upgrades made by the Utilities to comply with ADA rules that require additional space for parking and charging. The Team also compared retail rates for charging by station patrons and determined if TOU charges were in place. Finally, the Team quantitatively compared counts of chargers/ports and installed electrical capacity with the Utility-provided information.

Interviews

This section describes the approach, data sources, and analyses performed for the EY2023 Utility interviews. The Team conducted Utility staff interviews (SCE, PG&E, SDG&E, and Liberty) to provide insight into program design and implementation and context to analysis outputs and findings. For the Public Charging programs, the Team interviewed all Utility program managers to cover a variety of topics about their respective programs.

The Team developed interview guides outlining key topic areas and questions for discussion to ensure that we covered each topic area during the phone interview:

- Status updates and changes from EY2022 (and before)
- Program design
- Key milestones
- Key barriers to implementation and solutions
- Preliminary areas of success and lessons learned

The Evaluation Team tailored each interview guide based on information previously provided by the Utilities to ensure an effective use of time. A group of various Evaluation Team members conducted the interviews to ensure coverage across all relevant evaluation areas.

The Team reviewed verbatim notes taken during each interview as the basis of our analysis. We integrated those findings throughout the report, informing many sections including program overviews, materials reviews, and Utility interview analysis findings.

Vehicle-to-Grid (SDG&E) Evaluation Methodology

This section outlines the data collection and analysis for the V2G Pilot evaluation.

Data Collection Methodology

The following sections discuss data collection for the V2G Pilot evaluation, including Pilot data and materials; in-depth interviews; driver surveys; and AMI, EVSE, and telematics data.

Pilot Data and Materials

Pilot data provides essential insights into Pilot performance. The Evaluation Team reviewed all SDG&E Advice Letters and PAC presentations since 2020 and attended project team meetings during spring and summer 2023 on an as-needed basis.

Interviews

In-depth interviews provided critical insight on the original intent, actual implementation, and success of the Pilot and on its potential to scale up. For EY2023, the Evaluation Team conducted two phone interviews: one with Utility staff and one with the site host. We developed interview guides outlining key topic areas and questions for discussion to ensure that we covered each topic area during the phone interview. Topics included staff roles and responsibilities, Pilot design and implementation, and areas of challenges and successes. The Team's evaluation lead conducted the interviews and recorded notes to reference during our analysis.

Driver Survey

In Fall 2023, the Evaluation Team developed a driver survey guide and deployed it to 20 drivers and maintenance staff who interact with the electric school buses. The guide presented questions about the experience of driving these EVs and using the site's charging infrastructure.

AMI, EVSE, and Telematics Data

The Evaluation Team used SDG&E's AMI data to estimate charger usage, a key input for subsequent analyses and estimations of Pilot impacts, such as impacts to the grid, petroleum displacement, and emissions reductions from EV adoption. The Team collected and securely transferred all AMI data between the Utility and Microsoft Azure cloud-based environments. Our Team used Azure Databricks to transform and standardize the data, which we then imported into an SQL server data warehouse. Once we received this data, we input it into the Cadmus data warehouse for secure storage and retrieval and aggregated it for subsequent calculations and analysis. Time-stamped energy consumption data were recorded in 15-minute intervals.

The Evaluation Team collected and reviewed data from the Nuvve, the Pilot EVSP to examine charging session frequency, duration, and demand.

The Team also collected vehicle telematics data from Lion Electric's online Lion Beat platform, including odometer readings, charging session start and end state of charge, AC versus DC charging power input, and battery state of health.

Analysis Methodology

The following section provides an overview of the EY2023 analysis for the V2G Pilot.

Interviews

The Team conducted phone interviews with Utility staff and the site host. Then the Team integrated these findings in the report, informing the Pilot overview and status, interview analyses findings, and lessons learned. This section describes the approach and analyses performed for the EY2023 interviews.

The Team developed interview guides outlining key topic areas and questions for discussion to ensure that we covered each topic area during the phone interviews:

- Staff roles and responsibilities
- Pilot status
- Technology challenges
- Key barriers to implementation and solutions
- EY2023 areas of success and lessons learned
- Vehicle battery degradation impacts from V2G operation

The Team relied on Pilot materials and V2G site team meeting notes as the foundation for developing the interview guides. The Team reviewed notes taken during each interview, summarized findings, and developed insights and lessons learned from the individual interviews.

