Standard Review Projects and AB 1082/1083 Pilots

Evaluation Year 2021 (Year 1)

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
ACT	Advanced Clean Trucks
ADA	Americans with Disabilities Act
AFDC	Alternative Fuels Data Center
AMI	Advanced metering infrastructure
API	Application programming interface
AR5	IPCC's published fifth assessment
BEV	Battery electric vehicle
BTM	Behind the meter
CAISO	California Independent System Operator
CALeVIP	California Electric Vehicle Infrastructure Project
CARB	California Air Resources Board
CB	Census block
CBG	Census block group
CCS	Combined charging system
CEC	California Energy Commission
CH_4	Methane
CNG	Compressed natural gas
CO	Carbon monoxide
CO_2	Carbon dioxide
CPUC	California Public Utilities Commission
CRT	Charge Ready Transport
CTA	Call to action
CVRP	Clean Vehicle Rebate Program
CVUSD	Cajon Valley Union School District
DAC	Disadvantaged community
DC	Direct current
DCFC	DC fast charging
DERA	Diesel Emission Reduction Act
DGE	Diesel gallons equivalent
DMV	Department of Motor Vehicles
EIA	Environmental impact assessment
ELRP	Emergency Load Reduction Program
EMFAC	EMissions FACtor model
EPA	U.S. Environmental Protection Agency
ER	Emergency room
EV	Electric vehicle
EV-HP	Electric vehicle high-power rate
EVSE	Electric vehicle supply equipment
EVSP	Electric vehicle service provider
EY	Evaluation Year
FAQ	Frequently asked questions
FCEV	Fuel cell electric vehicle
GHG	Greenhouse gas, here including CO_2, CH_4, and N_2O
GRC	General rate case
GWP	Global Warming Potentials
HOV	High occupancy vehicle

Acronym	Definition
HVIP	Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project
ICE	Internal combustion engine
IDI	In-depth interview
IOU	Investor-owned utility
IPCC	Intergovernmental Panel on Climate Change
IT	Information technology
L2	Level 2
LCFS	Low Carbon Fuel Standard
LDV	Light-duty vehicle
MACRS	Modified Accelerated Cost Recovery System
MDHD	Medium-duty, heavy-duty
ME&O	Marketing, education, and outreach
MSRP	Manufacturer suggested retail price
MT	Metric Ton
N_2O	Nitrous oxide
NO_x	Oxides of nitrogen
NPV	Net present value
NREL	National Renewable Energy Laboratory
OEM	Original equipment manufacturer
OLS	Ordinary least squares
ORION	Off Road Inventory ONline
PAC	Program Advisory Committee
PEV	Plug-in electric vehicle
PG&E	Pacific Gas & Electric
PHEV	Plug-in hybrid electric vehicle
PM	Particulate matter
PYDFF	Power Your Drive for Fleets
RFP	Request for proposals
RFQ	Request for qualifications
RNG	Renewable natural gas
ROG	Reactive organic gases
SB	Senate Bill
SCE	Southern California Edison
SDG&E	San Diego Gas & Electric
SO_x	Oxides of sulfur
SRP	Standard Review Projects
TCO	Total cost of ownership
TE	Transportation electrification
TRUs	Transportation refrigeration units
TTD	Tahoe Transit District
TTM	To the meter
VALE	Voluntary Airport Low Emission
VAP	Vehicle Acquisition Plans
VCC	Vehicle classification code
VMT	Vehicle miles traveled
V2G	Vehicle-to-grid
ZCTA	Zip code tabulation area
ZEV	Zero-emission vehicle

1. Executive Summary

This report summarizes findings and lessons learned from the first evaluation year (EY2021) of 14 transportation electrification (TE) programs administered by four California investor-owned utilities (Utilities). These programs were authorized under California Public Utilities Commission (CPUC) decisions in 2018 and 2019 and support TE goals in Senate Bill (SB) 350 Clean Energy and Pollution Reduction Act of 2015 and Assembly Bills (AB) 1082 and 1032. Table 1 summarizes the 14 TE programs and their budgets.

Table 1. Summary of Utility Programs

Utility	Program	Budget
Liberty	EV Bus Infrastructure Program	$0.22M
	Schools Pilot	$3.9M
	Parks Pilot	$0.78M
Pacific Gas & Electric (PG&E)	EV Fleet Program	$236.3M
	EV Fast Charge Program	$22.4M
	Schools Pilot	$5.8M
	Parks Pilot	$5.5M
Southern California Edison (SCE)	Charge Ready Transport (CRT) Program	$342.6M
	Schools Pilot	$9.9M
	Parks Pilot	$9.9M
San Diego Gas & Electric (SDG&E)	Power Your Drive for Fleets (PYDFF) Program	$155M
	Vehicle to Grid (V2G) Pilot	$1.7M
	Schools Pilot	$9.9M
	Parks Pilot	$8.8M

This evaluation uses the following terminology to describe the status of sites in the activation process:

- **Utility Construction Complete:** Sites where the Utility has completed their scope (to-the-meter [TTM], and TTM and behind-the-meter [BTM], and turnkey installation)
- **Activated:** Sites with charging stations installed and available for use
- **Operational:** Sites where advanced metering infrastructure (AMI) and/or electric vehicle service provider (EVSP) energy usage data were received from the Utility or EVSP
- **Closed Out:** Sites where all financial documentation has been finalized by the Utility and rebates have been paid

Table 2 summarizes site count and completion status of sites by Utility program as of December 31, 2021, by status.[1] As shown in Table 2, the Medium-Duty Heavy-Duty (MDHD) programs (EV Bus Infrastructure, EV Fleet, PYDFF, and CRT) had the most sites completed (58), followed by the Parks Pilot

[1] Note that these numbers are not additive; for example, by the end of 2021, 24 of the 27 completed sites in the SCE CRT program were activated, 19 of the 24 activated sites were operational, and one of the 19 operational sites was closed out.

(five), EV Fast Charge (four), and the Schools Pilot (two). The V2G Pilot includes a single site that was activated but not operational as of the end of 2021.

Table 2. EY2021 Site Count By Program and Status

Utility	Program	Utility Construction Completed	Activated	Operational	Closed Out
Liberty	EV Bus Infrastructure	1	0	0	0
	Schools	0	0	0	0
	Parks	0	0	0	0
PG&E	EV Fleet	28	28	26	23
	Schools	0	0	0	0
	Parks	0	0	0	0
	EV Fast Charge	4	4	4	4
SDG&E	PYDFF	2	1	1	1
	Schools	1	1	1	0
	Parks	5	4	4	0
	V2G	1	1	0	0
SCE	CRT	27	24	19	1
	Schools	1	1	0	0
	Parks	0	0	0	0

1.1. 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 CRT, 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 EY2021.

Table 3. EY2021 Program Impacts, by Bundle

Impact Parameter	MDHD Bundle	Public Charging Bundle	V2G Bundle
Population of Activated Sites (#)	53	11	0
Sites Included in Analysis (#)[a,b]	41	7	0
Ports Installed in Analyzed Sites (#)	262	32	0
Electric Vehicles Supported (#) [c]	451	N/A	0
Electric Energy Consumption (MWh)	3,843	113	0
Petroleum Displacement (diesel gallons equivalent [DGE])	406,712	9,962	0
Greenhouse Gas (GHG) Emission Reduction (MT GHG) [d]	3,382	68	0
Oxides of Nitrogen (NO_x) Reduction (kg)	1,902	0	0
Particulate Matter (PM_{10}) Reduction (kg)	34	0	0
Particulate Matter ($PM_{2.5}$) Reduction (kg)	31	0	0
Reactive Organic Gases (ROG) Reduction (kg)	250	6	0
Carbon Monoxide (CO) Reduction (kg)	20,013	203	0

[a] Energy consumption, petroleum displacement, emission reductions, and health benefits are based on annualized data.
[b] The number of sites included in analysis differs from the population of activated sites because some sites were only activated for a short period during 2021 (such as one or two months).
[c] The team derived the EVs supported value for MDHD programs from applicants' vehicle acquisition plans. This value represents the maximum number of vehicles expected to be supported by the charging infrastructure.
[d] 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 the *Evaluation Methodology* section for more details).

1.2. 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.

1.2.1. Medium-Duty Heavy-Duty Bundle

Initial program findings indicate that site activation timelines varied and additional customer support can help reduce the activation timelines.

In its program materials, SCE estimated its process to activate a site to take between 11.5 months and 14.5 months. Of the 24 activated sites in the SCE's CRT program, the median start-to-finish timeline for site activation was 669 days (over 22 months). SCE program staff noted that 15 of the 24 activated sites (62.5%) were placed on hold for varying periods between the application review and site activation phases, which extended timelines. During site visits, some participants anecdotally reported that the COVID-19 pandemic had slowed the completion of their sites. Information from SCE program staff also indicated that the pandemic changed the scope of multiple projects throughout 2021, resulting in project delays. As program activity increases , the evaluation will continue to review activation timelines and factors driving them.

In its program materials, PG&E's EV Fleet program estimated its process to take 13 to 19 months. Of the 28 activated sites spanning five market sectors, the median start-to-finish timelines for EV Fleet site activation for different market sectors ranged from 364 days (12 months) to 615 days (over 20 months), with the largest market sector (school buses) taking a median of 507 days to activate (almost 17 months). Of the six program phases that comprise project timelines, the construction complete phase took the longest to complete, with a median of 169 days. During interviews, Utility staff indicated that one reason for the length of this phase was that all but one of the contracts issued through 2021 were with participants who were responsible for the design, permitting, and installation process for their site's BTM infrastructure. Utility staff indicated that because some of these customers (such as school districts) had little experience with requests for proposals (RFPs) and other procedural steps in this process, and because PG&E required sites to conduct some BTM work before PG&E completed its TTM work (to ensure that sites followed through on BTM infrastructure installation), this phase took longer than participants expected.

For sites where PG&E may have impacted activation timelines, additional customer support could be helpful to reduce the duration of the design and permitting and construction complete phases when customers are responsible for the BTM infrastructure installation process, while acknowledging that additional program support would likely impact the program's budget. During interviews, PG&E program staff noted that they sought to better support customers through the BTM process by providing them with a dedicated site manager after working with an onboarding specialist.

Across the Utilities, programs addressed participants' top barriers to electrification, and participants were satisfied with the programs overall.

Across Utility programs, most fleet manager survey respondents said that incentives for EV charging infrastructure and vehicles were a substantial motivator for transitioning to EVs, and that before participating in the program, the costs of EVs and of installing EV charging infrastructure were prohibitive.

For SCE CRT, Utility staff reported that the most substantial costs for site hosts were vehicle and infrastructure costs. SCE CRT fleet manager survey respondents also listed the range limitations of EVs for their routes as a major barrier. After participating in the program, respondents noted that the cost of installing EV charging infrastructure was less of a barrier, and that the EVs and charging infrastructure supported through the program addressed some of the range anxiety they felt prior to the program. However, the cost of EVs remained a key barrier as EV acquisition was not something the program was designed to address.

For PG&E EV Fleet, six of 13 program participants who completed surveys reported that barriers still existed after participating in the program, with the most prevalent remaining barrier for participants being that their routes were too long for the EVs available. These results indicate that major barriers to electrification (such as costs and the availability of chargers along routes) were reduced after participating in the EV Fleet program. Participants were satisfied with the program: 10 of 13 fleet managers rated themselves as *very satisfied* with the program overall, while three rated themselves as *somewhat satisfied*.

While EVs and EV charging equipment were generally found to be reliable, participants experienced some operational challenges.

In SCE's CRT, the six fleet manager survey respondents found the charging equipment reliable, while four of six found the EVs to be reliable. Respondents also mentioned vehicle reliability and range as key limitations of EVs when discussing EV options in their sector. Additionally, of the 15 sites visited, five fleet operators discussed co-costs associated with their fleet electrification. These five operators noted that they experienced vehicle recalls or reliability issues that often required repairs to be conducted by the vehicle manufacturer or dealer during the initial warranty period. Four of these operators said they experienced reduced flexibility with EVs compared to conventional vehicles, specifically for school buses. Two of these operators had to adjust their routes to accommodate the new buses or had to keep more conventional buses than they would have liked. Two operators reported increased maintenance costs.

Survey respondents in PG&E's EV Fleet program found that, overall, both EVs and EV charging equipment were reliable (11 of 13 respondents rated the EVs as reliable, while 10 of 13 respondents rated EV charging equipment as reliable). However, two respondents rated the charging equipment as *not at all reliable*, while two others rated it as *very reliable*, which indicates inconsistent experiences with the equipment. Three respondents reported some challenges with EV charging equipment due to regular failures, and one of these participants believed their chargers were not sized properly for school buses and that the failures were due to the limited amps provided. When asked about what they would have done differently if they were to go through fleet electrification again, four respondents noted issues with charging, saying they would have found a better charging solution, made sure the power source and chargers were more powerful than what was required, had a larger power supply brought in, and considered solar panels with storage batteries to supplement high demand during peak times to reduce costs and grid impacts.

Participants were satisfied with SCE's CRT program's services for BTM make-ready infrastructure.

In SCE's CRT, 23 of the 24 activated sites chose Utility ownership of BTM infrastructure instead of customer ownership. For these sites, SCE paid to design, construct, own, and maintain all infrastructure up to the charging stations. Customers were still responsible for procuring, installing, and maintaining the charging stations. Five of seven respondents rated themselves as *very satisfied* with the level of program services received. In interviews, Utility staff said they had added site management personnel to improve program implementation, since each site required significant time and effort.

Most fleet operators did not manage charging, resulting in increased operating costs. Flexibility in charge times—specifically for school bus fleets—provides opportunities for improved grid integration and further electrification.

While program data for SCE's CRT and PG&E's EV Fleet indicates that most of the EVs and EVSPs participating in the programs have the capability to limit charging during certain hours, only two of the 40 sites visited had a load management plan to reduce electric fuel costs and grid impacts. In addition, during site visits, few of the operators who discussed electric fuel costs were aware of their electric fuel costs, even after several months of operation. None of these operators had been able to access or analyze data on actual ranges and fuel economies derived from vehicle logs and charging sessions. As such, most fleet managers were not managing charging and, as a result, were paying more for charging than necessary.

For school buses—the largest market segment for both SCE CRT and PG&E EV Fleet in EY2021—the grid impacts analysis revealed that approximately 40% of school bus charging sessions impacted electricity consumption during peak hours, when rates were highest. The grid impacts analysis also showed that school bus charging could be shifted away from peak hours. For these fleets, the load curves and the time spent parked (but not actively charging) at chargers indicted that after the afternoon routes were completed, charging could be shifted to off-peak times. Therefore, increased awareness of electric fuel costs and how to mitigate them through charge management could help fleet managers reduce their electric fuel costs, manage grid impacts, and accommodate additional EVs.

There was general agreement among market experts that the EV market share for the school bus segment will increase over time, but they gave different explanations for the forces driving this growth.

Half the market experts on the Delphi panel on school bus electrification did not believe the Advanced Clean Truck (ACT) regulation would be the main driving force in electrification of the school bus market, citing factors such as bus replacement patterns, lack of available vehicles, or flexibility within the regulation that allows for sales of different types of vehicles to count toward compliance. The remaining half of panelists said the ACT regulation increased their baseline market forecast. Some panelists predicted that the regulation will induce a supply-side shift, causing manufacturers to view ICE vehicle production as no longer profitable or feasible in the long term. Other experts expect the ACT regulation to indirectly support electric school bus uptake, as it will help reduce battery and other input costs for all EVs.

1.2.2. Public Charging Bundle

All Public Charging Programs

Unexpected market impacts and site design requirements resulted in higher-than-expected site costs and limited participation.[2]

COVID-19 had unprecedented economic impacts across nearly every market, driving up costs for materials and labor and disrupting supply chains. These changes were so substantial that the estimates the Utilities had created for Decision 19-11-017 and Decision 18-05-040 did not reflect the actual costs for implementation. Though Utility staff conducted research ahead of Pilot design, these expenses were then compounded by inadvertent inaccuracies in Pilot design estimations. For example, while designing actual sites, Utility staff found that the costs associated with a typical trench length assumption had been underestimated. Similarly, more construction was needed than what was estimated to meet Americans with Disabilities Act (ADA) permit requirements. For example, the substantial rise in cost

[2] For SCE, this lesson can only be applied to the Schools Pilot, as limited movement occurred in EY2021 for the Parks Pilot.

estimates has been a driving reason for PG&E needing to wait-list 82% (n=56)[3] of their Schools Pilot applicants in 2021.

Schools Pilot and Parks Pilot

Staffing constraints contributed to conflicting priorities from site hosts, which resulted in site delays or withdraws.

Participating in either the Schools or Parks Pilot requires the site host to make a commitment that often spans several months. Site hosts must not only be willing to install electric vehicle supply equipment (EVSE) on their property, but—at a minimum—they must also work with Utility staff to coordinate site walks, approve site designs, and review and approve agreements, easements, and other critical documents. Across all Utilities, staff reported that hosts of both the Schools Pilot and the Parks Pilot had staffing constraints that either delayed or ultimately prevented participation.

In EY2021, the Utilities' Parks Pilots were most influenced by staff turnover at the California Department of Parks and Recreation. When Department staff transitions occur, Utility staff must often re-orient the new staff member to the purpose of the Parks Pilot, all the steps completed to date, and next steps.

The Schools Pilot was also influenced by staff constraints. While turnover was less of an issue with the Schools Pilot than with the Parks Pilot, Utility staff did notice that Schools Pilot site host staff were constrained by the available bandwidth of current staff, which was exasperated by COVID-19. Since the Pilot began, schools have been burdened with making ever-changing decisions regarding virtual versus on-site learning, mask mandates, and similar choices. Utility staff noted that the priority of ensuring school staff and student health and safety limited the schools' capacities to work with the Utility on getting the EV charging infrastructure installed.

Schools Pilot Only

Initial contacts at interested Schools Pilot sites were not necessarily the ultimate decision-makers, which resulted in site delays and sometimes withdraws.

SCE and PG&E staff tried to account for multiple layers of approval at the beginning of the Schools Pilot enrollment process by providing their primary site contact with example agreement and easement language to share with decision-makers. However, the lack of clarity around the layers of approval occasionally inhibited Utility staff from being able to help site hosts through the decision-makers' Pilot participation concerns.

For the SCE Schools Pilot, if agreement and easement language got rejected by someone further up the approval process than SCE's primary site contact, SCE staff occasionally did not receive clear information as to why the decision-makers decided not to move forward with the Pilot, despite repeatedly asking for feedback. While SCE staff continued to engage with the primary contact to ask for more detail about the concerns that led them to opt out of the Pilot, unclear higher-level concerns caused delays in the approval process and sometimes extended their expected timeline. In the worst cases, the primary site

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3 PG&E. February 16, 2022. "PG&E Program Advisory Council Meeting: Q4 2021." PowerPoint presentation.

contact was unable to facilitate any sort of problem-solving and the site ultimately opted out of enrollment.

PG&E staff were limited to what the primary site contact disclosed about what happened after the documents were passed off to decision-makers. If PG&E staff received approval from their site contact they were able to move forward with the design. However, PG&E staff reported instances where they learned in later steps of the process that their site contact was not authorized to provide permission, meaning the site came to a halt. While in some cases it was only a temporary delay, in other cases the site would fully pull out of the Pilot even after PG&E had made substantial investments in enrollment and site design. Moving forward, PG&E staff will seek to identify multiple site host champions to support the approval process.

PG&E EV Fast Charge

Adaptability in the program enrollment process enabled PG&E to successfully meet customer needs and secure participation in the EV Fast Charge program.

In addition to setting up procedures to coordinate with other internal departments, EV Fast Charge staff took the time to learn from the sites that went through the application process early in the program. For example, PG&E quickly learned that the boilerplate contract language would likely need to be adjusted for each site's different needs or requirements. Therefore, PG&E adjusted their assumption for how long a contract review would take, they encouraged the primary site contact to share programmatic documents with decision-makers early, and they added questions about contract signing to their phone screening process (such as who would be responsible and how long it would take). In general, PG&E honed the phone screen over time, adding questions to newer participants' calls that had been useful in previous calls, including requesting the presence of decision-makers in the preliminary call screens (not just site host points of contact). By updating their implementation process in real time, PG&E's EV Fast Charge process became more efficient and customer friendly with each application processed.

The lack of a formal commitment in advance of site walks resulted in PG&E starting to invest in uncommitted customers.

EV Fast Charge participants are not required to sign a formal participation agreement or contribute any funds to the site until the final site design has been completed and agreed upon. Therefore, PG&E accepts a certain amount of risk when investing in planning a site. Although withdrawals early in the process are not substantially disruptive, PG&E staff experienced challenges when promising sites withdrew partway through the planning process: this was particularly straining on the program budget, as PG&E had invested considerably in the sites (such as conducting site walks). Despite adapting the intake process, this challenge resulted in the Utility investing more resources in withdrawn EV Fast Charge applicants than anticipated.

1.2.3. V2G Pilot

A lack of standards for V2G technologies resulted in challenges in vehicle and charger interoperability, grid interconnection, and economic viability.

Continued support from the CPUC and Utilities is important for developing V2G standards or guidelines and advancing the technology. Examples include collaboration with Underwriters Laboratory and SAE International and the development of V2G-specific rates.