Driver Survey

The Evaluation Team deployed the driver survey via Qualtrics in Fall 2023, summarized the results, and developed findings and lessons learned.

AMI, EVSE, and Telematics Data

The Evaluation Team followed the same AMI data analysis methodology to estimate grid impacts, petroleum displacement, and GHG and criteria pollutant reductions as described in the Medium-Duty Heavy-Duty *Analysis Methodology* section. We also analyzed key vehicle telematics data including charging session start and end state of charge, AC versus DC charging power input, and battery state of health.

Truck Choice Model Methodology

This section introduces and outlines the data collection and analysis for the TCM, which the Evaluation Team used as one method of assessing the impacts of the Utility MDHD programs.

Introduction

The Evaluation Team used a modified version of the TCM developed at the University of California, Davis,[188] which focuses on factors that influence fleets' purchasing decisions about truck technology. In this study the key variable factor is the level of funding the California Utilities provide for installing electric infrastructure for fleets that purchase battery electric trucks or buses. By examining the results of varying amounts of funding from the Utilities, including zero level of support, the Evaluation Team can use the model to estimate the effect of infrastructure funding on fleet adoption of BEVs.

The Evaluation Team disaggregated MDHD vehicles (trucks and buses) into several categories that encompass specific vehicle types and use patterns (such as transit buses, short-haul trucks, medium-duty delivery trucks, and others).[189] The Team then segmented these truck categories into ownership categories (early adopter, late adopter, and in-between) that have different impacts on truck purchases. Early adopters are those fleets that may perceive less risk or greater value in new technologies. Late adopters are those fleets that may perceive more risk or less value in new technologies. In-between fleets fall somewhere between the early and late adopters. The Evaluation Team used the model to generate the calculated market sales shares.

The model is structured as a nested multinomial logit model that includes several important choice factors that influence individual fleet decision-makers' preferences among a suite of vehicle technology options. Choice factors include private economic costs, non-monetary costs, and incentives or subsidies. The Evaluation Team used the model to calculate a total generalized cost, which is a numerical value that represents the summation of both monetary and non-monetary factors, including capital cost, fuel cost, green public relations, uncertainty or risk associated with the new technology, incentives, refueling inconvenience, maintenance cost, carbon tax, and model availability cost. We calculated monetary factors in U.S. dollars and quantified non-monetary factors according to certain functions so these factors could also be expressed in U.S. dollars.

The Evaluation Team calculated the generalized cost for each truck type (such as long haul, medium-duty urban, transit bus, and so on) for each technology type such as diesel, natural gas, hybrid, FCEV, BEV, and gasoline. We then used these generalized costs to derive the market share for each technology type. The Team applied a monotone transformation on the total generalized costs for each truck and technology type (e.g. fuel cell short-haul trucks, diesel transit buses, battery electric medium-duty

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188 Miller, Marshall, Qian Wang, Lewis Fulton, NCST Research Report: Truck Choice Modeling: Understanding California's Transition to Zero-Emission Vehicle Trucks Taking into Account Truck Technologies, Costs, and Fleet Decision Behavior, Institute of Transportation Studies, University of California, Davis, Research Report UCD-ITS-RR-17-36, 2017.

189 These vehicle categories do not line up exactly with the market sectors the Evaluation Team uses throughout this study, because the Team uses a modified version of the TCM developed by University of California, Davis, which was developed before the start of this evaluation.

delivery trucks, etc.) to yield purchase probabilities; the technology with the highest total generalized cost has the lowest purchase probability, the technology with the second highest total generalized cost has the second lowest purchase probability, and so on.

The Evaluation Team used a variety of methods to project future values for the various factors. We estimated capital cost increases for conventional vehicles assuming increasing after-treatment or engine costs necessary to reduce emissions. We estimated reductions in the cost of BEVs and FCEVs using models of component costs such as batteries, fuel cells, hydrogen storage tanks, and power electronics. We assumed that maintenance costs for conventional vehicles, expressed in dollars per mile, remain constant and that these costs decrease over time for BEVs and FCEVs, based on studies of these advanced technologies in heavy-duty vehicles.

The Evaluation Team modeled non-monetary costs, such as uncertainty or green public relations, with an exponential reduction in their monetary value based on the assumption that as the technology gains market acceptance, the disincentive (uncertainty) or incentive (green public relations) decreases. The non-monetary factors have constants that determine the present disincentive or incentive value; however, these constants are difficult to pinpoint due to a lack of real-world data and the corresponding difficulty of properly calibrating the model. The model outputs the sales shares of each vehicle technology as a function of time.

The financial support the Utilities provided for the installation of hardware to charge fleet BEVs included support as required by AB 841 for TTM hardware along with the support available in the current Utility programs, including rebates for EVSE and incentives for BTM hardware. Several fleet adoption trajectories were run for each sector (vehicle type) depending on the level of support we assume the utilities will provide. The sectors included are transit buses, school buses, medium-duty delivery trucks, heavy-duty delivery trucks (short-haul), and transport refrigeration units (TRUs).

Model Inputs and Assumptions

The TCM uses a variety of inputs related to the various choice factors. In this section we describe some of the inputs the Team used, provide estimates of the values of those inputs, and discuss any assumptions we made.

Vehicle Cost

Vehicle cost estimates tend to vary from study to study, so a complete set of data from a single study will be more consistent than data from separate studies. Different studies may choose slightly different vehicle configurations for a given truck type. For example, medium-duty delivery trucks can be found in Class 4 through Class 6 and can have a variety of components. For each market sector in this report, we first looked for studies that had a complete or nearly complete set of cost data for diesel, BEV, and FCEV technologies for 2023, 2025, and 2030. In some cases no single study had such a complete set, so we used data from more than one study or used a single study with missing data and extrapolated for years when data was unavailable. In general, when it was necessary to combine data from different studies, we looked for studies that agreed reasonably well on cost estimates. The Evaluation Team also looked for studies that had similar projected costs for EV components for at least one technology type given that some studies assume significantly more rapid reductions than others.

Short-Haul Delivery Trucks

Studies by CARB[190], UC Davis[191], and ICCT[192] had reasonably complete cost estimates for short-haul trucks. In general, the estimates in these three studies agreed fairly closely for most of the costs. We chose to use the UC Davis values for each year and technology type. Table 190 shows the cost inputs for short-haul trucks. We assumed that only diesel, BEV, and FCEV would have significant sales.

Table 190. Cost Inputs for Short-Haul Trucks

Year	Technology		
	Diesel	BEV	FCEV
2020	$119,000	$275,000	$312,000
2025	$121,000	$225,000	$182,000
2030	$123,000	$160,000	$144,000

Medium-Duty Delivery Trucks

Studies by CARB[193] and UC Davis[194] have fairly complete cost estimates for diesel, BEV, and FCEV medium-duty trucks. The Evaluation Team used the UC Davis costs. Medium-duty delivery trucks have a significant share of gasoline trucks, so we include gasoline in our costs. Table 191 shows the cost inputs for medium-duty trucks.

Table 191. Cost Inputs for Medium-Duty Delivery Trucks

Year	Technology			
	Diesel	BEV	FCEV	Gasoline
2020	$90,000	$168,000	$248,000	$73,950
2025	$92,000	$143,000	$142,000	$85,000
2030	$95,000	$119,000	$111,000	$87,000

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190 Draft Advanced Clean Fleets Total Cost of Ownership Discussion Document. California Air Resources Board. September 9, 2021

191 Burke, Andrew, Marshall Miller, Anish Kumar Sinha, Lewis Fulton, Evaluation of the Economics of Battery-Electric and Fuel Cell Trucks and Buses. Methods, Issues, and Results, Institute of Transportation Studies, University of California, Davis, Research Report UCD-ITS-RR-22-88, 2022.

192 Ben Sharpe and Hussein Basma, A Meta-Study of Purchase Costs for Zero-Emission Trucks, International Council on Clean Transportation, Working Paper 2022-09, February 2022.