1.3. Structure of Report

The evaluation report is organized into six volumes:

- **Volume 1.** Executive Summary, Introduction, Methodology
- **Volume 2.** SCE Program Findings: Charge Ready Transport, Schools and Parks Pilots
- **Volume 3.** PG&E Program Findings: EV Fleet, Schools and Parks Pilots, EV Fast Charge
- **Volume 4.** SDG&E Program Findings: Power Your Drive for Fleets, Schools and Parks Pilots, V2G Pilot
- **Volume 5.** Liberty Utilities Program Findings: EV Bus Infrastructure, Schools and Parks Pilots
- **Volume 6.** Appendices

Each Program Findings volume contains three subsections:

- **Overview:** describes the evaluation objectives, logic model, theory of program impacts, and research questions
- **Findings:** details the program materials review, market research, in-depth interviews, surveys, 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 Assembly Bills 1082 and 1083, the CPUC issued major decisions in 2018 and 2019 authorizing investment in 14 Utility programs, evaluated in this report. Through these programs, outlined in Table 4, the Utilities invest in charging infrastructure to help spur light-, medium-, and heavy-duty EV adoption among fleets and households. Additional detail on program design is provided in subsequent chapters.

Table 4. Summary of Utility Programs

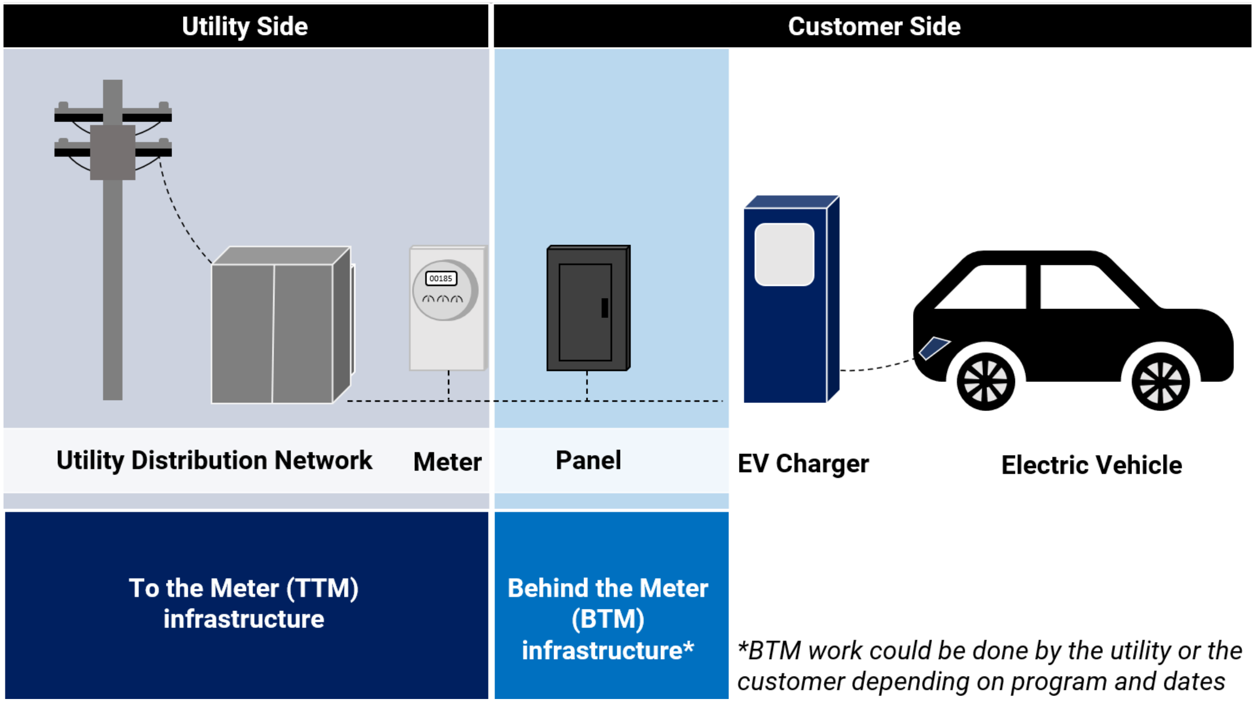
Utility	Program	Description	Decision [a]
Liberty	EV Bus Infrastructure Program	$0.22M for TTM and BTM infrastructure for electric transit buses.	4
	Schools Pilot	$3.9M for up to 56 Level 2 (L2) and two direct current fast chargers (DCFC) charging ports at 17 schools.	2
	Parks Pilot	$0.78M for five dual-pedestal EVSE at three sites.	2
PG&E	EV Fleet Program	$236.3M 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
	EV Fast Charge Program	$22.4M for make-ready infrastructure of 52 DCFC and rebates for EVSE.	1
	Schools Pilot	$5.8M for installation of four or six L2 charging ports at 22 schools.	2
	Parks Pilot	$5.5M for installation of L2 ports and DCFC at state parks and beaches.	2
SCE	CRT Program	$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
	Schools Pilot	$9.9M for installation of approximately 250 L1 and L2 charging ports at 40 K–12 schools.	2
	Parks Pilot	$9.9M for installation of approximately 120 L2 charging stations, 10 DCFC ports, and an optional 15 mobile stations across 27 state parks and beaches.	2
SDG&E	PYDFF Program	$155M 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
	Vehicle to Grid (V2G) Pilot	$1.7M for installation of V2G-capable chargers for school buses at the Cajon Valley Union School District (CVUSD).	3
	Schools Pilot	$9.9M for installation of and incentives for installing 184 L2 charging ports and 12 DCFC ports at 30 schools and educational institutions.	2
	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

[a] 1. Decision 18-05-040; 2. Decision 19-11-017; 3. Decision 19-08-026; 4. Decision 18-09-034

2.1. Electric Vehicle Infrastructure

The programs support EV infrastructure, typically categorized as TTM and BTM (Figure 1). The Utilities pay 100% for TTM infrastructure costs and some or all of BTM infrastructure costs depending on ownership (customer versus Utility), although requirements vary by program.

Figure 1. Illustration of To-the-Meter and Behind-the-Meter Infrastructure



2.2. Policy Landscape

The 14 Utility programs exist within a larger policy ecosystem aimed at spurring EV adoption through regulation, incentives, and other instruments. This section describes key policies at the federal, state, and Utility level.

2.2.1. Federal Level

At the federal level, the Bipartisan Infrastructure Law (BIL), enacted as the Infrastructure Investment and Jobs Act, provides California with $384 million in formula funding for EV charging under the National Electric Vehicle Infrastructure (NEVI) Formula Program. Accessing NEVI funding requires meeting the Federal Highway Administration's criteria for designation in its Alternative Fuel Corridor program. California will also have the opportunity to apply for grants out of the $2.5 billion available for EV charging.

The federal government also provides incentives for EV purchases through programs like the 30D tax credit or up to $7,500 per EV for the first 200,000 EVs sold by automakers. Additionally, the BIL provides up to $5 billion in funding for electric school and low emission buses and $500 million for electric or low-emission ferries.

Several additional federal programs support TE:

- **Federal Transit Agency's Low and No Emission Bus Programs**. Competitive grant for the purchase or lease of zero-emission and low-emission transit buses and supporting facilities.
- **Federal Transit Agency's Buses and Bus Facilities Competitive Program**. Competitive funding to states and direct recipients to replace, rehabilitate, and purchase buses and related equipment

and to construct bus-related facilities including technological changes or innovations to modify low- or no-emission vehicles or facilities.

- **Environmental Protection Agency's Diesel Emission Reduction Act (DERA).** Competitive grant funding for the replacement of school buses, Class 5 through Class 8 heavy-duty highway vehicles, locomotive engines, marine engines, and nonroad engines, equipment, or vehicles.
- **Federal Aviation Administration's Voluntary Airport Low Emission (VALE).** Competitive grant funding for low emission technologies at airports.

2.2.2. State Level

Within California, TE programs range widely in design and objective. The state-run website driveclean.ca.gov provides location-specific information about incentives within the state. There are several most notable existing and pending state-run programs that overlap with the 14 Utility programs in this evaluation:

- **AB 841.** Legislation requiring utilities to fully pay for utility-side make-ready costs for non-residential EV charging infrastructure up to the electrical meter.
- **Advanced Clean Cars II**. Rulemaking in final stages that requires automakers to deliver an increasing fraction of light-duty vehicles as electric within the state, with a 100% of new vehicle sales by 2035.
- **Advanced Clean Trucks.** Manufacturers' zero-emission vehicle (ZEV) sales requirement and a one-time reporting requirement for large entities and fleets.
- **Advanced Clean Fleets.** Draft regulation aimed at electrifying drayage trucks, off-road vehicles, and MDHD vehicles by 2045, where feasible.
- **CALeVIP Charging Grants.** Funding grants for L2 and DCFC installations.
- **Clean Vehicle Rebate Program (CVRP).** Provides consumers with up to $7,000 to purchase or lease a new plug-in hybrid electric vehicle (PHEV), battery electric vehicle (BEV), or a fuel cell electric vehicle (FCEV).
- **Electric Vehicle Charging Station Financing Program**. Loans for the design, development, purchase, and installation of EV charging stations at small business locations in California.
- **Hybrid and Zero Emission Truck and Bus Voucher Incentive Project (HVIP).** Provides fleets vouchers to reduce the incremental cost of qualified electric, hybrid, or natural gas trucks and buses at the time of purchase.
- **Innovative Clean Transit.** Requires all public transit agencies to transition to a 100% zero-emission bus fleet for new vehicles by 2029. Additionally, all on-road transit buses must be 100% zero emission vehicles by 2040.
- **Low Carbon Fuel Standard (LCFS).** Funding for low carbon fuel providers, including EV charging and hydrogen refueling station owners.

2.2.3. Electric Utility Level

At a national level, electric utilities are increasingly implementing TE programs. Atlas Public Policy maintains a database of electric utility TE filings.[4] As of the end of 2021, utility commissions had approved TE programs for at least 53 electric utilities across 34 states, amounting to an estimated $3 billion of approved investment for charging infrastructure (Table 5). The programs included in this evaluation report account for 14 of these approved programs

Table 5. Charging Infrastructure TE Filings, by Topic

Type of Utility TE Program	Description	Approved Filings [a]	Total Investment ($ Millions)
Make-ready	Make-ready infrastructure in preparation for a non-utility owned charging station.	83	$1,786
Line extension	Similar to make-ready but explicitly for upgrading infrastructure in preparation for a higher electrical load due to EV charging.	6	$49
Charger installation incentive	Incentives (usually monetary) to non-utility entities for use toward the installation of chargers.	96	$616
Utility-owned chargers	Electric utility installing chargers.	79	$529
	Total	**264**	**$2,980**

[a] Includes approved with modifications status. See the Atlas EV Hub for information about the methodology for categories.

Other electric utility filings focus on education, vehicle incentives, EV-specific rates, and other programs. These have a far smaller total investment than charging infrastructure, at $461 million, with the largest number of approved filings and largest total investment being for evaluation and administration programs (outlined in Table 6).

Table 6. Non-Infrastructure TE Filings

Type of Utility TE Program	Description	Approved Filings [a]	Total Investment ($ Millions)
Education	Funds for education and outreach about EVs and EV charging.	70	$122
Electric vehicle incentive	Incentives, often monetary, for EV purchasers.	7	$9
EV-specific rate	A special electricity rate for EVs, such as a time-of-use rate. EV rate types do not always have monetary investments, but can, and are elements where the utility is developing a specific rate type for EVs or EVSE users.	75	$16
Evaluation and administration	Funds set aside for the evaluation and/or administration of electric utility programs related to EVs and EV charging.	59	$240
Other	Other TE filings such as stakeholder engagement, research and development, program evaluation, and other.	27	$74
	Total	**238**	**$461**

[a] See the Atlas EV Hub for information about the methodology for categories.

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4 Atlas defines a filing as "a document submitted by a public utility to a government regulatory body requesting approval to fund services and programs. There is no standard format or process for these filings across states." See here for more information: https://www.atlasevhub.com/wp-content/uploads/2018/09/Atlas_EV_Hub_Electric_Utility_Filings_Tracking.pdf

3. Evaluation 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 Cadmus team collected primary or secondary data (data collection) and we transformed that data to produce findings (analysis). Some methodologies are identical across programs, while others are program-specific.

Table 7 lists the evaluation activities conducted for each program for Evaluation Year 2021 (EY2021). The individual program chapters discuss the evaluation activities, methodology, and findings.

Table 7. EY2021 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	MD HD	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 [a]	x
	Site Visits			x		x	x		x	x [a]	
	Interviews	x	x	x	x	x	x	x	x	x	x
	Surveys			x			x				
	Delphi Panel			x			x		x		
Analysis	EV Adoption					x				x [a]	
	Grid Impacts			x		x	x		x	x [a]	
	Counterfactual Development		x	x	x	x	x	x	x	x	
	Petroleum Displacement			x		x	x		x	x [a]	
	GHG and Criteria Pollutant Reductions			x		x	x		x	x [a]	
	Health Impacts			x		x	x		x	x [a]	
	Total Cost of Ownership		x [b]	x [c]	x [b]	x [b]	x [c]	x [b]	x [c]	x [b]	
	Site Visit Findings			x		x	x		x	x [a]	
	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		

[a] The team only conducted this work for the SDG&E Parks Pilot.

[b] The team based our analysis on a literature review contextual analysis.

[c] The team conducted this work for three MDHD market segments, largely using secondary (not program-specific) data.

The Cadmus team developed an evaluation methodology for the data collection and analyses to address three research objectives.

- **Research Objective 1.** Determine whether transportation electrification (TE) investments accelerated widespread TE, reduced petroleum dependence, helped meet air quality standards, reduced greenhouse gas (GHG) emissions, and achieved the goals of the Charge Ahead California Initiative.[5]
- **Research Objective 2.** Determine whether TE investments maximized benefits and minimized costs, including co-benefits and co-costs, and the extent to which the costs and benefits accrued to disadvantaged communities (DACs).
- **Research Objective 3.** Maximize learnings 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 segment.

The Cadmus team reviewed program participation and adjusted the sampling methodology, scope, and timeline of activities to derive maximum efficiencies. This report provides impact and process evaluation findings that were mainly derived using 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-segment participation levels were insufficient to allow reporting at any meaningful level of detail, the Cadmus 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 the participating sites or sites included in the evaluation effort:

- **Utility Construction Completed:** Sites where the Utility has completed their scope (TTM, TTM and BTM, and turnkey installation)
- **Activated:** Sites with charging stations installed and available for use
- **Operational:** Sites where AMI and/or EVSP energy usage data were received from the Utility or EVSP
- **Closed Out:** Sites where all financial documentation has been finalized by the Utility and rebates have been paid

5 https://environmentcalifornia.org/programs/cae/charge-ahead-california

3.1. Medium-Duty Heavy-Duty Programs Evaluation Methodology

This section outlines the data collection and analysis methodologies for the MDHD programs.

3.1.1. Data Collection Methodology

Data collection activities for the MDHD programs included program data and materials, AMI and EVSE data, site visit data, and surveys and interviews.

Program Data and Materials

Program data included information about program applications such as count of charging ports, number of EVs procured, site status (in a DAC or outside of DAC), time in each program stage, and average site costs, where available. These data provided the team with an understanding of program implementation, such as the median number of days spent in different program stages or the percentage of applicants from different market sectors.

We collected and transferred data securely between the Utilities' secure SharePoint sites or other secure file transfer systems and our own Microsoft Azure cloud-based environments. The team completed this transfer monthly for most data, with some variation in timing among PG&E, SCE, and SDG&E. Once we received data from these Utilities, we moved it to the Cadmus data warehouse for secure storage and retrieval.

In addition, the Cadmus team reviewed available program-related materials, such as program websites, marketing materials, Decisions, Advice Letters, and Program Advisory Committee (PAC) presentations. The program material review is important to establish a foundational understanding of the program design intent, to track changes in design over time, and to understand implementation progress.

Table 8 shows a list of the material types the Cadmus team reviewed by Utility.

Table 8. Medium-Duty Heavy-Duty Program Materials Reviewed

Utility	Program Materials Reviewed
Liberty	• Utility website • Regulatory documents such as Decisions and Advice Letters
PG&E	• Utility websites, including: ▪ EV Fleet Charging Guidebook ▪ Calculators and tools ▪ Application and application preparation and information documents ▪ Fact sheets and case studies ▪ Vehicle availability lists and approved EVSE product list ▪ Funding information ▪ Original equipment manufacturer information • PAC presentations • Regulatory documents such as Decisions and Advice Letters • *Joint IOU EV Load Research and Charging Infrastructure Cost Report* • Marketing materials, including: ▪ Emails and email collateral ▪ Webinars (such as from ACT News)

Utility	Program Materials Reviewed

	• Program documents, including:
	  ▪ EV Customer Information Sharing Agreement
	  ▪ Offer Letter and Contract
	• Utility information, including:
	• EV rate schedules

SCE	• Utility website, including:
	  ▪ EV Fleet Charging Guidebook
	  ▪ Program Handbook
	  ▪ Calculators and tools
	  ▪ Application and application preparation and information documents
	  ▪ Fact sheets and case studies
	  ▪ Vehicle availability lists and approved EVSE product list
	  ▪ Funding information
	• PAC presentations
	• Regulatory documents such as Decisions and Advice Letters
	• *Joint IOU EV Load Research and Charging Infrastructure Cost Report*
	• Marketing materials, including:
	  ▪ Emails and email collateral
	  ▪ Webinars
	• Program documents, including:
	  ▪ Program Participation Agreement
	  ▪ Technical requirements
	  ▪ Equipment registration forms
	• Utility information, including:
	• EV rate schedules

SDG&E	• Utility website, including:
	  ▪ EV Fleet Charging Guidebook
	  ▪ Calculators and tools
	  ▪ Application and application preparation and information documents
	  ▪ Fact sheets and case studies
	  ▪ Vehicle availability lists and approved EVSE product list
	  ▪ Funding information
	• PAC presentations
	• Regulatory documents such as Decisions and Advice Letters
	• *Joint IOU EV Load Research and Charging Infrastructure Cost Report*
	• Marketing materials, including:
	  ▪ Emails and email collateral
	  ▪ Webinars (such as from ACT News)
	• Utility information, including:
	  ▪ EV rate schedules
	  ▪ EVSE map
	  ▪ DAC map

AMI and EVSE Data

The Cadmus team used advanced metering infrastructure (AMI) data to estimate charger usage, a key input for subsequent analyses and estimations of program impacts, such as impacts to the grid, as well as 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. Our 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 team's 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 electric vehicle service providers (EVSPs). The 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 on a monthly basis.

Together, AMI and EVSE data provided the basis for analyzing program performance at a granular level. Of particular interest was the ability for customers to shift loads off peak in response to time-varying rates and other influences. The Cadmus team used data from EVSPs to examine port utilization, which is based on the percentage of time in which a vehicle parked at a charging station is actually 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 Cadmus team planned to acquire complete AMI and EVSE data for every charging session from the Utilities and EVSPs. However, some AMI data were not available from the Utilities. We are working with the utilities to obtain these data to incorporate into future analyses. Additionally, certain EVSPs did not consistently provide complete station data during this first program year.

Annualized Data

While Utilities completed construction on 58 sites, 53 sites were activated and 46 were operational by the end of EY2021. The team considered all 46 operational sites for annualization.[6] However, AMI data were missing for six of these 46 sites. Consequently, we generated representative AMI data for these six sites based on available EVSP data through a synthesizing process using a conversion factor. We derived subsegment-, Utility-, and EVSP-specific conversion factors by evaluating the ratio of total kilowatt-hours delivered as reported by EVSPs versus total kilowatt-hours delivered as reported in AMI data for sites within the same market segment (such as school buses), the same Utility, and the same EVSP. In the rare case where there was no specific match, the team used a factor to account for electricity losses between the meter and the EVSE.

To calculate synthetic AMI data, the Cadmus team divided the sum of the EVSP 15-minute interval data for each port at a given site by the applicable conversion factor for different EVSPs or by the loss factor when an EVSP-specific conversion factor was not available. We then summed the data for each port to

6 The Cadmus team annualized electricity usage data for sites with more than two months of operational data (data indicating that EVs were actively being charged). The annualization process is to extrapolate partial year site electricity usage data out to a full year to provide an estimate for site-to-site and year-over-year comparison.

create synthetic AMI data for that site. Of the six sites for which we generated synthetic AMI data, the Cadmus team was able to use a specific conversion factor for two and used the loss factor for the remaining four. If the missing AMI data becomes available, the team will replace the synthetic AMI data with actual AMI data in future evaluation years.

Once the Cadmus team had actual or synthetic AMI data for the 46 sites that were operational by the end of EY2021, we generated annualized results for 41 of these sites (and we excluded five sites that did not meet the annualization criteria).

Site Visits

Site visits are an important part of the data collection process, as they provide an on-the-ground view of the sites, as well as 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 serve 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.

The Cadmus team attempted a census approach for site visits. The team performed 41 MDHD site visits out of the 53 activated sites during EY2021. In the remainder of cases the Cadmus team was not granted access to the site. Table 9 shows a breakdown of the activated MDHD site visits by market segment.