193 Final Regulation Order, Advanced Clean Trucks Regulation, California Air Resources Board. 2021. https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2019/act2019/fro2.pdf

194 Burke, Andrew, Marshall Miller, Anish Kumar Sinha, Lewis Fulton, Evaluation of the Economics of Battery-Electric and Fuel Cell Trucks and Buses. Methods, Issues, and Results, Institute of Transportation Studies, University of California, Davis, Research Report UCD-ITS-RR-22-88, 2022.

Transit Buses

As part of CARB's ICT regulation, CARB created a transit fleet cost model that estimates the cost of diesel, CNG, battery electric, and fuel cell buses.[195] Table 192 shows the cost inputs for transit buses.

Table 192. Cost Inputs for Transit Buses

Year	Technology			
	Diesel	BEV	FCEV	CNG
2020	$477,409	$785,000	$800,000	$542,896
2025	$536,281	$775,000	$742,760	$602,445
2030	$602,412	$795,000	$781,000	$669,337

School Buses

The World Resources Institute published a study about school bus TCO that provides present costs for only diesel and BEV school buses.[196] The California HVIP program lists many eligible battery electric school buses but no fuel cell school buses, so we considered only diesel and BEV school buses for this study. We assumed that cost increases for diesel school buses will be similar to the increases CARB estimated for medium-duty delivery trucks. To estimate the cost reductions in BEV school buses through 2030, we assumed the same percentage reduction as seen for medium-duty and short-haul BEVs. Table 193 shows the cost inputs for school buses.

Table 193. Cost Inputs for School Buses

Year	Technology	
	Diesel	BEV
2020	$103,000	$352,000
2025	$106,709	$246,400
2030	$110,403	$221,760

Transportation Refrigeration Units (TRUs)

TRUs are refrigeration systems powered by diesel engines or battery packs that are integral to the unit. We considered them as separate systems, and rather than estimating the costs for the entire vehicle we estimated the cost for the units themselves. CARB produced a technology assessment of TRUs that includes estimates of their capital and operating costs but does not include costs for eTRUs.[197] Go Electric produced an eTRU fact sheet that does include costs for both diesel and electric TRUs. The diesel

[195] California Air Resources Board, Transit Fleet Cost Model, 2023. Accessed on March 27, 2023. https://ww2.arb.ca.gov/resources/documents/transit-fleet-cost-model

[196] Levinson, M., P. Burgoyne-Allen, A. Huntington, and N. Hutchinson. "Recommended total cost of ownership parameters for electric school buses: Summary of methods and data." Technical Note. Washington, DC: World Resources Institute. 2023.

[197] 2022 Technology Assessment: Non-Truck Transport Refrigeration Units (TRU), Trailer TRUs, Domestic Shipping Container TRUs, Railcar TRUs, and TRU Generator Sets. October 2022. https://ww2.arb.ca.gov/sites/default/files/2022-10/CARB%202022%20TRU%20Technology%20Assessment%2010-14-22.pdf

costs from the CARB and Go Electric sources were similar, so we used the capital costs from the Go Electric fact sheet. The sources did not attempt to project costs for 2030, and we assumed constant costs from 2025 through 2030. Only costs for diesel and battery electric TRUs are included in this study. Table 194 shows capital costs for TRUs.

Table 194. Costs Inputs for eTRUs

Year	Technology	
	Diesel	BEV
2025	$30,100	$34,750
2030	$30,100	$34,750

Fuel Costs

Weekly California diesel and gasoline fuel prices are collected by the Energy Information Agency.[198] These prices vary somewhat from week to week, and the Evaluation Team chose an average for recent weeks. Electricity costs are taken from data supplied to the Team from the Utilities. These data vary slightly for different sectors, but we chose to use $0.25 per kilowatt-hour for all sectors. UC Davis researchers have studied hydrogen fueling stations for several years and have produced estimates of future hydrogen costs for vehicles. These costs vary significantly based on a variety of factors. We chose to use $12 per kilogram for 2025 and $10 per kilogram for 2030. Table 195 shows the projected prices for diesel, gasoline, electricity, and hydrogen through 2030. We assume prices will remains constant for all except hydrogen.