Table 9. 2021 Site Visit Sample by Market Segment

Utility	Program	School Bus	Medium-Duty Vehicles	Heavy-Duty Vehicles	Transit Bus	Forklifts	Total
PG&E	EV Fleet	17	3	1	2	2	25
SCE	Charge Ready Transport	10	2	2	1	0	15
SDG&E	Power Your Drive for Fleets	0	1	0	0	0	1
Total		**27**	**6**	**3**	**3**	**2**	**41**

The Cadmus team collected data during in-person site visits for fleets operating under the PG&E EV Fleet program (school buses, medium-duty vehicles, heavy-duty vehicles, transit buses, and forklifts), the SCE Charge Ready Transport (CRT) program (school buses, medium-duty vehicles, heavy-duty trucks, and transit buses), and the SDG&E Power Your Drive for Fleets program (which had a single site during EY2021 consisting of medium-duty vehicles). We arranged appointments through the Utilities with their customer-site hosts to visit the charging stations installed through the MDHD programs.

During the site visits, the team collected qualitative and quantitative information that provided us with an understanding of fleet composition and operations, and we verified Utility-provided information for individual sites. This included information on the make, model, and number of EVs or electric-powered equipment on site, 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, as well as whether there was interest in on-site solar and/or storage associated with the site. The team held meetings on the premises with facility managers and other personnel to learn about the particulars of each site. Additionally, we inquired about the availability of telematics or fleet usage records to characterize their operations. The team emulated this same process for each visit with the same questions and conversation. We entered data into Cadmus' Arkenstone proprietary web-based tool for site visit data collection after each site visit to compile notes and photos for aggregate analysis.

Interviews, Surveys, and Expert Opinions

Interviews

The Cadmus team completed a series of interviews and surveys to address the research objectives relevant to the MDHD bundle. Specifically, the team interviewed Utility staff members and surveyed fleet managers who participated in the program and those who withdrew from the program.

The Cadmus team interviewed each program manager from the four participating Utilities with MDHD programs. In some cases, we completed multiple interviews with the same Utility in the EY2021 evaluation if a major event happened, such as program staffing changes (PG&E) or a program closeout (Liberty). During each interview we covered specific topic areas:

- **Program Design**: Confirmed program design and changes, confirmed program goals, asked about site selection criteria, and gathered insight on program cost thresholds
- **Program Implementation**: Reviewed program status and progress (specifically in DACs) and asked about program successes, challenges, and next steps
- **Lessons Learned**: Asked about opportunities for implementation efficiencies, as well as reasons for possible changes in the program activity level and opportunities for program improvement

The Cadmus team tailored each interview guide based on information previously provided by the Utilities to ensure an effective use of time. The interview team consisted of various Cadmus team members to ensure coverage across all relevant evaluation areas.

Surveys

The Cadmus team surveyed fleet managers of activated sites that participated in the program (known as program participants) who had complete contact information. Given the number of activated sites per Utility when we fielded the survey, the Cadmus team only included PG&E and SCE sites that had valid contact information. We plan to include SDG&E sites in a future survey effort and will interview the fleet manager for the Liberty site separately. The purpose of the survey was to cover 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

The Cadmus team conducted the survey via an online survey platform, Qualtrics, and delivered the survey via email to the site hosts through the contact information provided by PG&E and SCE. To encourage participation, the Cadmus 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 Cadmus team offered each respondent a $50 gift card.

For EY2021, the Cadmus team attempted to reach a census of program participants in the PG&E EV Fleet and SCE CRT programs. See Table 10 for sample sizes by Utility. The Cadmus team only included sites with valid contact information in the sample.

Table 10. Program Year 2021 Fleet Manager Survey Sample

	PG&E	SCE
Number of surveys sent	25	23
Number of completed surveys	13	6

The Cadmus team surveyed site hosts who withdrew from the PG&E or SCE program (known as withdrawn fleet managers). During the sample selection process, the Cadmus team worked with the PG&E and SCE program managers to ensure that the survey was only sent to sites that were eligible for and later withdrew from the program—not to those sites that applied and were not eligible. Surveying only eligible sites strengthened the insights gathered through these surveys and allowed us to focus on the reasons for withdrawal that PG&E or SCE might be able to address.

Given the number of withdrawn sites per Utility when the Cadmus team fielded the survey, we only included PG&E and SCE withdrawn sites; the Cadmus team plans to include SDG&E withdrawn sites in a future survey wave.[7] 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
- Assess nonparticipant spillover

For EY2021, the Cadmus team attempted to reach a census of sites that withdrew from the PG&E EV Fleet and SCE CRT programs. We invited withdrawn fleet managers to complete the survey via email and sent them several follow-up emails. To encourage participation, the Cadmus team offered a $50 gift card to respondents who completed a survey. See Table 11 for sample sizes by Utility for the fleet withdrawal survey. The Cadmus team only included sites with valid contact information in the sample.

Table 11. Program Year 2021 Fleet Withdrawal Survey Sample

	PG&E	SCE
Number of surveys sent	13	10
Number of completed surveys	3	2

7 Note that the Liberty MDHD program only includes one site and there were no withdrawn sites.

Expert Opinions

To support the estimation of market effects, the Cadmus team conducts Delphi panels to develop baseline electrification adoption curves.

Delphi 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 including the use of a group of anonymous experts with opinions collected through a series of two to three sequential, structured questionnaires. Opinions from the first round are summarized and provided to the experts for the second round, and they are asked to re-evaluate their original responses. They 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 areas of limited previous data. A panel moderator controls and manages interactions among the experts, with communication typically conducted remotely.

The Cadmus team conducted a Delphi panel with eight school bus market experts to develop a consensus forecast of the market baseline for school bus electrification in California through 2030. We recruited the panelists in February 2022, and they provided two rounds of structured feedback in March 2022. The Cadmus team provided all panelists with the same background information, including historical school bus market data from a recent EMFAC download[8] and data derived from the Advanced Clean Trucks (ACT) regulation.[9] In the first round, we asked experts to provide a forecast of the electric school bus market share assuming no intervention by the electric Utilities, along with a rationale for the shape of their forecast. The Cadmus team aggregated the first-round results, calculated the median forecast,[10] and shared the anonymized market predictions with the panel in the second round. The experts 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), which happened for this panel in the second round. As a final inquiry, the Cadmus team asked experts to assess the impacts of various market interruptions including the ACT regulation and Utility programs.

The Cadmus team recruited experts from different organizations to provide input. The composition of the panel is shown in Table 12. As every organization and expert carries their own biases, it was crucial for the Delphi panel 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 the school bus

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8 EMFAC is a platform managed by the California Air Resource Board (CARB) that complies vehicle emissions factors and contains a vehicle fleet database based on vehicle registration data from the California Department of Motor Vehicles.

9 The ACT regulation is a manufacturers' zero emission vehicle sales requirement and a one-time reporting requirement for large entities and fleets.

10 Although Delphi panels typically use an average of experts' responses, for this study we employed the median to mitigate the impact of outlier responses. After analyzing the first round of input, the Cadmus team found little variation between the average and median forecasts.

market or transportation electrification policy in California, and that they had no conflicts of interest (financial or otherwise) that would impact their objectivity. We did not permit multiple experts originating from the same organization to participate in this panel.

Table 12. Delphi Panelist Composition

	Academia	Nonprofit	ICE and EV Bus Manufacturer	Third-Party Evaluator
Number of Panelists	2	4	1	1

3.1.2. Analysis Methodology

The following subsections provide an overview of the analyses for the MDHD bundle. These analyses include determining the characteristics of counterfactual vehicles[11] and assessing grid impacts, petroleum displacement, GHG and criteria pollutant reductions, and health impacts. The Cadmus team also estimated the total cost of ownership (TCO) and addressed research objectives using data collected from site visits, Utility interviews, and surveys. As discussed below, the petroleum displacement, emissions reduction, and health impact analyses included additional calculations 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 to develop estimates of total electricity consumption, on-peak and off-peak usage, maximum electric demand, and load factors.

For the analysis we used primary and secondary data sources, as shown in Table 13.

Table 13. 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 Cadmus data warehouse and calculated results using a 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 using AMI data for each site.

11 Counterfactual data are used to establish a counterfactual fuel economy (miles per gallon) and vehicle emissions factors to estimate petroleum displacement, emission reductions, and health impacts.

The Cadmus 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 unstable periods representing when vehicles were not in full operation, had ongoing technical problems, or were not fully integrated with the EVSE or other equipment.

We used California Independent System Operator (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 team assessed charging flexibility to determine the extent to which managed charging could increase benefits, such as by lowering electricity prices (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 demand). While 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, then leveraged this data to generate a statistically representative full year of operation.

The emissions calculations require the date and time of AMI data to be matched with the electric generation mix at the time of usage. This approach necessitates normalizing emissions calculations across the whole year due to 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 seasonal variability); also, 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.

Out of the 46 operational sites, the team annualized data for 41[12] MDHD sites that met the annualization criteria by taking four steps:

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 2021 AMI data.
2. **Identify the start month:** The starting month for the actual data used in developing the annualized data was the one where total usage exceeded 75% of the maximum month's usage.
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.
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).

[12] The 46 operational sites had between one month and 12 months of AMI data collected in 2021.

Counterfactual Development

The team identified the market segments in each Utility program and the counterfactual vehicle and fuel type that corresponds with each market segment. A counterfactual vehicle is the vehicle type that would have been used in absence of the program.

Rather than assessing the composition of each legacy fleet (conventional ICE vehicles displaced by the program), we established a generic counterfactual vehicle type. In total, the Cadmus team used 20 counterfactual vehicles, defined by weight class and fuel type. The team assigned all sites an initial counterfactual vehicle type based on Utility program applications, then we refined this information based on additional vehicle information included as part of participants' vehicle acquisition plans (VAPs) submitted to Utilities.

Each counterfactual vehicle type had a corresponding fuel economy (miles per gallon) for on-road vehicles and fuel consumption (gallons per hour) for off-road equipment as well as emissions factors (GHG and criteria pollutants). Additionally, we 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 Cadmus team processed 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. Where electricity consumption rates were not available for a particular vehicle or equipment type, we used supplemental data sources to determine an appropriate rate. Table 14 shows the primary and secondary data inputs.

Table 14. MDHD Counterfactual Data Inputs

Category	Source
Primary Program Data	Utility VAPs, site visits, fleet manager surveys, and Original Equipment Manufacturer interviews
Secondary Data	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 NREL), MDHD vehicle registration data as available, DMV Motive Power Report, and California DMV 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 segments to each of the CPUC-defined market segments and their associated counterfactual vehicle type (such as electric type C school bus and diesel type C school bus).

Petroleum Displacement

For this analysis, the Cadmus team estimated the reductions in counterfactual vehicle fuels compared to electricity usage attributable to the MDHD programs. Expected fuel types and typical end-uses included diesel (such as trucks and school buses), CNG (such as transit and shuttle buses), propane (such as forklifts) and gasoline (such as trucks and vans). Based on the *Counterfactual Development* analysis, all fuel displaced was presented as petroleum-based in diesel gallon equivalent 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 off-road equipment's fuel consumption (gallons per hour). We then converted the amounts of petroleum displaced to diesel gallon equivalents for ease of comparison. Then the team calculated the petroleum displaced by each MDHD program by Utility, in DACs, and by market segment.

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 15 shows the data collection categories and sources.

Table 15. 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 16 shows the analysis steps.

Table 16. 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 and - 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 EY2021 (in future evaluation years, the team will compare AMI data to EVSE session data for more accuracy)
Calculate vehicle miles	Calculate EV miles based on kilowatt-hours consumed and vehicle efficiency
Estimate petroleum displacement	Estimate petroleum displacement based on ICE vehicle miles and efficiency, converted to a diesel gallon equivalent

[a] California Air Resources Board. March 31, 2021. *EMFAC2021 Volume III Technical Document.* Version 1.0.0. p. 33. https://ww2.arb.ca.gov/sites/default/files/2021-03/emfac2021_volume_3_technical_document.pdf

Greenhouse Gas and Criteria Pollutant Reductions

The MDHD programs are expected to reduce the amount of GHGs and criteria pollutants emitted as fossil-fuel-powered on- and off-road MDHD vehicles are replaced by EVs. This section describes the approach, data sources, and analyses performed to estimate these reductions.

The Cadmus team first calculated GHG and criteria pollutant emission reductions from the petroleum displaced by the EVs incented through the programs.[13] The GHG emissions estimates included carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4). Criteria pollutant reductions analyzed included particulate matter ($PM_{2.5}$ and PM_{10}), carbon monoxide (CO), oxides of nitrogen (NO_x), and oxides of sulfur (SO_x). Additionally, the team estimated reductions of reactive organic gases (ROG), which are not criteria pollutants but contribute to the formation of ground-level ozone, which is a criteria pollutant.

Next, the Cadmus 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. 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 pollutants such as 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 Cadmus team used the GHG and criteria pollutant inputs shown in Table 17 regarding electricity usage, resource mix, emissions, vehicle types, and petroleum displaced.

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[13] The Cadmus team counted tailpipe emissions for the counterfactual vehicles and electricity grid emissions for electric vehicles. 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.

Table 17. 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): http://www.caiso.com/todaysoutlook/pages/emissions.html
CO_2 grid emissions by five-minute interval	Metric tons	CAISO emissions (real time): http://www.caiso.com/todaysoutlook/pages/emissions.html
Resource mix by interval	% by generator fuel	CAISO supply (real time): http://www.caiso.com/todaysoutlook/pages/supply.html
NO_x, SO_x, CH_4, and N_2O emission rates	g/kWh	EPA eGRID (2019)
CO_2 emission rate	kg/kWh	EPA eGRID (2019)
CO_2-equivalent emission rate	kg/kWh	EPA eGRID (2019) 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)
Vehicle type (vehicle classification code for linkage to emission tables)	standard category	*Petroleum Displacement*
Petroleum use by month	unit measure for fuel type	*Petroleum Displacement*
Petroleum fuel type	fuel type	*Petroleum Displacement*
Petroleum fuel energy content	MMBtu/unit	U.S. DOE Alternative Fuels Data Center

The analysis comprised four steps. The team used the CAISO API and the latest version of GREET 3.0 to perform this work:

1. **Counterfactual emissions:** We determined emissions from counterfactual vehicle fuel usage using EMFAC emissions data for specific displaced fuels. We used a standard source for lower heating value energy content available within that fuel, converted to a Btu-per-gallon basis to achieve a grams per gallon, and ultimately a grams per year, determination.
2. **Electricity emissions:** We used CAISO five-minute demand and resource mix data reported by zone to establish an emission record for each pollutant. The Cadmus team averaged five-minute interval emissions data to apply it to each 15-minute AMI interval.
3. **GHG calculation:** We used the United Nations Intergovernmental Panel on Climate Change (IPCC) Global Warming Potentials (GWPs) for CO_2 equivalence (CO_2e) on a 100-year timeframe based on the IPCC fifth assessment (AR5). For EY2021, we used GWP-100 factors of 28 for methane (CH_4) and 265 for N_2O. Equation 1 presents the GHG calculation based on CO_2e:

Equation 1. GHG Calculation

$$CO_2e = CO_2 + 28 * CH_4 + 265 * N_2O$$

4. **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 emission reductions for sites both in 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 being adopted. To understand the effects of the MDHD programs on air pollution and related health benefits, the team estimated the value of health benefits from each Utility-funded program. As part of this analysis, we also examined the impact on DACs, which may be disproportionately burdened by sources of pollution that could include air pollution from ICE vehicles. 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.[14] This section describes the approach, data sources, and analyses performed to estimate health impacts associated with the MDHD programs.

The primary goal of this analysis was to estimate the health benefits of the Utility TE programs overall and in DACs in particular.[15] Specifically, the Cadmus team determined the $PM_{2.5}$[16] emission reductions associated with each site, for all sites, and for sites in DACs, then estimated the economic value of the health benefits associated with each.

Because only a small number of sites were activated and operational during EY2021, the health benefits of reducing $PM_{2.5}$ were minimal.[17] To identify these benefits, the team took an analytical approach for EY2021 that included simplifying assumptions that allowed the BenMAP-CE model[18] to use the $PM_{2.5}$ data available from the *Greenhouse Gas and Criteria Pollutant Reductions* and data from CES 4.0—which includes $PM_{2.5}$ concentrations in CES from all sources, not just transportation or diesel fuel—to estimate health benefits without more complex modeling of the location of emission reductions. We calculated outcomes at the site level and aggregated them to other geographic levels.

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14 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.

15 The team conducted the EY2021 analysis for PG&E, SCE, and SDG&E SB 350 programs.

16 $PM_{2.5}$ are tiny particles or droplets in the air that are two and one half microns or less in width.

17 The data available in a given evaluation year will determine the level at which the pollution reductions are *reported.* For example, we may measure pollution reductions for each site and “roll up” the reductions to a larger level (such as census tract, county, or program/Utility) when reporting the emission reductions.

18 BenMAP-CE is an EPA model that estimates the economic value of health impacts resulting from changes in air pollution concentrations.

To complete the valuation analysis through BenMAP-CE, the team leveraged three data sources:

- **CES 4.0 data**: Primarily census tract air quality monitoring and population data and census tract shapefiles
- **Criteria pollutant reductions ($PM_{2.5}$) by site:** We assumed all reductions occur in the census tract in which the site is located, as vehicle telematics or routes were largely unavailable
- **Built-in BenMAP-CE health impact and valuation functions:**
  - ER visits, all respiratory illnesses
  - ER visits, all cardiovascular illnesses
  - Hospital admissions, all respiratory illnesses
  - Mortality, all-causes
  - Work loss days

Once the team finalized inputs from CES 4.0 and the *Greenhouse Gas and Criteria Pollutant Reductions*, we prepped the data for input into BenMAP-CE. First, we converted site-level $PM_{2.5}$ data from grams to grams per second. We assumed that each cubic space receives the mass each second and is refilled the next second at the same rate. Though this approach is simplified, due to the small amount of emissions reduced in EY2021, this approximation provides a reasonable, conservative estimate. Once the program reduction data aligned with CES 4.0 census tract and air quality data, the team formatted inputs and ran BenMAP-CE. The analysis resulted in an estimated economic value of health benefits, by pollutant ($PM_{2.5}$ for EY2021) associated with each site, for all sites and for sites in DACs, delineated by program and Utility as appropriate.

Total Cost of Ownership

For the MDHD total cost of ownership (TCO) analysis, the Cadmus team examined the costs of owning and operating a representative 10-vehicle fleet for each of three market segments: school buses, transit buses, and medium-duty package delivery vehicles. We conducted these fleet TCO analyses for each large Utility program in EY2021 since the inputs to the analysis (particularly electricity costs, program incentives, and discount rates) vary by Utility.

While electric MDHD vehicles have a much higher incremental purchase price than traditional diesel vehicles, EVs typically cost less to power and maintain. The team assessed the TCO of a fleet of 10 counterfactual vehicles in the three market segments compared to a fleet of 10 EVs to determine whether the electric fleets will cost more or less than the counterfactual fleets over a 10-year period.

To conduct this TCO analysis, we conducted a side-by side comparison of a 10-vehicle fleet for each of the three main market segments in the Utility MDHD programs thus far (school buses, transit buses, and medium-duty package delivery vehicles) and their costs of ownership and operations over a 10-year period. We developed an upfront cost of each fleet (both counterfactual and electric) for each Utility from the perspective of the fleet owner that covered the capital expenses associated with purchasing the vehicle (including vehicle price, sales tax, and charging infrastructure). The charging infrastructure included any costs associated with electrification such as charger cost, construction, engineering, and commissioning of chargers. We included TTM and BTM costs in the upfront costs. Then the team assessed the cost of operating these two different fleets over a 10-year period including operation and maintenance costs for the fleets.

For this TCO analysis the Cadmus team relied on both primary and secondary data. As more program data become available through surveys and Utility data collection in subsequent evaluation years, we expect primary data to increase. Table 18 shows the TCO data inputs for EY2021.

Table 18. TCO Analysis Data Inputs

Data Inputs	Details	Source
Vehicle Market Segment	School bus, transit bus, and package delivery trucks	Based on Utility MDHD program site data
Number of Vehicles in Fleet	10	Based on site visits as average fleet size
Number of Years in Operation	10	Assumption made by evaluation team as part of methodology development
New Vehicle Purchase Price	Multiple sources depending on market segment: • School buses from site visit data • Transit buses from APTA 2020 [a] vehicle database (average cost in California for a 40-foot bus manufactured between 2019 and 2021) • Package delivery trucks from multiple secondary sources	**School Bus** (assumption based on discussions with fleet managers during site visits and discussions with OEMs) **Transit Bus** (from APTA 2020 vehicle database Average cost, CA, 40' manufactured 2019-2021), **Medium Duty Class 4 Package Delivery Truck** (based on estimated M.S.R.P. costs of class 4 EV delivery vehicles: Green Power EV Star Cargo, Motiv Epic E-450 and Rivian R1T Step).
Sales Tax	Sales tax on purchase and excise tax (if applicable)	California weighted average is 8.5%, with no sales tax on public transit fleets until 2024 (per AB 784)
Annual Vehicle Miles Traveled	Average annual VMT for vehicles in each market segment	Secondary data from Alternative Fuel Data Center 2018 [b]
Vehicle Efficiency	Kilowatt-hours per mile (electric) Miles per Diesel Gallon Equivalent (diesel or CNG)	From counterfactual analysis (see counterfactual methodology)
Fuel Costs (counterfactual)	$ per gallon	School bus and delivery truck based on EIA California 10-year average cost of diesel fuel with EIA Annual Energy Outlook escalator. Transit bus based on EIA California 10-year average cost of CNG for commercial customers' price per diesel gallon equivalent with EIA Annual Energy Outlook escalator. [c]
Fuel Costs (electricity)	$ per kilowatt-hour	Primary data from fleet electricity usage divided by fleet electricity billing data with outliers removed
Maintenance and Repair Cost Per Mile Estimate (counterfactual)	$ per VMT	Counterfactual data from various secondary sources depending on market segment and vehicle type: CARB, Transit Fleet Cost Model Spreadsheet, 2018 and from CARB Advanced Clean Trucks TCO Tool [d]
Maintenance and Repair Cost Per Mile Estimate (electricity)	$ per VMT	Used 75% of per mile diesel maintenance costs as conservative estimate until we get more information in future years. [e]
Discount Rate	Discount rate used in 2021 avoided costs calculator of electric sites	From 2021 ACC Electric Model v1 [f]

Data Inputs	Details	Source
Insurance Costs	Accounted only for physical damage insurance, because liability and other commercial insurance components would be the same for EVs and ICE vehicles	"Physical Damage" insurance is 1/70th the cost of the new vehicle. Insurance costs decline at depreciation rate. [e]
Depreciation Costs	Residual value at end of 10-year period	Depreciation rates and table from Advanced Clean Fleets TCO Discussion Document and CARB Advanced Clean Trucks Tool [e]
EVSE Costs	Cost of charger	Charger costs for electric vehicle fleets. Utility Upgrades are not included in this cost. Based on L2 chargers for School Bus Fleets and Medium Duty Package Delivery Trucks. Based on 50kW DCFC for Transit Buses. From mid-range value of literature review.
EVSE Networking and Maintenance costs (Annual)	Per charger subscription for networking plus estimated maintenance and repair of chargers.	Based on quotes from EVSP for networking, maintenance contract, and estimated repairs.
Infrastructure Costs	Utility-side (TTM) and customer-side (BTM) costs of installing EVSE	Total site infrastructure costs based on estimates from 2021 MDHD program sites includes all infrastructure and installation costs: construction, trenching, line extensions, transformer upgrades, switchgear and labor.
Utility Incentives	To understand the cost impact of MDHD program incentives on these fleets	Author estimates of Utility incentives based on Utility infrastructure cost data from EY2021 sites.
LCFS Credit Revenues	To understand the cost impact of Low Carbon Fuel Standard credit revenue on these fleets	Calculated credits using CARB Credit Value Calculator [g] based on annual kilowatt-hour used per vehicle. Used credit price of $181 as midpoint value between EY2021 highest value ($218) and EY2021 lowest value ($143). Transit buses did not generate LCFS credits in this analysis because we assumed the LCFS credit value from their use of RNG was used to offset the additional cost of RNG over CNG. Full treatment of LCFS credits and transit buses is in Appendix B.

[a] American Public Transportation Association. 2020. "Public Transportation Vehicle Database." https://www.apta.com/research-technical-resources/transit-statistics/vehicle-database/

[b] U.S. Department of Energy, Energy Efficiency and Renewable Energy. Last updated February 2020. "Average Annual Vehicle Miles Traveled by Major Vehicle Category." https://afdc.energy.gov/data/widgets/10309

[c] U.S. Energy Information Administration. n.d. "Annual Energy Outlook 2022." Table 12. Petroleum and Other Liquids Prices. https://www.eia.gov/outlooks/aeo/data/browser/#/?id=12-AEO2022&cases=ref2022&sourcekey=0

[d] Arneja, Paul. 2019. CARB Transit Fleet Cost Model. Version 20170622. https://www.arb.ca.gov/regact/2018/ict2018/appk-transitfleetcostmodel.xlsx

[e] California Air Resources Board. September 9, 2021. *Draft Advanced Clean Fleets Total Cost of Ownership Discussion Document.* https://ww2.arb.ca.gov/sites/default/files/2021-08/210909costdoc_ADA.pdf

[f] Energy + Environmental Economics. June 28, 2021. "CPUC Approves 2021 Avoided Costs for Valuing Distributed Energy Resources." https://www.ethree.com/cpuc-approves-2021-avoided-costs-for-valuing-distributed-energy-resources/

[g] California Air Resources Board. Last updated 2022. "LCFS Data Dashboard." https://ww2.arb.ca.gov/resources/documents/lcfs-data-dashboard

To conduct the EY2021 TCO analysis, the Cadmus team calculated initial investments for the 10-vehicle fleets for each market segment. This included vehicle price, sales tax, and infrastructure costs (in the case of EVs). We then calculated the annual costs to maintain and operate the vehicles over the 10-year duration of vehicle operation. The team completed this process for the counterfactual fleets in each market segment for each Utility as well as for the EV fleets in each market segment for each Utility. Table 19 shows the three different scenarios we analyzed for each market segment.

Table 19. TCO Analysis Scenarios

	Medium Duty Package Truck	School Bus	Transit Bus
Vehicle Class	Class 4	Class 7 Type D	Class 8 (40-foot)
Counterfactual (baseline for all three scenarios)	X	X	X
Fleet Electrification with no Grants, Utility Infrastructure Cost Coverage, or Incentives	X	X	X
Fleet Electrification with Grants, Utility Infrastructure Cost Coverage, Incentives and LCFS	X	X	X

The team had two goals for this analysis. The first goal was to understand whether EV fleets are cost-competitive with fossil fuel fleets over the life of the vehicles. The second goal was to understand these fleets' sensitivity to incentives, particularly to the Utility incentives that were part of the MDHD programs. For EY2021 there were limited data on these incentive amounts for fleets, particularly because much of the Utility contribution to fleet electrification is in the form of free advisory services, support, education, TTM grid upgrades, and BTM upgrades. Thus, this information was not embedded in the site costs and was not broken out in discrete categories like traditional incentive information. We worked with the Utilities to collect as much of this information as possible to evaluate the impacts of these incentives on fleet TCO. We also incorporated LCFS credit estimates into the TCO to understand their impact on the financial feasibility of fleet electrification.

In addition to the scenario analysis the evaluation team conducted, we conducted a managed charging analysis to assess the impact of managed versus unmanaged charging on electric fuel costs of EV school bus fleets. A school bus fleet was modeled over a 10-year period using 60% on-peak charger and 40% off-peak charging compared to the same fleet using 70% off-peak charging and 30% super off-peak charging. The purpose of this analysis was to measure the impact of managed charging on the TCO of an electric school bus fleet over a 10-year period.

The TCO was primarily conducted from the perspective of a fleet owner or manager, but the evaluation team also conducted an analysis of cumulative utility revenue from the fleet electrification projects. Using utility billing data, the team added the electricity sales from the projects since their activation. Because this is the first year this analysis was conducted and there were limited projects eligible, this data was not annualized. The purpose of this analysis was to measure the impacts from these projects on electricity sales.

Finally, the Cadmus team examined the magnitude and variance of costs per site, per vehicle supported, and per kilowatt in PG&E's EV Fleet program. Data were analyzed by school bus sites and aggregated other vehicle types, which consists of a combination of other heavy-duty Class 8 vehicles, transit buses, medium-duty vehicles, and forklifts.

Site Visits

The team visited MDHD program sites that were activated during EY2021 to provide quantitative and qualitative infrastructure insights. This section describes the approach, data sources, and analyses performed for EY2021 MDHD site visits.

The team took a census approach, conducting visits at 41 of 53 EY2021 activated sites. The team collaborated with the Utilities and site hosts, as appropriate, to access each site and complete the 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 and photos and entered data into the Arkenstone data collection platform. We used these data to support the grid impacts and petroleum displacement analyses since they rely on site-specific energy consumption, which can be impacted by the reliability of charging systems for EVs and by 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 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),
  - Total vehicle load (kW) both currently and expected by operators, and
  - Expandability, which may be indicated by the size of transformers, details of service panels (amperage and space for circuit breakers), 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.
- Determine reasons behind lessons learned, challenges, and operability (EVs and or charging hardware) such as software, hardware, staffing, and passenger loads that support the site utilization rates.

Co-Benefits and Co-Costs

Through the fleet manager surveys, the Cadmus team collected information on co-benefits and co-costs for fleet managers. Specifically, the team asked both closed- and open-ended questions to understand which co-benefits and co-costs fleet managers experienced. Given that some fleets have been operating for a short time, the Cadmus 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 they *expect,* not what they have experienced, because many of the co-benefits are felt by drivers and the local communities, and not by the fleet managers specifically. To supplement the survey responses, we incorporated relevant data from the site visits. While we did not formally ask about co-benefits and co-costs during the site visits, the Cadmus team was able to obtain anecdotal information from site representatives.

In future evaluation years, the Cadmus team plans to expand the co-benefits and co-costs analysis to incorporate additional data collection activities (fleet driver surveys) and to collect information more formally during site visits.

Net Impacts

Qualitative Assessment of Spillover

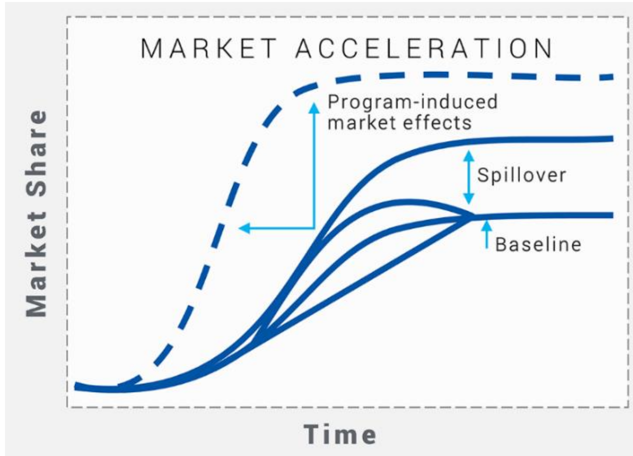
The Cadmus team collected both participant and nonparticipant spillover data from the fleet manager and fleet withdrawal surveys and site visits. To assess participant spillover, the team collected the number of vehicles procured and when (according to sites' vehicle acquisition plans). For nonparticipants, if a withdrawn site representative said they electrified their fleet outside the program, the survey asked the respondent about how influential the program was to their decision to electrify. As part of the net impacts analysis in future evaluation years, the Cadmus team will assess both freeridership and participant spillover through fleet manager surveys.

Market Effects: School Bus Electrification Market Share Baseline

Measuring market effects is intended to inform Research Objective 1: "whether transportation electrification (TE) investments accelerated widespread TE."

Market effects arise from changes in the structure of a market or the behavior of market participants in the form of increased adoption of clean energy products, services, or practices causally related to market interventions (such as program incentives and trainings). In the context of the MDHD programs, effects in the MDHD market are the adoption of EVs by fleets that did not directly participate in the programs. As illustrated in Figure 2, 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 cause a shift in the adoption curve to the left as well as upward, indicating faster and higher levels of EV adoption compared with the baseline scenario where no Utility market interventions occurred.

Figure 2. Market Effects: Acceleration and Transformation



Estimating market effects requires knowing the actual adoption, program participant net impacts, and naturally occurring baseline market adoption. Ideally, measurement of the naturally occurring baseline occurs prior to significant program activity since the baseline represents adoption in a scenario without Utility market intervention.

School Bus Electrification Naturally Occurring Baseline

Based on a review of the MDHD programs' pipeline, the Cadmus team determined that school buses were a major market category. Therefore, we conducted a Delphi panel with eight industry experts to generate a consensus forecast of the naturally occurring baseline market share of electric school buses in California (labeled Baseline in Figure 2 above). In the future, when actual adoption is known, the Cadmus team will calculate market effects based on the baseline adoption curve we developed. This baseline accounts for existing market trends, product availability, and other non-Utility efforts to promote electrification. For this report, the Cadmus team examined California's school bus market, which represents the largest share of active applications in the MDHD programs' pipeline.

The Cadmus team conducted a two-round Delphi panel with eight school bus market experts to develop a consensus forecast of the market baseline for school bus electrification in California through 2030. The baseline assumes no market development efforts by the electric Utilities.

The eight panelists provided their inputs through an online survey, which the Cadmus team had programmed to capture electrified market share in 2022, 2024, 2026, 2028, and 2030. The online survey allowed the panelists to see their forecasted adoption curve generated in real time and to make adjustments dynamically.

In the first round of the Delphi process, experts provided a forecast of electric school bus market share assuming no intervention by the electric Utilities. The experts also provided a rationale for the shape of their forecast. The Cadmus team reviewed the forecasts and calculated a median forecast. In the second round, the panelists reviewed the forecasts submitted in the first round and indicated whether they agreed with the median or wanted to submit another forecast. Five panelists agreed with the median and three submitted new forecasts during the second round. As over half of the experts agreed with the original median forecast, we used that median forecast as the consensus forecast.

While the main purpose of this Delphi panel was to develop a consensus market baseline forecast, the Cadmus team recognized that panelists' rationales contained valuable qualitative information, and we summarized these rationales. Based on this summary, the team drew insights into those factors that panelists believe will accelerate or impede school bus electrification in California.

Process Evaluation

The following subsections discuss the process evaluation for MDHD surveys and interviews.

Surveys

The Cadmus team used qualitative 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 qualitative survey data, the Cadmus 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.

Twenty-two fleet managers responded to the fleet manager survey (of which 19 completed the full survey), and five responded to the fleet withdrawal survey. The Cadmus team compiled survey data to produce and interpret graphical analysis of the survey responses.

The Cadmus team primarily analyzed the fleet manager and fleet withdrawal surveys 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 Cadmus team expects a larger sample size, which will allow for a more robust analysis among different strata. Due to the small sample sizes, the Cadmus team did not apply any significance testing to EY2021 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 conducted the first round of interviews in EY2021 with each participating Utility. The Cadmus team compiled and synthesized all relevant information from each Utility in a workbook. 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.

3.2. Public Charging (Schools, Parks, and EV Fast Charge) Evaluation Methodology

This section outlines the data collection and analysis for the Public Charging program evaluation.

3.2.1. Data Collection Methodology

The following subsections discuss data collection for the Public Charging program evaluation, including program data, materials, and the webpage; AMI and EVSE data; site visits; and Utility interviews.

Program Data

Program data provides essential insights into program performance. The Cadmus 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.[19] Once we received data from these Utilities, we moved it to the Cadmus data warehouse for secure storage, retrieval, and analysis.

These data included program application status and timing (from initial engagement to site activation for those site that were complete and operational in EY2021), as well as details such as the number of ports, site status (DAC or non-DAC), program, application phase timing, and site costs. These data provided the Cadmus team with an understanding of program implementation and helped us to identify lessons learned, such as possible bottlenecks in application processing or areas of higher-than-expected costs that may impact performance.

Program Material

In addition, the Cadmus team reviewed available program-related material such as marketing education and outreach documentation, Commission Decisions, Orders, Advice Letters, the *Joint IOU EV Load Research and Charging Infrastructure Cost Report* (filed on March 31, 2022), PAC presentations, Utility-based customer satisfaction survey questions, and some application materials. The program material review is important to establish foundational insight into understanding the program design intent, changes, and implementation progress.

The Cadmus team reviewed all PG&E, SCE, and SDG&E PAC presentations since 2020, as well as SCE PAC presentations back to 2018. The key legislative documents we reviewed included (but were not limited to) the original Decisions 18-05-040 (defining PG&E's MDHD and DCFC programs), 19-08-26 (defining SDG&E's V2G program), and 19-11-017 (defining the Schools and Parks Pilots) and Advice Letter 3890-E (a joint filing from SDG&E on behalf of all program Utilities providing a program status report).

Table 20 shows a list of the material types the Cadmus team reviewed by Utility.

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19 Liberty provided no site data for EY2021 (as no public charging sites were completed).

Table 20. Public Charging Materials Reviewed

Utility	Program Materials Provided
Liberty	• Utility website review • Regulatory documents such as Decisions and Advice Letters • EV and EVSE perception summary presentation • EV and EVSE perception survey results presentation
PG&E	• (Schools and Parks Pilots and EV Fast Charge) Utility website review • (Schools and Parks Pilots and EV Fast Charge) PAC presentations • (Schools and Parks Pilots and EV Fast Charge) Regulatory documents such as Decisions and Advice Letters • (Schools and Parks Pilots and EV Fast Charge) *Joint IOU EV Load Research and Charging Infrastructure Cost Report* • (Schools and Parks Pilots and EV Fast Charge) Customer satisfaction survey questions • (Schools and Parks Pilots and EV Fast Charge) Marketing/FAQ about EVSE installed through the program • (Schools and Parks Pilots and EV Fast Charge) Program overview presentations • (Schools and Parks Pilots only) Marketing/awareness email collateral • (EV Fast Charge only) Contractor onboarding presentation • (EV Fast Charge only) Application preparation and information documents • (EV Fast Charge only) Solicitation summary documents • (EV Fast Charge only) Approved "Product Feature" workbook
SCE	• Utility website review • Regulatory documents such as Decisions and Advice Letters • *Joint IOU EV Load Research and Charging Infrastructure Cost Report* • PAC presentations • (School Pilot only) Summary of welcome kit • (School Pilot only) Fact sheet
SDG&E	• Utility website review • PAC presentations • Regulatory documents such as Decisions and Advice Letters • *Joint IOU EV Load Research and Charging Infrastructure Cost Report* • Participation agreement • Marketing materials

Utility Web Page

Because the broad accessibility of program web pages makes them a core element of customer-facing communications and their non-static nature enables them to reflect current stages of the implementation process, we find them to be an insightful element within the materials review. With our web page assessment tool, which guided our review of the general web page characteristics, we examined web navigation, design, credibility, and content clarity.

AMI/EVSP

AMI data are used to determine charger usage, which is a key input for subsequent analysis and estimation of program grid impacts. The team collected and securely transferred these data between the Utilities and Microsoft Azure cloud-based environments monthly, with some variation in timing among the Utilities. Once the data were received, the team moved them into the Cadmus data warehouse for secure storage and retrieval and complied them for subsequent calculations and analysis. Time-stamped energy consumption data (kilowatt-hours) in 15-minute intervals provided insights that the team used to determine the potential impacts of EV adoption to the grid, as well as avoided petroleum consumption, reduced emissions, and associated health impacts.

A second critical data source was EVSE data, which the Cadmus team collected directly from the participating EVSPs. The Utilities developed a process for screening and approving EVSPs, based in part on their ability to provide essential data on charging such as EVSE session, interval, station, and port data. On a monthly basis, the Cadmus team collected this information for each Utility program's active sites by having EVSPs upload these data to a secure Microsoft SharePoint portal. We then reviewed the uploaded files for completeness, adherence to the agreed-upon Utility format, and accuracy of each site's information, then we imported the data into a secure database in a Microsoft Azure Machine Learning cloud environment. After additional quality control checks, the team securely transferred the monthly EVSE charging data into the Cadmus data warehouse.

Together, AMI and EVSE data provided the basis for analyzing program performance at a fairly granular level. We used these data to identify load management opportunities such as the ability to shift loads off peak in response to time-varying rates. The team used data from EVSPs to examine charging session trends, such as the percentage of time in which a vehicle connected to a charging station is actually charging. Port utilization rates can be expected to rise as the program matures, consumers and fleets acquire more vehicles, and the pandemic impacts are reduced.

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 EY2021, the Public Charging site visits brought supplemental qualitative insights, especially in regard to lessons learned (such as why some sites have higher usage than others). The team attempted a census of activated sites for EY2021, conducting 10 site visits, as shown in Table 21.

Table 21. EY2021 Site Visits By Utility and Program

Utility	Program	Sites Activated	Sites Operational	Site Visited
Liberty	School Pilot	-	-	-
	Parks Pilot	-	-	-
PG&E	EV Fast Charge	4	4	4
	Schools Pilot	-	-	-
	Parks Pilot	-	-	-
SCE	School Pilot	1	-	-
	Parks Pilot	-	-	-
SDG&E	School Pilot	1	-	1
	Parks Pilot	5	4	5

Interviews

In-depth interviews provide critical insight on the original intent, actual implementation, and success of the Pilots and programs, as well as the potential to scale up. For EY2021, we conducted preliminary interviews in September 2021 with core staff overseeing the public charging programs[20] across the four Utilities and a close out interview with the same staff in late March and early April 2022, for a total of 10 interview sessions. 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. The evaluation lead conducted the interview and the process lead took verbatim notes to reference during analysis.

3.2.2. Analysis Methodology

This section provides an overview of analyses for the Public Charging bundle, including estimating EV adoption and grid impacts, developing the vehicle counterfactual, and determining petroleum displacement, GHG and criteria pollutant reductions, and health impacts, as well as preparing for a TCO analysis, qualitative site visits, and Utility interview analysis. As further discussed below, the petroleum fuel reductions, GHG and criteria pollutant reductions, and health impacts analyses include a DAC carve out to consider these impacts on DACs in particular.

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.[21] Recent research shows that growth in the availability of public charging networks can lift EV purchases.[22] However, the specific mechanism through which the availability of public charging affects EV purchases is not clear. Understanding this mechanism may help the Utilities and other investors in public EV charging facilities to make more productive investments. This section describes the Cadmus team's approach, data sources, and analyses to estimate EV adoption as influenced by the Public Charging programs.

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20 This specifically pertained to the School Pilot, Parks Pilot, and PG&E DC Fast Charging.

21 These investments were made through Utility EV Pilots and programs including the PG&E EV Fast Charge program and Schools and Parks Pilots.