Table 195. Diesel, Gasoline, Electricity, and Hydrogen Costs in California

Year	Diesel (per gallon)	Gasoline (per gallon)	Electricity (per kWh)	Hydrogen (per kg)
2025	$5.32	$5.26	$0.25	$12
2030	$5.32	$5.26	$0.25	$10

Fuel Economy

The Evaluation Team used values for fuel economy for short-haul trucks, medium-duty delivery trucks, and transit buses from the UC Davis TCO study.[199] Each vehicle was modeled using the Advisor Simulation Program developed by Argonne National Lab and extensively modified at UC Davis.[200] The vehicles were simulated using representative drive cycles to determine fuel economy, and the vehicle characteristics varied over time such that the fuel economies increased. We used values for school bus

198 Weekly Gasoline and Diesel Prices. Accessed on May 8, 2024. https://www.eia.gov/dnav/pet/pet_pri_gnd_dcus_sca_w.htm

199 Burke, Andrew, Marshall Miller, Anish Kumar Sinha, Lewis Fulton, Evaluation of the Economics of Battery-Electric and Fuel Cell Trucks and Buses. Methods, Issues, and Results, Institute of Transportation Studies, University of California, Davis, Research Report UCD-ITS-RR-22-88, 2022.

200 Burke, A.F. and Zhao, H., Projected fuel consumption characteristics of hybrid and fuel cell vehicles for 2015–2045, paper presented at the Electric Vehicle Symposium 25, Shenzhen, China, November 2010.

fuel economy for 2020 from the World Resources Institute study.[201] Because the study did not project fuel economies, we assumed they would increase by the same ratio as the transit bus fuel economies from 2020 through 2030. Table 196 shows the fuel economies for each sector and technology type over time.

Table 196. Vehicle Fuel Economy for Each Sector in Miles per Gallon of Gasoline-Equivalent

Year	Diesel	Battery Electric	Fuel Cell	Gasoline	Natural Gas
Short-Haul Trucks					
2020	6.16	14.34	9.09		
2025	6.60	14.98	10.00		
2030	7.22	15.97	10.53		
Medium-Duty Delivery Trucks					
2020	9.94	40.60	24.80	7.13	
2025	10.56	42.60	25.50	8.00	
2030	11.18	44.69	27.20	8.25	
Transit Buses					
2020	3.96	16.05	10.00		4.24
2025	4.40	16.85	11.11		5.08
2030	4.84	18.52	12.05		5.30
School Buses					
2020	6.59	22.10			
2025	7.32	23.21			
2030	8.05	25.50			

TRUs are not used to propel vehicles and do not have associated fuel economies in energy per mile. Instead, TRU fuel use is calculated as the fuel used per hour multiplied by the expected number of hours in operation. The CARB assessment estimates TRU fuel use for diesel TRUs as $5,200 per year and for eTRUs as $3,040 per year.[202]

Maintenance Costs

Relatively little data exists on maintenance costs for advanced technology trucks. Until more trucks are commercialized and data becomes available, we will have to make assumptions about the expected reductions in cost for BEVs and FCEVs. A study at UC Davis estimated maintenance cost reductions over time for heavy-duty vehicles.[203] We used the results from that study to project maintenance costs through 2030 for BEVs and FCEVs. The study concluded that BEV maintenance costs are currently

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[201] Levinson, M., P. Burgoyne-Allen, A. Huntington, and N. Hutchinson. "Recommended total cost of ownership parameters for electric school buses: Summary of methods and data." Technical Note. Washington, DC: World Resources Institute. 2023.

[202] 2022 Technology Assessment: Non-Truck Transport Refrigeration Units (TRU), Trailer TRUs, Domestic Shipping Container TRUs, Railcar TRUs, and TRU Generator Sets. October 2022. https://ww2.arb.ca.gov/sites/default/files/2022-10/CARB%202022%20TRU%20Technology%20Assessment%2010-14-22.pdf

[203] Wang, Guihua, Marshall Miller, Lewis Fulton, Estimating Maintenance and Repair Costs for Battery Electric and Fuel Cell Heavy Duty Trucks. Institute of Transportation Studies, University of California, Davis, UCD-ITS-RR-22-28, 2022.

roughly 12% lower than those for diesel and will decrease to 29% lower than diesel maintenance costs in 2035. Current FCEV maintenance costs are roughly equal to those for diesel and are expected to decrease to 25% lower than diesel maintenance costs in 2035.