22 See 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.

The team estimated the effect of public charging stations on EV adoption for populations neighboring public charging stations[23] with a two stage analysis:

1. Historical analysis of public EV charging impacts on vehicle ownership
2. Analysis of ownership attributable to PG&E EV Fast Charge program Investments.

In the first stage, the team estimated the effects of access to any neighboring public charging on EV ownership.[24]

The end results are provided in the IOU EV Adoption findings sections 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 non-random siting of public EV charging.[25] In the second stage, which was an attribution analysis, the team applied the regression coefficient estimates of public charging access in the first stage to the specific Utility investments in public charging to estimate their impact on EV ownership (for the EV Fast Charge program and Parks Pilot).

The Cadmus team assembled a CGB panel dataset on annual EV ownership and access to public EV charging for calendar years 2015 through 2020 to perform the analysis. In addition, 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 (census block group [CBG] and census block) shape files. Table 22 lists these data sources.

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23 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 availability of EV charging equipment at convenient locations (for midday charging away from home) is expected 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 availability of nearby charging infrastructure is expected to lower the cost of EV ownership by providing alternatives to home charging. It is expected 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 lift EV ownership through both channels and that there may be positive interactive effects between the channels that lift the overall impact of public charging networks. The Cadmus team focused on analyzing the second channel. We will analyze the impacts for the first channel separately when data become available.

24 For the stage one analysis, the 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.

25 The Cadmus team estimates the first-stage impacts as a function of different station characteristics, such as the location (school, mall, other), ownership type (private versus public), charger type (L1, L2, DCFC), and neighborhood characteristics (including type of housing and income range). Estimating different treatment effects is important since Utility investments in charging infrastructure are in specific locations (beaches and parks, schools, and traditionally underserved neighborhoods).

Table 22. 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: https://arb.ca.gov/emfac/fleet-db	CBG
EV charging stations	EV station attributes and location	NREL Alternative Fuels Data Center: 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 could be used to identify DACs	California Environmental Protection Agency 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 10 largest cities in California	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 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/	Land zone

Data Element	Description	Source	Reporting Unit
		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	
California Utility investments in EV charging stations	EV station attributes and location	California Utilities	Fuel station

The team then reviewed all data for completeness and accuracy and documented any significant gaps or other issues that would affect the analysis results.

Our analysis sample includes all California CBGs except those meeting one or more exclusion criteria:

- The CBGs was in a rural area;[26]
- The CBG did not have any households;
- The CBG was new since the 2010 census; or
- The CBG has outlier EV registration numbers (those greater than the 99th percentile in 2020).

After applying these sample exclusion criteria, there were 131,105 CBG-year observations remaining in the analysis sample.

The goal of the stage one analysis was to estimate the impact of public EV charging access on EV ownership. During this stage, we first measured access 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 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 with two approaches. To accomplish this, we first conducted an ordinary least squares estimation of a panel or long differences regression. The panel model included year fixed effects, CBG fixed effects, and county time trends. The CBG fixed-effects and county-time trends are intended to control, respectively, for time-invariant CBG and time-varying county characteristics that could be correlated with the location decisions of public charging and subsequent EV adoption.

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26 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 found that the inclusion of rural areas could lead to overestimating the effect of chargers on these non-urban residents, and limiting 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.

However, the estimates from this analysis may be biased if public EV charging location decisions were based on unobservable within-county trends, such as higher EV demand within certain areas (endogeneity of the location decisions). Therefore, in the second approach, the Cadmus team estimated the public EV charging impacts by using a two-stage least squares regression, which included instrumental variables. The instrumental variables 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[27] while controlling for the income and percentage of multifamily housing units in CBGs.

In stage two, the team estimated the impact of California Utility investments in public charging on EV adoption in the study period.[28] To estimate the impact of the Utility public charging stations on EV adoption, we followed three steps:

- **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.[29]
- **Step 2:** We used the regression model estimates to determine, for each affected CBG, the change in EV ownership from 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.

A notable benefit of this two stage approach to assessing EV and EVSE market acceleration is that it can be applied to evaluations of other programs that also increase EV charging access, ensuring methodological consistency.

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27 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 only be located on suitably zoned land and land zoning remains relatively unchanged over time, proximity to space zoned for commercial, public uses, or parking should be correlated with the change in access in public charging between 2015 and 2020 but uncorrelated with EV adoption over this period.

28 The team developed the current methodology to study the impact of public EV charging on existing EV adoption. To forecast the impact in a future period, a separate approach and additional data on the Utility investments in public charging are required.

29 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.

Grid Impacts

The team estimated 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 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.

This data are reported by site, in aggregate and on a daily and monthly basis.[30]

The team used the essential primary and secondary data summarized in Table 23 for the Public Charging grid impacts analysis.

Table 23. Public Charging Grid Impacts Data Inputs

Category	Source
Primary Data	Utility AMI data, historical California Independent System Operator (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

The team calculated total electric energy consumption for vehicles using Public Charging stations installed through the programs. We examined AMI data to determine on-peak and off-peak electricity usage by Utility. For the purpose of this analysis, the team defined on-peak as 4 p.m. to 9 p.m., which represents the high grid impact period with corresponding highest energy costs on any given day. Two kinds of time varying rates are applicable in this study, with the same designated peak period for each. We then calculated load factors using AMI data and the load factor equation:

Equation 2. Load Factor Calculation

$$\textit{Average Load} \div [\textit{Maximum Load in Given Time Period} * \textit{Projected Kilowatt Consumption at Max Load for Calendar Month}]$$

[30] 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. The team used CAISO locational marginal price data combined with system load data to compare program load curves with overall system demand. 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. Managed charging in which EVs consume power during off-peak periods when solar output is high (mid-day) 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.

While grid impact analysis was applied to the actual AMI data for the eight activated sites in EY2021, the team annualized AMI data to support analyses with forecasts including the petroleum displacement and GHG and criteria pollutant emissions reductions. Through the annualization of AMI data the team identified the region of stable operation, then leveraged this data to generate a statistically representative full year of operation.

The 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 due to 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, and 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.

Out of the eight activated Public Charging sites in EY2021, the team annualized AMI data for the seven[31] sites that met the annualization criteria through the following four steps:

- **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 2021 AMI data.
- **Step 2: Identify the start month:** The starting month for the actual data used in developing the annualized data was the one whose 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).

[31] The eight operational sites ranged in operation from two months to 12 months of AMI data.

Counterfactual Development

The team conducted secondary research to inform the development of the electric light-duty vehicle (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 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 team calculated the electric LDV counterfactual for EY2021 as average EV efficiency (kilowatt-hours per mile) using a weighted averaged for the most popular new EVs in each Utility territory. Next, the team calculated the conventional LDV counterfactual for EY2021 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 mostly sedans with a few small SUVs, 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 team used the secondary data summarized Table 24 to develop the electric and conventional LDV counterfactuals.

Table 24. 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	Battery EV and plug-in hybrid EV 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

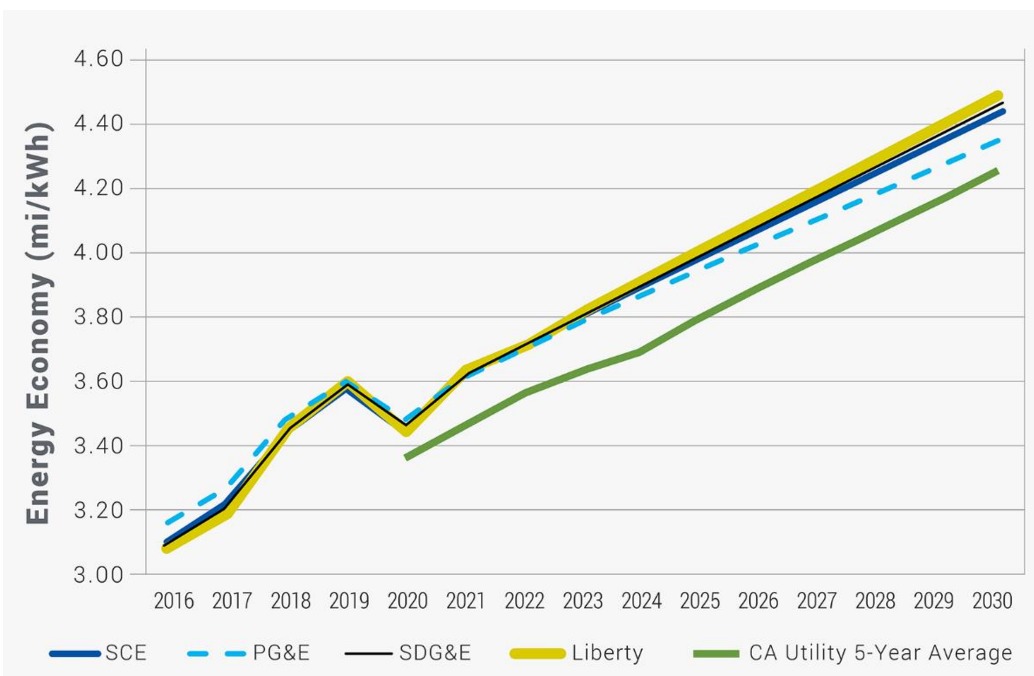
The counterfactual results, both actual since 2016 and predicted through 2030 (using Microsoft Excel's forecast algorithm), are shown in Table 25.

Table 25. 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	Data Origin
2016	3.09	3.17	3.10	3.09	3.11	2.6%	-	-	Actual
2017	3.19	3.28	3.23	3.21	3.23	2.8%	-	-	Actual
2018	3.45	3.48	3.44	3.45	3.46	1.3%	-	-	Actual
2019	3.60	3.60	3.58	3.59	3.59	0.7%	-	-	Actual
2020	3.45	3.48	3.45	3.46	3.46	0.9%	3.37	**0.30**	Actual
2021	3.63	3.62	3.62	3.61	3.62	0.5%	3.47	**0.29**	Actual
2022	3.72	3.71	3.71	3.71	3.71	0.3%	3.57	**0.28**	Predicted
2023	3.82	3.79	3.81	3.82	3.81	0.6%	3.64	**0.27**	Predicted
2024	3.92	3.87	3.90	3.91	3.90	1.2%	3.70	**0.27**	Predicted
2025	4.01	3.95	3.99	4.00	3.99	1.6%	3.81	**0.26**	Predicted
2026	4.11	4.03	4.08	4.09	4.08	1.9%	3.90	**0.26**	Predicted
2027	4.20	4.11	4.17	4.18	4.17	2.2%	3.99	**0.25**	Predicted
2028	4.30	4.19	4.26	4.28	4.26	2.6%	4.08	**0.25**	Predicted
2029	4.39	4.27	4.35	4.37	4.35	2.9%	4.17	**0.24**	Predicted
2030	4.49	4.35	4.44	4.46	4.44	3.2%	4.26	**0.23**	Predicted

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 make up) is not significant, as shown in Figure 3.

Figure 3. EV Efficiency per Utility Per Year



The team then identified the comparable vehicle type mix, shown in Figure 4, which resulted in California-wide counterfactual weighted averages, both actual since 2017 and predicted through 2035 (using Microsoft Excel's forecast algorithm), as well as the prior five-year average (as shown in Figure 4 and Table 26).

Figure 4. EV Market Share Penetration Rates to Reach 100% BEV Sales by 2035

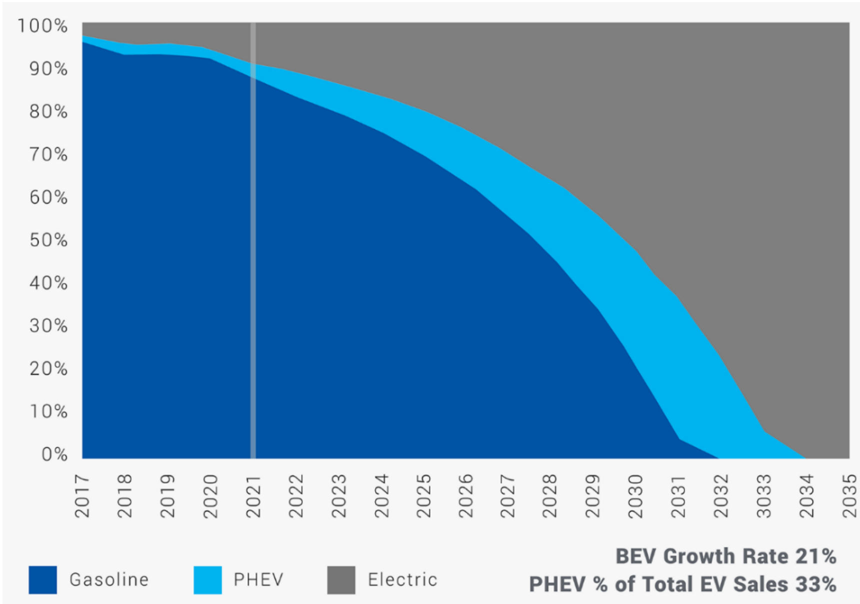


Table 26. Counterfactual Vehicle Fuel Economy by Year

Year	Gasoline	PHEV	Electric	Weighted Average	Last 5-Year Average	Data Origin
2017	27.00	71.83	109.38	30.21	-	Actual
2018	27.06	72.98	111.82	32.33	-	Actual
2019	26.90	72.69	117.07	32.64	-	Actual
2020	27.46	70.65	115.95	33.76	-	Actual
2021	28.13	63.06	121.75	38.18	**33.43**	Actual
2022	27.63	63.10	122.15	40.50	**35.48**	Predicted
2023	27.76	60.92	126.38	43.75	**37.77**	Predicted
2024	27.89	58.74	127.27	47.17	**40.67**	Predicted
2025	28.02	56.55	131.50	51.96	**44.31**	Predicted
2026	28.16	54.37	132.40	57.02	**48.08**	Predicted
2027	28.29	52.18	136.63	64.10	**52.80**	Predicted
2028	28.42	50.00	137.53	71.62	**58.37**	Predicted
2029	28.55	47.82	141.76	82.11	**65.36**	Predicted
2030	28.69	45.63	142.66	93.30	**73.63**	Predicted
2031	28.82	43.45	146.89	108.89	**84.00**	Predicted
2032	28.95	41.26	147.79	123.64	**95.91**	Predicted
2033	29.08	39.08	152.02	144.76	**110.54**	Predicted
2034	29.21	36.90	152.92	152.92	**124.70**	Predicted
2035	29.35	34.71	157.15	157.15	**137.47**	Predicted

Petroleum Displacement

One goal of the Public Charging programs was to reduce the amount of petroleum fuels used by ICE vehicles as they are replaced by EVs. As part of this analysis, the team examined these reductions at the program and bundle levels. This section describes the approach, data sources, and analyses performed to estimate the Public Charging–related petroleum fuel reductions.

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. In addition, the team examined the petroleum fuel reduction for Public Charging programs overall, by Utility, and for impact on DACs in particular. We analyze the issue in more depth in the *Health Impacts* section below.

The team developed a petroleum displacement tool that converted electrical energy use in kilowatt-hours from Utility AMI data to petroleum displaced using the electrical energy consumption rate to calculate the EV miles traveled. For this analysis, we used the same number of miles for conventional ICE vehicles that would have been driven in absence of the program (the counterfactual). The team then calculated the petroleum displacement in gasoline gallons equivalent using the petroleum displacement equation:

Equation 3. Petroleum Displacement Calculation

Number of Miles Used by the Non-EV ÷ Counterfactual Vehicle's Fuel Economy (miles per gallon)

The team used the primary and secondary data summarized in Table 27 for the Public Charging petroleum analysis.

Table 27. Public Charging Petroleum Displacement Data Inputs

Category	Source
Primary (critical) Data	Utility AMI data, historical CAISO data (demand, supply sources, renewable curtailments), charging session data from EVSP networks, EMFAC and EPA databases and counterfactual tables
Secondary Data	Time varying Utility rates in effect at sites, EVSE (interval and charging session) data, site management details (charger capacities), site visits

The team conducted a range of categorical analyses (shown in Table 28) using tools such as Azure Studio (SQL statements for the resulting calculations and Power BI dashboard .csv tables to report results), the counterfactual lookup table (populated by the EMFAC and other sources), and outputs from the *Grid Impacts* analysis described above. As noted above, Utility AMI data were the basis for much of this analysis.

Table 28. Analysis of Petroleum Displacement

Category	Analysis
Reference counterfactuals and secondary data	For each vehicle type, referenced gallons per mile or kilowatt-hours per mile efficiency from: - Vehicle counterfactuals - EMFAC/EPA fuel economies for both EV and ICE real-world efficiencies
Determine EV energy consumption	Referenced annual kilowatt-hours consumed by EVSE at each site in *Grid Impacts* analysis
Account for charging losses	Compared AMI data to EVSP session data. If necessary, determined different factors between DCFC and L2 chargers.
Calculate vehicle miles	EV Miles: Determined from kilowatt-hours consumed (and vehicle efficiency if available) ICE Miles: Determined how much would have been driven if the EV were not on the road
Estimate petroleum displacement	Estimated petroleum displacement based on ICE miles and efficiency of ICE vehicles

Greenhouse Gas and Criteria Pollutant Reductions

The Public Charging program is expected to reduce the amount of GHG and criteria pollutants emitted into the environment as EVs replace conventional ICE vehicles. This section describes the approach, data sources, and analyses performed to estimate GHG and criteria pollutant reductions.

The team calculated reduced emissions from displaced fossil fuel use from ICE vehicles that were not in service because of the Public Charging programs. 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.

Criteria pollutants emission reduction calculations account for oxides of nitrogen (NO_x), particulate matter ($PM_{2.5}$ and PM_{10}), carbon monoxide (CO), and oxides of sulfur (SO_x).

Since the electric grid emissions profile varies substantially by time of day and season, the team estimated reductions using actual 8760-hour load curves based on Utility AMI meter data. Next, we calculated the annual avoided emissions implied by the gallons of fossil fuels that were displaced. This report presents the total program emissions impacts for key pollutants as the net of annual emissions from the displaced counterfactual fossil fuel equipment and the electricity consumed annually by the adopted electric equipment. We also present local emissions reductions for the remaining pollutants.

In addition, the team examined the increase in emissions attributed to grid power that serves the new electric loads from EVs that charge through the programs. A net reduction in emissions would be expected because some of the grid power generated to provide the electricity occurs during the hours in which solar production is dominant.

The team calculated the increase in emissions from new electric load on the grid by examining the carbon intensity and emissions profile of the grid at the time of charging. Then we calculated the reduction in emissions attributable to EVs charging at stations installed through the program using the counterfactual analysis.

In addition, the team examined the GHG and criteria pollutants reduction for Public Charging programs overall, by Utility, and for the DACs in particular. We analyze the issue in more depth in the *Health Impacts* section below.

The team used the data inputs shown in Table 29.

Table 29. GHG and Criteria Pollutant Data Inputs

Category	Unit	Source
Site-level AMI electric data in 15-minute intervals	kWh	Utility AMI (~1 month delay between measurement and reporting)
Overall electricity demand in 5-minute intervals	MWh	CAISO demand (real time): http://www.caiso.com/todaysoutlook/pages/emissions.html
CO_2 grid emission in 5-minute intervals	Tons	CAISO emissions (real time): http://www.caiso.com/todaysoutlook/pages/emissions.html
Resource mix by time interval	% by generator fuel	CAISO supply (real time): http://www.caiso.com/todaysoutlook/pages/supply.html
Electricity criteria emission factors (NO_x, SO_x) by resource	lbs/MWh	EPA eGRID (2019): https://www.epa.gov/egrid
NO_x emissions rate	grams/kWh	
SO_x emissions rate	grams/kWh	
CO_2 emissions rate	kgs/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	gallons/mile	CARB EMFAC (2021): https://arb.ca.gov/emfac/
Vehicle type (vehicle classification code or linkage to emission tables)	Standard category	*Petroleum Displacement*
Petroleum use by month	Unit measure	*Petroleum Displacement*
Petroleum fuel type	Type of fuel	*Petroleum Displacement*
Petroleum fuel energy content	MMBtu/unit	AFDC: https://afdc.energy.gov/files/u/publication/fuel_comparison_chart.pdf

The team completed the analysis in three steps, using CAISO API and the latest version of GREET 3.0.

- **Step 1: Utility electricity emissions.** Calculated emissions from grid energy used to charge EVs at the Public Charging stations. Using the CAISO (California Air Resources Board 2020) five-minute demand and resource mix reporting, the team established a corresponding Utility emission per record for each pollutant. The team also used CAISO data on the generation mix with five-minute period emissions averaged to apply to each 15-minute interval per application.
- **Step 2: Counterfactual emissions.** Calculated counterfactual emissions, which is necessary to calculate emissions for baseline ICE vehicles. The team determined baseline emissions for counterfactual vehicles using EMFAC for displaced fuels. We assessed the displaced fuels by determining the application and uses of a standard source for lower heating value energy content available within that fuel on a per-unit energy basis, most often measured in Btus per gallon to determine grams per gallon and ultimately grams per year.

- **Step 3: CO_2 calculation and GHG and criteria emissions reductions.** Calculated emissions reductions from ICE vehicles. First the team calculated CO_2 by creating an equivalency for other gases based on their atmospheric interactions. In general, these equivalencies are guided by the IPCC. Every few years, the IPCC assesses the overall impacts of various pollutants in terms of climate change. As a result of these assessments, the IPCC assigns each GHG a multiplier for its GWP in terms of CO_2 equivalence on a defined timescale. The GWP factors typically used are on a 100-year time frame. The GWP 100-year considered pollutants weighted in the GHG calculation are CH_4 and N_2O. For EY2021, the GWP 100-year factors used are based on the IPCC published fifth assessment (AR5) of 28 for CH_4 and 265 for N_2O. The GHG total that summarizes these factors is provided in an equation:

Equation 4. GHG Calculation

$$CO_2e = CO_2 + 28 * CH_4 + 265 * N_2O$$

Next, the team calculated the GHG and criteria emissions reductions as the difference between the application-level counterfactual emissions and actual Utility electricity emissions in the net reduction.

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 being adopted. To understand the effects of the Public Charging programs on air pollution and related health benefits, the team estimated the value of health benefits from each Utility-funded program. As part of this analysis, we also examined the impact on DACs that are disproportionately burdened by multiple sources of pollution, including air pollution from ICE vehicles. 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 regional service territory definition of DAC.[32] This section describes the approach, data sources, and analyses performed to estimate health impacts associated with the Public Charging programs.

The primary goal of this analysis was to estimate the health benefits of the Utility[33] TE programs, overall and in DACs in particular. Specifically, the Cadmus team determined the $PM_{2.5}$[34] emission reductions associated with each site, for all sites, and for sites in DACs, then estimated the economic value of the health benefits associated with each.

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32 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 CalEnviroScreen statewide definition. However, the service territory definition produces a broader definition and calculated 180 DAC census tracts in SDG&E service territory.

33 The team conducted the EY2021 analysis specifically for PG&E EV Fast Charge program and SD&E Parks Pilot.

34 $PM_{2.5}$ are tiny particles or droplets in the air that are two and one-half microns or less in width.

The health benefits were minimal during EY2021 because only a small number of sites were completed and active during the year.[35] The team took an analytical approach for EY2021 that included simplifying assumptions that allowed the BenMAP-CE model[36] to use the available criteria pollutant reduction data available from other analyses in the evaluation (*Greenhouse Gas and Criteria Pollutant Reductions*) and from CES 4.0—which includes $PM_{2.5}$ concentrations in CES from all sources, not just transportation or diesel fuel—that estimate health benefits without more precise, complex modeling of the location of emission reductions. The team primarily leveraged these data to create the inputs for EPA's BenMAP-CE. We calculated outcomes at the site level and aggregated them to other geographic levels.

To complete the valuation analysis through BenMAP-CE, the team leveraged three data sources:

- **CES 4.0 data**: Primarily census tract air quality monitoring and population data and census tract shapefiles.
- **Greenhouse gas and criteria pollutant reductions output by site**
- **Built-in BenMAP-CE health impact and valuation functions**:
  - ER visits, all respiratory illnesses
  - ER visits, all cardiovascular illnesses
  - Hospital admissions, all respiratory illnesses
  - Hospital admissions, all cardiovascular illnesses
  - Mortality, all causes
  - Work loss days

Once the team finalized inputs from CES 4.0 and the *Greenhouse Gas and Criteria Pollutant Reductions*, we prepped the data for input into BenMAP-CE. First, we converted site-level $PM_{2.5}$ data from grams to grams per second. We assumed that each cubic space receives the mass each second and is refilled the next second at the same rate. Though this approach is simplified, due to limited available data in EY2021, this approximation provides a reasonable, conservative estimate. Once the program reduction data aligned with CES 4.0 census tract and air quality data, the team formatted inputs and ran BenMAP-CE. The analysis resulted in an estimated economic value of health benefits, by pollutants ($PM_{2.5}$ for EY2021) associated with each site, for all sites and for sites in DACs, delineated by program and Utility as appropriate.

Total Cost of Ownership

For EY2021, there were a limited number of completed and operational Public Charging sites and available cost data. Due to these data limitations and acknowledging the high variance in costs of

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35 The data available in a given evaluation year will determine the level at which the pollution reductions are *reported.* For example, we may measure pollution reductions for each site and "roll up" the reductions to a larger level (such as census tract, county, or program/Utility) when reporting the emission reductions.

36 BenMAP-CE is an EPA program that estimates the economic value of health impacts resulting from changes in air pollution concentrations.

infrastructure, the team analyzed observed trends in the industry to frame future TCO analyses for Public Charging sites within the scope of the remaining evaluation period. This section describes the approach, data sources, and analyses performed to examine TCO for public charging sites.

To prepare for future Public Charging TCO analyses, we conducted a literature review and benchmarked recent historical trends in infrastructure costs, soft costs, and supply chains for EV charging. Through our review and analysis we identified:

- Sources of significant costs for public charging site hosts,
- Sources of uncertainties in cost considerations, and
- Trends related to increasing or decreasing costs and benefits over time.

The team reviewed 14 publicly available sources spanning 2018 through 2022. These data sources consisted of information provided by Utilities, CARB, CEC reporting, non-profit reports, academic peer-reviewed articles, federal government resources, and PAC presentations (Table 30).

Table 30. Public Charging TCO Literature Review Sources

Organization [a]	Organization Type	Year	Infrastructure Costs	Soft Costs	Supply Chain Trends	Learnings Overtime
CARB	Regulator	2018	X	-	-	X
	Regulator	2020	X	X	-	X
CEC	Government agency	2022	X	X	-	X
ICCT	Non-profit	2019	X	X	X	X
Joint Utilities	Utility	2021	X	X	-	X
	Utility	2022	X	X	-	X
NREL	Government agency	2019	-	X	-	X
	Government agency	2020	X	X	-	X
	Government agency	2022	X	X	X	X
PG&E	Utility	2021	X	X	-	X
	Utility	2022	X	X	-	X
RMI	Non-profit	2019	X	X	X	X
UC Davis	University	2018	-	-	-	X
White House	Government agency	2021	-	-	X	-

[a] Organization refers to the organization of the lead author when the source is a peer-reviewed study.

Upon collating data sources, we benchmarked several data categories:

- **Infrastructure costs.** These are hardware and installation costs, including BTM and TTM costs.
- **Soft costs.** These are networking/communication, easement, permitting, site design, and other similar costs.
- **Supply chain trends**. Current supply chain constraints can increase the costs of infrastructure while also increasing soft costs due to resulting delays.
- **Learnings over time.** Considering that EV charging is a nascent technology, there have already been significant learnings to note.

Site Visits

The team conducted visual site visits for the Public Charing programs during EY2021 to provide qualitative insights on activated EV infrastructure sites. This section describes the approach, data sources, and analyses performed for the EY2021 Public Charging site visits.

The team took a census approach in EY2021, conducting site visits to all 10 active sites. The team collaborated with the Utilities and site hosts, as appropriate, to access each site location and complete the EY2021 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 number of dedicated parking spots and other parking spots within reach of charging ports, charger signages, distance from surrounding buildings to charging, whether the design optimizes 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 be compliant with Americans with Disabilities Act rules that require additional space for parking and charging.

Interviews

The team conducted Utility staff interviews to provide insight into program design and implementation and context to analysis outputs and findings. For the Public Charging programs, the team interviewed each Utility program manager to cover a variety of topics about their respective programs. Then the team integrated these findings throughout the report, informing many sections including program overviews, materials reviews, and Utility interview analysis findings. This section describes the approach, data sources, and analyses performed for the EY2021 Utility 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 interview:

- Staff roles and responsibilities
- Program design
- Recruitment process and how DACs were prioritized
- Electrification barriers addressed by the program
- Key barriers to implementation and solutions
- Preliminary areas of success and lessons learned

The team relied on program materials as the foundation for developing the initial interview guide. As an example, for the September 2021 interviews, the team reviewed regulatory documents such as Decisions, Advice Letters, and PAC meeting slide decks. By the time we conducted close out interviews in March and April 2022, the team was also able to review additional program materials received from Utilities up through that point, such as marketing materials and interim status updates.

The team reviewed verbatim notes taken during each interview as the basis of our analysis. After each set of interviews, we coded full verbatim notes in DeDoose, a specialized analysis software designed to facilitate coding of qualitative data. Through this coding, the team was able to summarize findings and develop insights from individual interviews, compare findings between Utilities, and allow for a comparison between initial and close-out interviews.

3.3. Vehicle-to-Grid (SDG&E) Evaluation Methodology

This section outlines the data collection and analysis for the V2G Pilot evaluation.

3.3.1. Data Collection Methodology

The following sections discuss data collection for the V2G Pilot evaluation, including Pilot data and materials and in-depth interviews.

Pilot Data and Materials

Pilot data provides essential insights into Pilot performance. The Cadmus team reviewed all SDG&E Advice Letters and PAC presentations since 2020 and attended weekly site team meetings from June through August 2021. After August 2021, SDG&E held site team meetings on an as-needed basis through December 2021.

Interviews

In-depth interviews provided critical insight on the original intent, actual implementation, and success of the Pilot, as well as the potential to scale up. For EY2021, the team conducted phone interviews with Utility staff, the site host, and key vendors overseeing the Pilot, for a total of five interviews. 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 Cadmus team's evaluation lead conducted the interviews and recorded notes to reference during analysis.

3.3.2. Analytical Methodology

This section provides an overview of the EY2021 analysis for the V2G Pilot.

Interviews

The team conducted phone interviews with Utility staff, the site host, and key vendors (Baker Electric, Nuvve, and Lion Electric) to provide insight into Pilot design and implementation and context to analysis outputs and findings. Then the team integrated these findings in the report, informing the Pilot overview, interview analyses findings, and lessons learned. This section describes the approach, data sources, and analyses performed for the EY2021 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 design
- Recruitment process
- Electrification barriers addressed by the Pilot
- Key barriers to implementation and solutions
- Preliminary areas of success and lessons learned

The team relied on Pilot materials and V2G site team meeting notes as the foundation for developing the initial interview guides.

The team reviewed notes taken during each interview, then summarized findings and developed insights and preliminary lessons learned from the individual interviews.

4. Southern California Edison Programs

This section provides process and impact evaluation findings and lessons learned for the CRT program and the Schools and Parks Pilots.

4.1. Charge Ready Transport Program

4.1.1. Overview

Per Decision 18-05-040, SCE's CRT program provides infrastructure for fleet electrification at a low or no cost to participants procuring or converting at least two medium- or heavy-duty (MDHD) EVs. Launched in May 2019, SCE designed CRT to accelerate the adoption of MDHD EVs by lowering the TCO for fleets, assisting businesses in reducing emissions, offering an avenue for customers to take advantage of current incentives, and enabling enjoyable experiences for drivers.[37] CRT has an approved budget of $342.6M and a goal to enroll and support a minimum of 870 sites with 8,490 EVs procured or converted to electric.[38] As of December 31, 2021, CRT was working with 139 sites, which includes applications under review as well as committed sites, that can potentially support over 4,200 MDHD EVs.

CRT Goal

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

CRT covers the cost of all or most 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 behind-the-meter (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 charging station. The participant will then pay to install, own, and maintain the charging station. If the participant decides to own the BTM infrastructure, then SCE will pay to design, construct, own, and maintain all to-the-meter (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 otherwise have cost SCE to perform the BTM work or the participant's actual installation costs, whichever is less. Additional charger rebates are available for transit and school bus deployments and fleets located in DACs that are not Fortune 1000 companies.

To participate in CRT, 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 types: medium-duty vehicles, heavy-duty vehicles, transit buses, school buses, forklifts, airport ground support equipment, port cargo trucks, and transport refrigeration units, among others. Program-eligible vehicles include commercial plug-in EVs approved by SCE for use in the outlined sectors, as well as on-road vehicles with

Status of CRT as of December 2021

Currently working with 139 sites that can potentially support over 4,200 MDHD EVs

[37] SCE. Accessed April 2022. "Charge Ready Transport Program."

[38] This amount does not include the budget for the Evaluation.

a gross vehicle weight rating exceeding 6,000 pounds (Class 2 through Class 8) and non-road vehicles.[39] Additionally, fleets must own or lease the property, operate and maintain the infrastructure for 10 years, provide data related to EV usage, and use approved vendors for the EVSE, among other requirements. Pursuant to the SB 350 Decision, CRT's infrastructure budget is to be spent as follows: a minimum of 15% for transit agencies, maximum of 10% for forklifts, minimum of 25% for ports and warehouses in SCE's territory, and minimum of 40% of the infrastructure results in installations in DACs in SCE's territory. SCE offers EV-specific TOU rates to support commercial EV fleet customers (TOU-EV-7, 8, and 9), which provide demand charge relief until 2024.

Implementation and Timeline

To participate in CRT, fleets may work with their SCE Account Manager, engage directly with CRT's Business Development leads, or submit an interest form through SCE's website. SCE uses the interest form to screen initial potential customer applications before enabling them to apply. Typically, within three months of submission, applications are reviewed and evaluated to ensure they meet program requirements and cost parameters. Once an application is approved and a CRT Program Agreement is executed, funding is reserved for site electrification, after which it takes approximately 45 days to acquire the requisite pre-construction documentation, such as proof of vehicle and charging equipment acquisition. Site design and construction can then take approximately six to nine months. After construction is complete, it can take approximately one month for fleets to receive their rebate, provided all post-construction documentation is submitted and reviewed by SCE.[40]

Site Summary

Participating sites in SCE's CRT program were reviewed and analyzed by program status. Table 31 provides the count of construction complete sites in the CRT program by completion status as of December 31, 2021.[41]

Table 31. EY2021 SCE CRT Program Complete Site Count By Status

Site Status	2021
Utility Construction Complete	27
Activated	24
Operational	19
Closed Out	1

39 SCE. Accessed May 2022. "Charge Ready Transport: Program Handbook."

40 SCE. March 18, 2022. "SCE Transportation Electrification Program Advisory Council." Presentation. Timelines can vary depending on the project and the ability of participants to complete participant deliverables. SCE. December 17, 2021. "SCE Transportation Electrification Program Advisory Council." Presentation.

41 Note that these numbers are not additive; for example, by the end of 2021, 24 of the 27 completed sites in the SCE CRT program were activated, 19 of the 24 activated sites were operational, and one of the 19 operational sites was closed out.

ME&O Summary

The program material review is important to establish a foundational understanding of the program design intent, to track changes in design over time, and to understand implementation progress. The Cadmus team reviewed available program-related materials, such as program websites, marketing materials, Decisions, Advice Letters, and Program Advisory Committee (PAC) presentations. In the program materials review process for CRT, the team assessed the level of accessibility of program web pages, presentation and navigation, overall layout and design, efficacy of the materials to establish trust and credibility, content clarity, how materials engaged eligible customers, and how the materials set program expectations and aided in decision-making.

Budget Summary

The CPUC Decision approving CRT set a total budget of $342.6 million for the program, excluding additional budget approved for the evaluation, as well as the authority to recover program costs through rates that were in effect prior to the CPUC's evaluation of the program, provided that *per se* reasonableness metrics are met. SCE reports on these *per se reasonable* measures in Appendix B of its annual SB 350 report to the CPUC. As of December 31, 2021, SCE had executed program agreements with 66 sites to support 1,415 MDHD vehicles, and had spent $11.7M (constant dollars) of the approved program budget.[42]

Program Updates

On October 21, 2021, PG&E and SCE staff hosted a joint Program Advisory Council (PAC) meeting to review their proposal to file a Tier 3 Advice Letter, pursuant to Ordering Paragraph 2 of Decision 18-05-040. In this meeting, PG&E and SCE (the Joint Utilities) proposed several adjustments to the program metrics used to determine *per se* reasonableness:

- **Extend the program through 2026.** The Joint Utilities noted that market nascency and COVID-19 impacted program participation: business slowdowns, reduced capital and expenditures, delayed manufacturing, shifts in scopes, and slower permitting review and issuance contributed to slower uptick in the early years of both programs. A two-year extension would allow for the programs to support MDHD electrification as the market recovers and evolves. In these two years, PG&E and SCE noted that more vehicles will become available, upfront costs will continue to decline, and both programs will be able to support fleet customers as they develop and implement their electrification plans.
- **Emphasize and prioritize program vehicle goals.** The Joint Utilities suggested focusing on supporting increased EV adoption versus balancing site and vehicle goals. They note that there is a trade-off when balancing site and vehicle goals while remaining within their approved budgets. Sites that support a greater number of vehicles tend to be more cost-effective on a per-vehicle basis; however, the programs are currently significantly limited in the number of large sites they can support without compromising their site goals. Sites with fewer vehicles

[42] De-escalated dollars.

tend to be more costly on a per-vehicle basis, and supporting a greater number of sites with lower vehicle counts, while aiming to remain within budget, places the vehicle goal at risk.

- **Adjust infrastructure budget category requirements to support customer, versus technology or vehicle type, electrification readiness**. The Joint Utilities initially suggested this adjustment to build more flexibility into the infrastructure budget category requirements specifically for transit agencies. This proposal has since been removed from the Joint Utilities' Advice Letter.[43]

Following their joint PAC presentation, PG&E and SCE reviewed and incorporated stakeholder feedback into their proposals through December 2021 in preparation to file their formal proposal in 2022.[44]

4.1.2. Findings

This section provides evaluation findings for SCE's CRT program. Table 32 summarizes key impact parameters for EY2021.

Table 32. CRT EY2021 Impacts Summary

Impact Parameter	Annual Estimate [a]	Percentage in DAC
Population of Activated Sites (#)	24	75%
Sites Included in Analysis (#) [b]	16	88%
Ports Installed in Analyzed Sites (#)	63	78%
Electric Vehicles Supported (#) [c]	184	96%
Electric Energy Consumption (MWh)	1,029	94%
Petroleum Displacement (DGE)	99,699	95%
GHG Emission Reduction (MT GHG) [d]	722.96	94%
NO_x Reduction (kg)	277.61	87%
PM_{10} Reduction (kg)	1.32	92%
$PM_{2.5}$ Reduction (kg)	1.25	92%
ROG Reduction (kg)	14.24	97%
CO Reduction (kg)	7,055.26	100%[e]

[a] Energy consumption, petroleum displacement, emission reductions, and health benefits are based on annualized data.
[b] The number of sites included in analysis differs from the population of activated sites because some sites were only activated for a short period during 2021 (such as one or two months).
[c] The team derived the EVs supported value from applicants' vehicle acquisition plans. This value represents the maximum number of vehicles expected to be supported by the charging infrastructure.
[d] GHGs include CO_2, CH_4, and N_2O multiplied by their respective GWP as defined by IPCC AR5 (see the Methodology section for more details).
[e] Rounded up from 99.8%; driven by the majority of CRT annualized sites being in DACs, including all transit bus sites, the counterfactual of which have relatively high CO emissions since they run on CNG.

Program Performance Metrics

As of December 31, 2021, the CRT program was working with 139 sites that could potentially support over 4,200 MDHD EVs across seven market sectors. Of the 139 active applications, utility construction

43 PG&E and SCE. October 2021. "SB 350 Tier 3 Advice Letter Overview." Presentation.

44 The Joint Utilities submitted their joint Tier 3 Advice Letter on April 1, 2022.

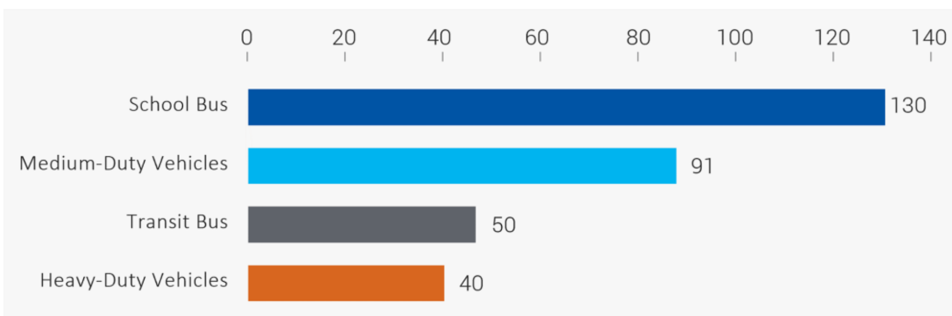
was complete for 27 sites, and 24 sites, across four market sectors, were activated. As shown in Table 33, 75% of activated sites (or 18 of 24) are located in a DAC.

Table 33. CRT Activated Sites Summary, by Market Sector

Market Sector	Number of Sites in DAC	Number of Sites in Non-DAC
Heavy-Duty Vehicles	4	-
Medium-Duty Vehicles	2	1
School Bus	8	5
Transit Bus	4	-
Total	**18**	**6**

As shown in Figure 5, through December 31, 2021, CRT installed infrastructure to support 311 MDHD vehicles across four market sectors.[45] Reflecting the market sector distribution of activated sites, school buses comprise the majority market segment (130, or 42%) of MDHD vehicles electrified within the program, followed by medium-duty vehicles (91, or 29%). The next most commonly electrified MDHD vehicles are transit buses (50, or 16% of MDHD vehicles). The heavy-duty vehicle market segment registers the lowest number of vehicles, with 40, or 13% of all MDHD vehicles electrified in the program.

Figure 5. CRT Vehicles Supported by Market Segment



The CPUC established six phases in the program timelines per the SB 350 reporting template. As presented in Table 34, the majority of customer applications are in the early phases of the program's activation process. As of December 31, 2021, a third of the customer applications (34%) were in review, 10% were undergoing site assessments, and 9% were in the contract issuance phases. In total, 53% of customer applications were within the first three phases of the program.