The World Resources Institute study on school buses uses a maintenance cost of $0.57 for diesel school buses.[204] The Evaluation Team's review uses $0.60 for transit bus maintenance costs.[205] We assumed the same cost reduction results for BEVs and FCEVs as in the UC Davis study. Table 197 shows the maintenance costs for each sector and technology over time.

Table 197. Maintenance Costs for Each Sector and Technology in Dollars per Mile

Sector and Year	Diesel	BEV	FCEV
Short-Haul			
2020	0.20	0.18	0.20
2035	0.20	0.14	0.15
Medium-Duty Delivery			
2020	0.20	0.18	0.20
2035	0.20	0.14	0.15
School Bus			
2020	0.57	0.50	0.57
2035	0.57	0.40	0.43
Transit Bus			
2020	0.60	0.53	0.60
2035	0.60	0.43	0.45

The CARB assessment of TRUs estimates TRU maintenance costs as $1,900 per year for diesel TRUs and $1,000 per year for eTRUs.

Miscellaneous Inputs

There are several additional key inputs to the TCM. Table 198 shows the values for these inputs for each sector.

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204 Levinson, M., P. Burgoyne-Allen, A. Huntington, and N. Hutchinson. "Recommended total cost of ownership parameters for electric school buses: Summary of methods and data." Technical Note. Washington, DC: World Resources Institute. 2023.

205 Third Party Evaluation Report, Standard Review Projects and AB 1082/1083 Pilots. Evaluation Year 2021. Cadmus Group, Energetics Incorporated, 2022.

Table 198. Miscellaneous Inputs for Each Sector

	Short-Haul	Medium-Duty Delivery	Transit Bus	School Bus	TRU
Discount Rate	7%	7%	7%	7%	7%
Payback Period	4 years	8 years	12 years	12 years	7 years
VMT per Year	50,000 miles	20,000 miles	43,000 miles	14,000 miles	N/A
Max Vehicle Incentive					
BEV	$160,000	$60,000	$120,000	$140,250	N/A
FCEV	$280,000	$60,000	$240,000	N/A	N/A
LCFS Cost Reduction					
Electricity 2025	$0.1/kWh	$0.1/kWh	$0.1/kWh	$0.1/kWh	$0.1/kWh
Electricity 2030	$0.09/kWh	$0.09/kWh	$0.09/kWh	$0.09/kWh	$0.09/kWh
Hydrogen 2025	$1.5/kg	$1.5/kg	$1.5/kg	$1.5/kg	$1.5/kg
Hydrogen 2030	$1.25/kg	$1.25/kg	$1.25/kg	$1.25/kg	$1.25/kg

Vehicle incentives come from the California HVIP program and the Federal Commercial Clean Vehicle Credit and can vary somewhat in certain circumstances. An incentive cannot exceed 90% of the cost difference between the ZEV and the diesel vehicle. These incentives are continually updated but projections of future values are not available. We assumed that the present values will hold and reduced the incentive to 90% of the ZEV-to-diesel cost difference if necessary.

The LCFS cost reduction is calculated from the LCFS credit price, fuel carbon intensities, and the yearly carbon intensity target. We assumed an average credit price of $75 for 2025 and 2030.

Assumptions

CARB has passed the ACT[206] and the ACF regulations,[207] which require truck manufacturers to provide ZEV trucks for sale and for fleets to purchase ZEV trucks based on specified timelines. The regulations are quite aggressive and require ZEVs to be sold and purchased starting in 2024. This analysis ignores these regulations and assumes that the sales percentage of ZEVs will be determined solely by the model inputs and purchase decision factors.

206 Final Regulation Order, Advanced Clean Trucks Regulation, California Air Resources Board. 2021. https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2019/act2019/fro2.pdf

207 Advanced Clean Fleets Regulation and Advisories, California Air Resources Board. Accessed May 2024. https://ww2.arb.ca.gov/our-work/programs/advanced-clean-fleets/advanced-clean-fleets-regulation-advisories

Appendix B. Deep Dives

To maintain customer confidentiality, deep dive sites are anonymized. Appendix B includes the following Deep Dives:

Appendix C. Data Collection Instruments