45 The Cadmus team calculated vehicle counts per customer applications' vehicle acquisition plans (VAP).

Table 34. CRT Sites and Vehicles by Program Phase, as of December 31, 2021

Program Phase	Number of Sites	Total Number of EVs Supported [a]
Application Reviewal	47	2,204
Site Assessment	14	349
Contract Issuance [b]	12	305
Design and Permitting	29	692
Construction Complete	13	432
Activated	24	311

[a] Vehicle counts were derived from customer applications' VAP. Totals include customer applications without the vehicle market segment(s) being specified.

[b] Contract issuance only includes projects with Agreements out for signature

As of December 31, 2021, SCE had installed infrastructure to support the electrification of 311 MDHD vehicles within CRT and had customer applications with vehicle acquisition plans (VAP) that accounted for another 3,982 MDHD vehicles. Altogether, the 4,293 MDHD vehicles in the program pipeline could satisfy approximately 50% of the program's goal of 8,490 additional vehicles electrified.

Based on CRT sites' past performance, the amount of time to complete a program phase varied significantly by phase, from seven calendar days to 208 calendar days (as illustrated in Table 35). The design and permitting phase took considerably longer to complete than any other phase, with the median number of calendar days exceeding the next longest duration (construction complete, 109 calendar days) by almost 100 calendar days. The application reviewal and activation phases had a similar median number of calendar days, at 59 and 52, respectively, while the site assessment and contract issuance phases took the shortest amount of time, at 27 and seven calendar days, respectively. Anecdotal information from SCE program staff indicated that the COVID-19 pandemic changed the scope of multiple projects throughout 2021, resulting in project delays and multiple projects being placed on hold for varying periods of time.

Table 35. SCE CRT Median Calendar Days Per Phase

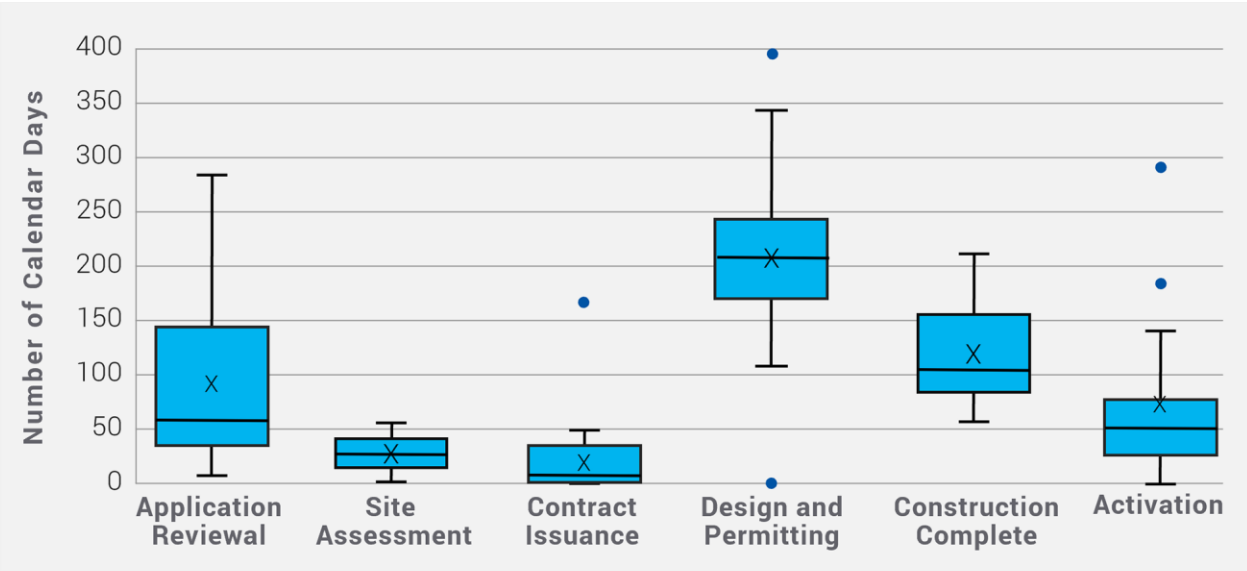
Program Phase	Calendar Days (Median)
Application Reviewal	59
Site Assessment	27
Contract Issuance	7
Design and Permitting	208
Construction Complete	109
Activation	52

Note: This table only includes data from activated sites.

Of the 24 activated sites in the SCE's CRT program, the median start-to-finish timelines for site activation for these sites was 669 days (over 22 months). It is of note that 15 of the 24 activated sites (62.5%) were placed on hold for varying periods between the application reviewal and site activation phases. Program staff indicated that this was due to the COVID-19 pandemic or outside circumstances, extending the overall median start-to-finish timeframe.

This analysis of program phase duration is expanded in Figure 6, showing the calendar day median per phase (denoted by X), as well as the 1st quartile (bottom of square), 3rd quartile (top of square), minimum (bottom tail), maximum (top tail), and outliers (dots). Based on the calendar day distributions, applicants experienced the highest degree of variation in completion time within the application reviewal phase, which involves significant back-and-forth with customers to finalize project scopes and ensure that the application met program requirements, followed by the design and permitting, activation (which is solely a participant responsibility), then construction complete phases. Customer applications in the contract issuance and site assessment phases experienced the lowest mean, median, and variance in calendar days among all the program phases. According to SCE, program staff spent time performing project feasibility studies to ensure project scopes are finalized during the application review phase, which enabled sites to move much more expeditiously through the site assessment and contract issuance phases.

Figure 6. SCE CRT Summary of Calendar Days per Phase



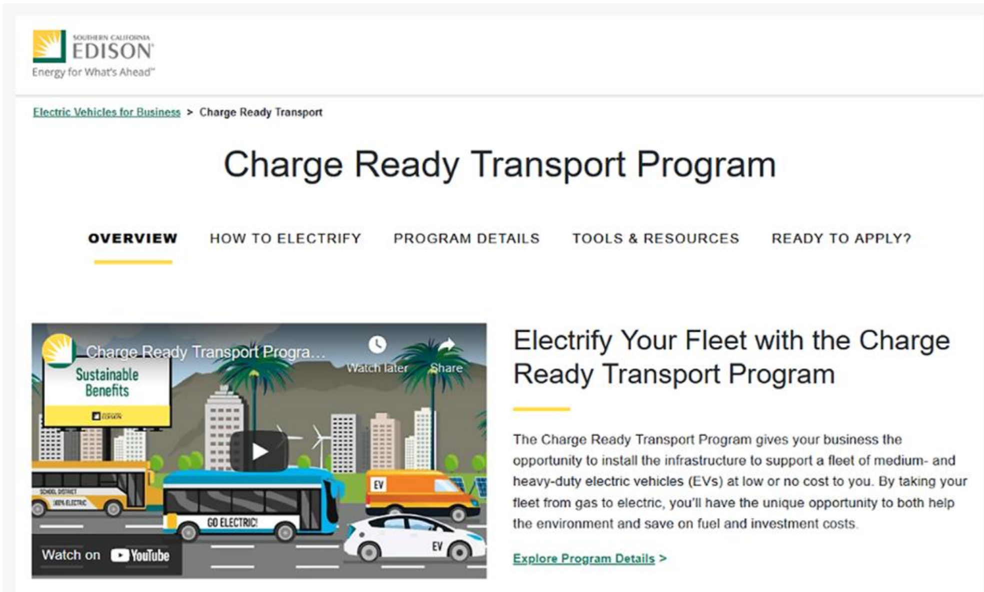
Program Materials Review

The program materials review was important for the Cadmus team to understand program design intent, changes, and implementation progress. Because the broad accessibility of program web pages makes them a core element of customer-facing communications and their non-static nature enables them to reflect current phases of the implementation process, we found them to be an important element within the materials review. The Cadmus team also reviewed other program materials as noted in the *Methodology* section.

SCE MDHD Program Web Page Assessment Findings

In April 2022, the Cadmus team reviewed SCE's program web page "Charge Ready Transport Program," as well as its subpages—"How to Electrify," "Program Details," "Tools and Resources," and "Ready to Apply?,"—and the online interest submission form. Figure 7 shows a screenshot of the main program page.

Figure 7. Screenshot of SCE's CRT Page



The team used an assessment template to group assessment criteria into seven areas. The first four areas addressed navigation, design, credibility, and content clarity. The last three areas guided our review of how the pages supported the primary page objectives. Based on the current implementation stage and web page content, we determined that the page objective criteria were to drive qualified program leads, set program expectations, and aid in decision-making about fleet electrification.

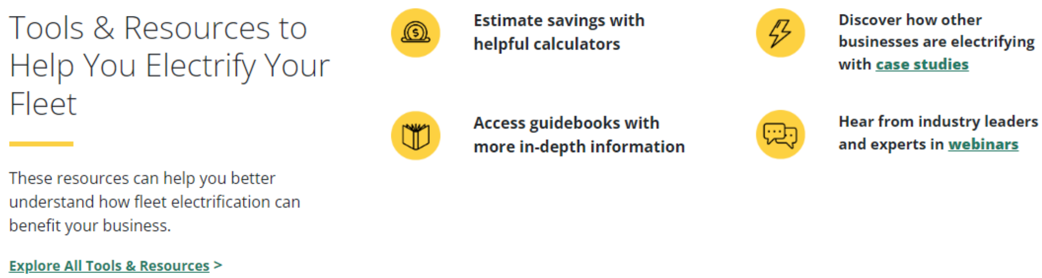
The program web page assessment findings were based on our review of the web pages listed above, which are associated with SCE's CRT program.

Navigation and Information Architecture

SCE's CRT program web pages have a clear and intuitive structure that makes them easy to navigate. Navigation labels and link text are accurate, succinct, and descriptive. Navigation tabs at the top of the page link to subpages, organize information, and make it easy to find the most sought-after information, such as program details and how to apply.

Overall, the navigation and information architecture performed well, but the team identified a number of opportunities for improvement that could support a more positive user experience. The pages do not include a site search function and there are several places where internal site links could be added, such as links to the calculator tools and guidebooks from callouts on the overview page; Figure 8 shows a screenshot of this instance.

Figure 8. Screenshot of Section from Overview Tab Where Links Could be Added



Layout and Design

The pages have an attractive, easy to digest layout and design. The structure is consistent from page to page; the content balances text, images, and white space; and images and icons support the text they accompany. The site is responsive to screen size, maintaining functionality and legibility when viewed on a mobile device. SCE could increase the accessibility of the pages by adding alt-text, which can be read by screen readers and displays if the image fails to load.

Trust and Credibility

The program pages are attractively designed and free of typographical or other surface-level errors, which promotes credibility. The pages also use SCE branding.

Content Clarity

SCE's CRT program web pages provide clear and concise information. Text is brief and to-the-point and uses lists in place of paragraphs where it makes sense. Pages also use accordion sections that expand when clicked to provide additional information, while keeping pages uncluttered. Titles and subtitles effectively introduce page sections, visual elements complement rather than duplicate text, and information is not repeated within the same page.

Drive Qualified Leads

The web pages provide a path to submit an interest form, as well as a button with the call-to-action (CTA) "Take the Next Step," in multiple places. Web pages typically include a single CTA since multiple CTAs on one page compete with each other; however, when the only CTA option was "Take the Next Step," SCE received a high volume of non-qualified customers and industry experts who were interested in what the program was doing, but not ready or qualified to enroll. SCE added the "Connect with Us" CTA and optimized the language for both CTA buttons to help sort qualified leads from unqualified leads and avoid overwhelming sales staff.

The interest form itself uses a simple, user-friendly interface, but could be shortened and include simple validation (such as verifying the correct number of digits in phone numbers). The "Would you like a SCE representative to contact you?" question could be removed because it is the implied next step to submitting an interest form.

Set Program Expectations

The program pages provide helpful information about the type of support SCE provides to businesses through the program, but other relevant and more detailed information about participation, including rebates and incentives available to participants, the process for how the SCE program team works with sites, and typical site timelines is accessible via the Electrification & Infrastructure Guidebook, Application Resources page and Quick Reference Guide. SCE program staff review these materials with customers once they have been deemed ready to apply in order to appropriately set expectations to support a positive participant experience. Prospective applicants and Program participants do have ongoing access to these materials for reference throughout their application journey. Additionally, stating available rebates and the incentive structure can create interest and motivate action.

Aid Decision-Making

The web pages offer information about the benefits of electrifying vehicle fleets and provide tools to help fleet owners and operators understand what participation might mean to them. Tools include a fuel savings calculator, *EV Charging* and *Electrification & Infrastructure* guidebooks, an approved product list, information about rate options, fact sheets, case studies, and recorded webinars with additional information. The pages do not list fleet types that may be well-suited to the program or sort case studies and other tools by fleet type. Providing examples of fleet types that may be interested in the program and guiding viewers toward relevant information could help them recognize the opportunity for their fleet.

Utility Staff Insights

The Cadmus team interviewed SCE CRT program staff to better understand program operations, drivers of cost, and desired program improvements.

Based on the interview with SCE program staff, CRT moved away from a public-facing application system to ensure customers are equipped with knowledge about MDHD electrification and the program tenets and requirements. Program staff began to use an interest form to screen potential applicants before enabling them to apply to help streamline the application review process. To improve program implementation, program staff added site management personnel, since each site requires significant time and effort. Additionally, program staff have sought to increase the different types and sizes of sites in the program to better meet program goals.

To better assist and guide customers through the program, SCE program staff also increased the level of technical support for customers by more heavily relying on field engineers to perform feasibility studies to assess infrastructure needs and ensure the supporting charging infrastructure was designed to meet the operational characteristics of the fleet. SCE program staff also encouraged sites to commit to a larger number of vehicles over the 10-year commitment period, where possible. To allow greater flexibility, SCE allows customers to phase-in vehicles over 10 years; however, all chargers are required to be installed at the same time once infrastructure installation is complete, so those factors needed to be considered when planning infrastructure.

Although cost information and additional discussion of cost drivers will not be included in the 2021 CRT evaluation report, Program staff noted that larger sites often required larger equipment, such as transformers and panels to meet the operational needs of the fleet. It was sometimes possible to use existing panels and transformers for small sites, which had the potential to lower overall infrastructure deployment costs. Outside of infrastructure installation, Program staff noted that the most significant costs for site hosts pertained to vehicle acquisition, which tends to require greater up-front capital investment, as well as charging equipment and networking costs. The number of vehicles, chargers, and the networking costs are all significant cost drivers because these costs increase with scale.

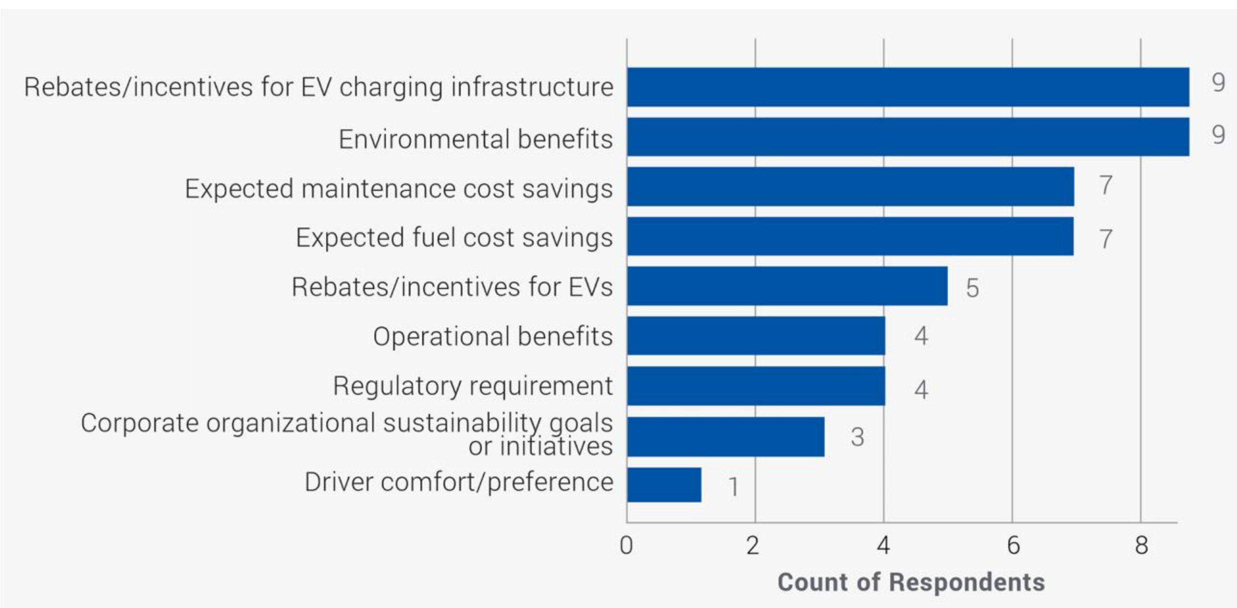
Survey Results

The Cadmus team surveyed six fleet managers who participated in CRT (known as "program participants") about their motivations for and barriers to electrification, satisfaction and experience with the program, experience with EVs and charging infrastructure, the impact of the program on fleet electrification, and their perspective on the industry. In some cases, the number of responses to a question is greater or less than six. 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.

Electrification Motivators and Barriers

The Cadmus team asked SCE program participants about their reasons for transitioning to EVs. As shown in Figure 9, out of six respondents, the top motivators for fleet electrification were rebates for EV charging infrastructure (five mentions), environmental benefits (four mentions), and the rebates for EVs (four mentions). This indicates that that incentives for electrification and environmental drivers were key motivators.

Figure 9. Program Participant Motivators for Transitioning to EVs

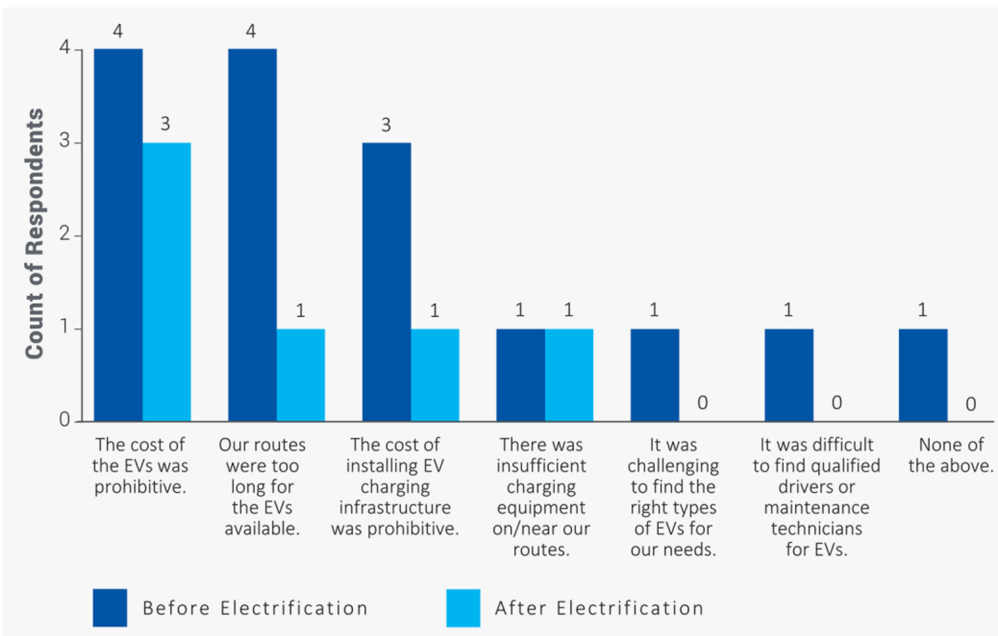


Source: Fleet Manager Survey Question C1. "Why did your fleet decide to transition to EVs? Select all that apply." (n=6; multiple responses allowed)

The Cadmus team asked program participants which barriers to electrification their fleets faced before electrification (via participation in CRT) and what barriers remained after participation. As shown in Figure 10, participants in CRT responded that the top barriers prior to electrification were the cost of EVs, routes being too long for the available EV options, and the cost of installing EV charging infrastructure. This aligns with participants' statements that incentives for infrastructure and vehicles were a significant motivator for transitioning to EVs, as incentives directly address the cost barriers.

After participating in the program, the largest remaining barrier was the cost of EVs, with three of four program participants saying this was still a barrier. Additionally, one said there was insufficient charging equipment on or near their routes, likely due to the placement of charging infrastructure at their main hub. All other barriers were primarily addressed as part of program participation. Based on these survey responses, infrastructure incentives were effective at alleviating costs. It also appears that the EVs and/or chargers supported through the program helped alleviate some of the range anxiety that fleet managers felt prior to the program.

Figure 10. Barriers to Electrification before and after Program Participation

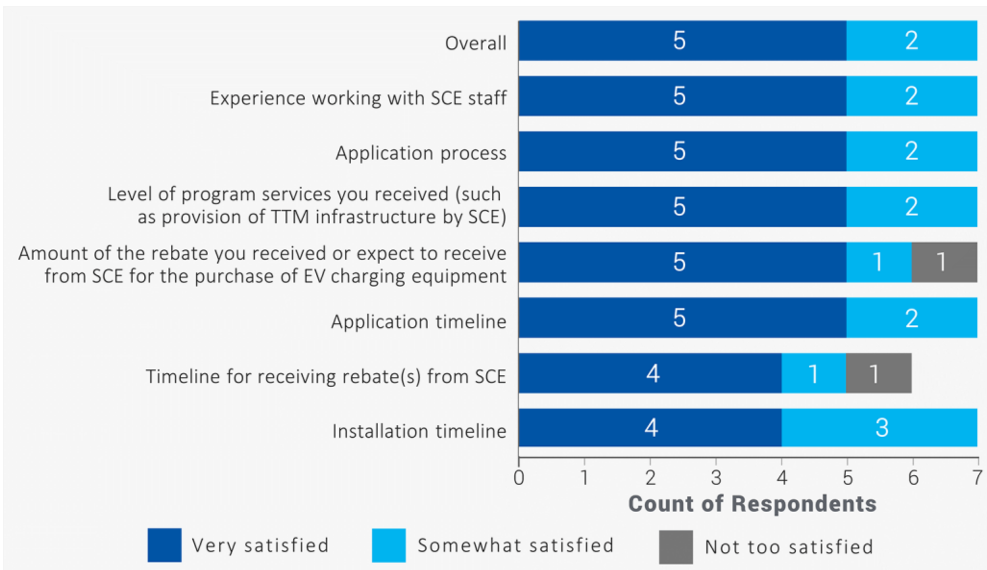


Source: Fleet Manager Survey Questions F3 and F4. "Which of the following barriers to electrification did your fleet face before participating in the Charge Ready program?" (n=6) and "You mentioned that the following were barriers to electrification before participating in the Charge Ready program. Do any of these barriers still exist after you participated in the program?" (n=4)

Program Satisfaction and Desired Changes

When asked to rank the likelihood of recommending the program on a scale of 1 to 10, with 10 being the most likely to recommend, five of seven program participants selected a 10, indicating that they would be extremely likely to recommend the program or had already recommended it. One program participant selected a 7.[46] Together, these ratings led to a net promoter score of +83.[47] Overall, program participants were pleased with the process, staff knowledge, communication, and support from SCE, as shown in Figure 11. Six out of seven program participants rated themselves as *satisfied* with the charging equipment rebate amount and six out of seven participants were *satisfied* with the timeline for receiving these rebates. Participants are required to provide post-construction documentation such as the EVSE installation invoice, permit and evidence of final inspection, and an EVSE commissioning report, which must be provided to SCE prior to receiving a rebate. When asked, these program participants did not share anything they would have done differently if going through the program again, nor did they volunteer any factor that caused them to be dissatisfied.

Figure 11. Satisfaction with Program and Elements



Source: Fleet Manager Survey Question B1. "Thinking about your experience with the Charge Ready program, how satisfied are you with the following?" (n=6 or 7)
Note: No respondents provided a rating of *not at all satisfied* for any element.

Program Experience

The Cadmus team asked program participants how they learned about CRT. Three of five program participants said they learned about the program from SCE, while none learned about the program from engineers, contractors, EV manufacturers, or EV service equipment manufacturers. Two program participants learned about the program from another source: one from Ventura Air Board and the other from the Port of Long Beach. Prior to joining the program, four program participants knew that they needed to upgrade the electrical infrastructure from the Utility grid to their meter to charge EVs at their

46 The other participant did not respond to this question.

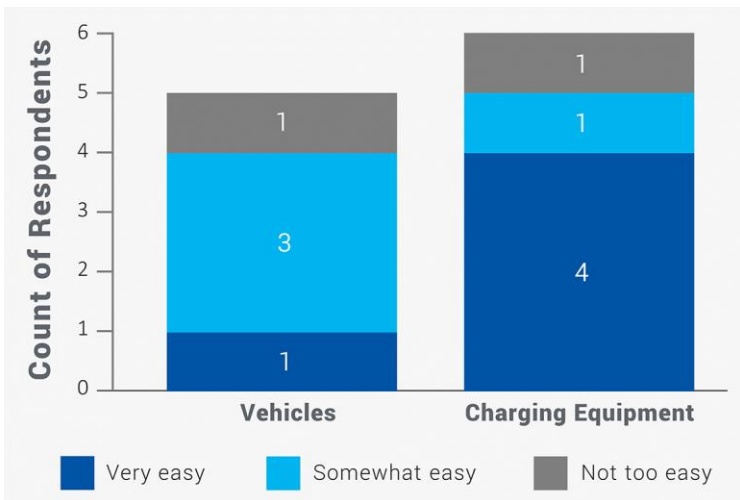
47 The net promoter score is calculated by subtracting program detractors (those who rated their likelihood to recommend the program to others as a 0 through 6) from the program promoters (those who rated their likelihood to recommend the program as a 9 or 10). Those who gave a rating of 7 or 8 were labeled as passives and did not negatively or positively impact the score.

site, while two did not. Regarding ownership, five program participants said that their company or organization owned the EV charging infrastructure, and one did not provide an answer.

Experience with EVs and Charging Infrastructure

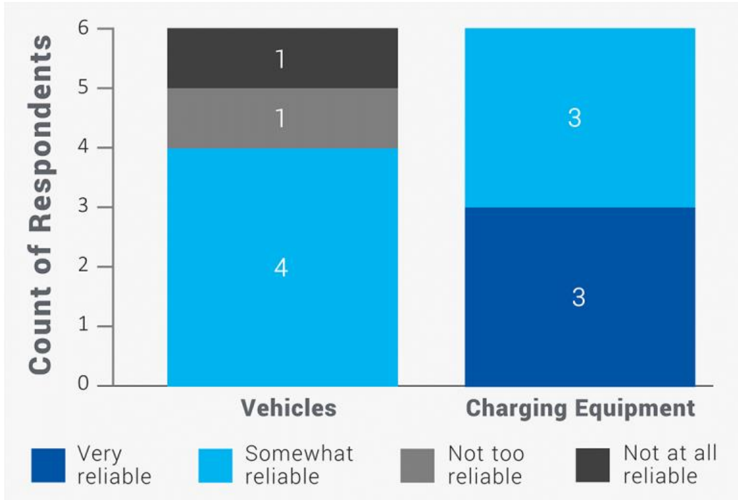
When asked to rate the reliability and ease of use of EVs and EV charging equipment, program participants generally found both technologies reliable and easy to use. As shown in Figure 12, five respondents found EV charging equipment easy to use, with four rating it as *very easy*. While four of five program participants rated the vehicles as easy to use, only one rated it as *very easy*, likely reflecting the differences in operation for EVs compared to conventional vehicles. Responses for reliability tell a similar story as shown in Figure 13, all program participants found the charging equipment reliable while only four of six found the vehicles reliable.

Figure 12. Ease of Operating Vehicles and Charging Equipment



Source: Fleet Manager Survey Questions C4 and C7. "How would you rate the ease with which your drivers operate the electric vehicles?" (n=5) and "How would you rate the ease with using the electric vehicle charging equipment?" (n=6)

Figure 13. Reliability of Vehicles and Charging Equipment



Source: Fleet Manager Survey Questions C3 and C5. "How would you rate the reliability of the electric vehicles that are part of your fleet?" and "How would you rate the reliability of the electric vehicle charging equipment?" (n=6)

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, three program participants said yes, while three indicated that their rate of procurement would remain unchanged. One program participant reported that having more infrastructure meant they could buy more buses if and when funding was acquired. Another indicated that SCE's "ability to smoothly take care of all of the make-ready infrastructure" impacted their electrification plans.

Of the seven survey respondents, two shared that they had electrification plans for the next 10 years. One fleet plans to electrify support vehicles in that timeframe and another plans to electrify some forklifts and LDVs.[48] Another program participant said they are prepared to acquire six electric buses within the next two years as a result of their experience with CRT and the infrastructure built through the program. Another said, "The savings we realized by participation in the Charge Ready Transport program enabled us to consider purchasing additional electric school buses. We had originally planned on purchasing six Blue Bird and five Lion school buses. Now we are looking at purchasing an additional eight Lion or Blue Bird school buses."

Industry Perspective

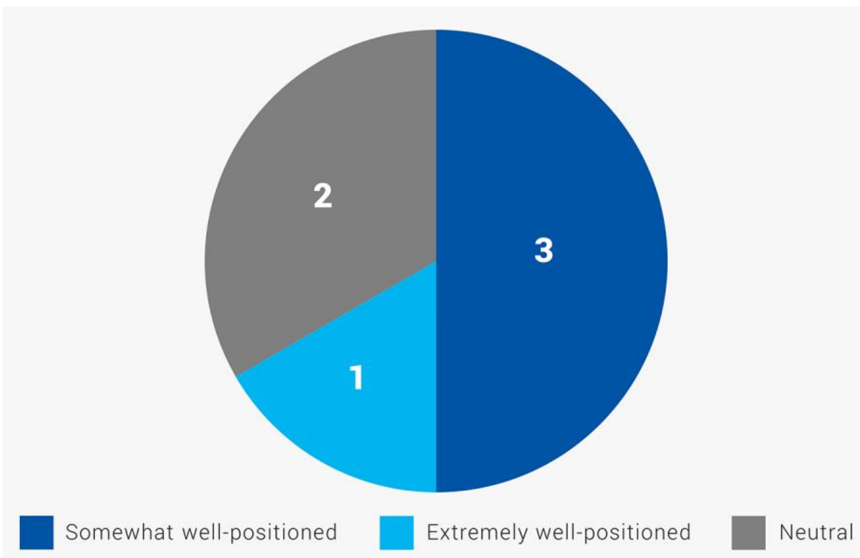
The surveyed program participants represented the school bus (three respondents), transit bus (one respondent), and other MDHD (two respondents) market segments. The Cadmus team asked these participants for their thoughts on how well their industry or sector is positioned for electrification. As shown in Figure 14, four of six program participants rated their industry, as a whole, as *extremely* or

48 The Cadmus team asked this as an open-ended question and thus did not limit respondents to the vehicles approved under the MDHD VAP.

somewhat well-positioned for future electrification efforts. The program participant who rated their industry as *extremely well-positioned* for electrification said, "the state and federal governments are going to be putting a lot of money toward school districts to upgrade to electric buses." One of the program participants who rated their industry as *somewhat well-positioned* said, "[the] range and reliability of the transit bus needs to be improved," and that, "technology such as smart charging also needs to be improved and readily available to operators." Another who rated their industry as *somewhat well-positioned* said that it was hard to obtain grant funding for electrification.

Two program participants selected the neutral option when describing how well-positioned their industry is for electrification. One said they did not think they were "ready for electric infrastructure statewide," citing blackouts. Another said that the initial cost of purchase was too high for them to afford school buses without grant funding.

Figure 14. Industry Positioning for Electrification among Program Participants



Source: Fleet Manager Survey Question F1. "How well-positioned do you think your industry/sector is for electrification?" (n=6)

When asked about the availability of EV options in their sector, four of six were satisfied with the EV options available, while two were not satisfied. Respondents mentioned range and reliability as key limitations of EVs for their sectors. Another program participant said that in their industry, the technology is still undergoing testing.

In terms of future outlook, including accounting for requirements for fleets to purchase EVs, four program participants said that EVs seem like a riskier purchasing decision than diesel vehicles, while one said diesel vehicles seem riskier. However, for MDHD trucks specifically, two program participants said that EVs are riskier, while three said diesel vehicles are riskier. One did not provide an answer to either question.

Withdrawn Fleet Managers
In addition to the program participants, the Cadmus team surveyed two fleet managers who withdrew from the program (known as withdrawn fleet managers). Of these two fleet managers, only one provided a reason for withdrawing, saying that because the site was fully funded with public funds, the respondent "did not want to incorporate additional funding requirements for a fully funded project." This respondent did not have any issues with the program design or barriers to electrification; the only issue was related to the respondent's desire to fund the site internally and not be "subject to the program's funding requirements."

Both the fleet managers who withdrew from the program rated themselves as *somewhat satisfied* with the application timeline. When asked about the application process or level of program services offered as part of the program, one rated themselves as *not at all satisfied* and one rated themselves as *somewhat satisfied*. The respondent who was *not at all satisfied* with the level of program services and the application process said they ended up building out the site as intended but did not receive any rebates/grants for the work from other sources. When asked what could be improved, this respondent requested "[fewer] restrictions on equipment and contractors."

Site Visit Findings

Of 24 activated projects, the Cadmus team attempted a census and performed 15 CRT site visits representing 10 school districts, two medium duty vehicle sites (two locations for the same operator), one transit bus site and two heavy-duty truck sites (with the same operator), and all but two sites had operational EV fleets. The site visit effort brought useful insight and a different perspective covering multiple regions of the state.

The Cadmus team used the site visits to verify aspects such as which charging stations were installed and with what EVSP, types of EVs on the site or to be delivered, and influences on construction designs. Table 36 presents a summary of visited site characteristics by market segment. Notable are the charging capacities for school bus (10 sites) and medium-duty vehicle (two sites) market segments, at 1.2 MW and 700 kW, respectively. While sites in all four of the listed market segments installed DCFC, only school bus sites installed L2 charging stations.

Table 36. SCE CRT Program Site Visit Summary

Market Segment	Number of Sites	Number of DCFC Ports	Number of L2 Ports	Charger Power (kW)	Total Charging Capacity (kW)
School Buses	10	2	70	L2: 16.8 DCFC: 50	1,276
Medium-Duty Vehicles	2	14	-	50	700
Transit Buses	1	4	-	62.5	250
Heavy-Duty vehicles	2	4	-	62.5	250

During the site visits, the team collected qualitative and quantitative information that provided an understanding of fleet composition and operations. This included information on the make, model, and number of EVs or electric-powered equipment on site, 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, as well as whether there was interest in on-site solar and/or storage associated with the site.

During site visits, across all market segments, we found different impacts on site operations due to the pandemic. Several operators reported that miles driven had been curtailed as a result of the pandemic and also reported isolated instances of difficulty with vehicle reliability. Some sites were still unable to fully operate their EV fleet due to vehicle reliability limitations. An early issue observed by the Cadmus team was a significant learning curve on the part of the drivers operating the new vehicles.

None of the 15 sites we visited had load management plans actively employed with software controls to schedule charging. Despite SCE's efforts to educate customers on TOU rates and off-peak charging benefits during the project feasibility phase, designated fleet operators were seldom aware of their own electric fuel costs after several months of site operation or of how the electric Utility rates worked.

Only one fleet operator was aware of EVSPs' capability to limit charging during peak hours. This lack of awareness for managed charging is consistent with findings reported in the *Grid Impacts* section below, indicating that more than one-third of total electricity was consumed during the peak periods when prices were the highest.

Sites appeared to opt for larger installations due to the availability of rebates and because it was less expensive on a cost-per-vehicle basis. Several options for expanding charging capacity were mentioned: using remaining circuit breaker space in a service panel, using hand-holes to continue trenching in the future, and having full make-ready infrastructure with conduit and concrete pads ready for EVSE to be installed. A few of the sites will be able to easily expand their capacity beyond what exists today.

School Bus

School districts operate a mix of vehicle sizes, which the Cadmus team verified during site visits. Recent EV purchases follow this trend of both larger and smaller buses. School fleets are heavily reliant on public funding through local Air Districts, the California Energy Commission, and CARB's Hybrid & Electric Truck & Bus Voucher Incentive Project. One fleet operator said their district only intends to fund EVs at this time.

There are still challenges to safeguard against vehicles unexpectedly running out of charge. Fleet operators expressed that vehicle gauges for fuel and range were only approximate and did not provide sufficient granularity to assess charge status. None of the operators had been able to access or analyze data on actual ranges and fuel economies derived from vehicle logs and charging sessions.

Charging station protection is important in busy fleet yards with many commercial vehicles entering and exiting several times daily. Figure 15 depicts a charging station with bollards installed to protect the chargers as well as the yellow wheel stop by the front right tire.

Figure 15. School Bus with Charger Station and Switchgear

Note: The bollard placement protects equipment but reduces parking area flexibility.

During site visits, school representatives confirmed that buses return to base midday, allowing charging between morning and afternoon shifts. The Cadmus team's *Grid Impacts* analysis identified this trend as well. Midday charging is beneficial to create range confidence, especially for longer routes, ensuring that buses are topped off twice daily to accomplish all necessary driving. In this case, a limited size battery may be charged twice daily to ensure adequate range. Midday charging may also make use of low emissions electricity available during off-peak periods (as shown through *Grid Impacts* and *Greenhouse Gas and Criteria Pollutant Impact* analyses), coinciding with higher renewable generation on the grid. Operators discussed that substantial charging between 4 p.m. and 9 p.m., the highest cost and often highest emissions period of any day, takes place when the buses return to base due to no load management, which was confirmed through the *Grid Impacts* analysis. Many EVSPs market their ability to provide load management, which could provide benefits directly to operators. *Grid Impacts* analysis on charging sessions indicates that evening charging is short enough that delaying charging until after 9 p.m. would allow for readiness of morning routes.

Many school districts contacted during site visits between October 2021 and April 2022 described that their operations have not returned to pre-pandemic levels. In some cases, driver shortages limited the number of routes being operated, in turn increasing passenger loads. One district said their new EVs had fewer seats, which limited usage due to increased loads. These buses are anticipated to be used more during summer school, which fewer students attend.

Fleets exhibited a range of intentions to procure additional EVs. Expandability of infrastructure is modest. Some sites have no clear path to add infrastructure while others are prepared to expand trenches.

During in-person site visits, site representatives indicated that as built, utilization is likely to increase due to several qualifications:

- Vehicle reliability issues prevented full and consistent utilization
- The full order of vehicles had not yet arrived
- Future orders of buses were pending grant solicitations
- Site representatives described a range of built-in expandability (across transformers, service panels, and parking)

Figure 16 shows a school bus charging installation that uses a stand-alone hardware controller to automate non-networked EVSE. Pending the type and quantity of EVSE used, this may be a low-cost option. This operator installed an awning behind each EVSE as protection from the sun.

Figure 16. Charge Controller (and Switchgear in Background) to Enable Non-Networked EVSE

One site installed charging indoors, as shown in Figure 17 (this was the smallest site with the simplest installation of only two charging stations). This helps keep equipment shielded from the elements and may reduce vehicle cooling needs during hot days.

Figure 17. Electrical Meter and Panel on Outside of Wall Supplying Indoor EVSEs

Medium-Duty Vehicles

The Cadmus team visited two medium-duty vehicle sites, which had the same operator. Similar to the school bus segment, the fleets reported (and we observed in the *Grid Impacts* analysis) pandemic impacts limiting EV operations. The operator mentioned that operations required more than one EV to replace each conventional vehicle due to range and charging limitations.

The operator had operated EVs for several years and said their previous experience helped them leverage the Utility program design to minimize their own costs through placing main electrical disconnect switches adjacent to the chargers. This fleet relies on both opportunity charging at a transit center (right side of image in Figure 18) and charging at a depot overnight (left side image).

The same operator reported that spacing DCFCs farther apart could help charging stations run cooler and potentially more reliably in the future. The compact installation shown in Figure 18 significantly reduced the costs to the site host compared to a previous charging station installation. The compact site design also reduced heat dissipation and increased high-frequency noise when several charging stations are in use. The canopy provides shade and hosts a solar array connected to a different utility meter.

Figure 18. Compact Design Leveraging Utility Programs to Reduce Customer Installation Costs

Heavy-Duty Vehicles

The Cadmus team visited two sites by the same operator in the heavy-duty vehicle segment. This low representation limited findings and trends.

With heavy-duty vehicle charging, it may be a challenge to ensure that equipment does not obstruct the path of travel for large vehicles. The chargers selected by this operator have relatively short cords of 10-feet that may limit charging access for certain vehicles. Due to the size of vehicles, longer charging cords closer to 20-feet can add flexibility in reaching a charging receptable, whether on the front, back, or sides of a vehicle.

As shown in Figure 19, the operator was able to use an existing transformer, with roughly half the trenching distance in softscape, to prepare for future expansion. Main disconnect switches were located adjacent to chargers, reducing the site host costs for the charging station installation.

Figure 19. Heavy-Duty Vehicles and Chargers (Foreground) and Transformer (Background)

Co-Benefits and Co-Costs

Via surveys and site visits, the Cadmus team identified a number of co-benefits and co-costs associated with the program's vehicle electrification projects. Given the relatively short timeframe that these fleets have been electrified and the fact that the team did not survey fleet drivers in EY2021, we asked program participants to describe the co-benefits and co-costs they expect rather than what they have experienced.

Table 37 shows that nearly all survey respondents (known as program participants) believed that benefits will be realized for their community or fleet because of electrifying. Most program participants expect either *significant benefits* or *some benefits* because of electrifying, with improved air quality/health as the most cited *significant benefit*. Aside from these benefits, two of six program participants mentioned reduced maintenance costs as a benefit their fleets expect to realize.

Table 37. Benefits Expected from Electrification

	Significant Benefits	Some Benefits	No Benefits
Improved air quality/health	4	1	1
Improved driver comfort/convenience	2	3	1
Reduction in noise pollution	3	3	-

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)

Table 38 shows program participants' responses to survey questions of how costs have changed since transitioning their fleets to EVs. Changes in operating costs differ substantially by cost type: vehicle maintenance, fueling, and fueling infrastructure tend to be lower since electrification. Conversely, training for drivers and maintenance staff tend to skew higher. In addition to the costs in Table 38, respondents also mentioned costs from towing vehicles due to driver error, managing burdensome warranty repairs, and extra labor to ensure that charging is performed at the optimal time, while smart charging is still in development. In general, program participants either said these costs were what they expected or that they did not know what costs to expect as a result of electrification (Table 39).

Table 38. Cost Change Since Electrification

Cost	Costs are Lower	Costs are Relatively Equal	Costs are Higher	Don't Know
Vehicle maintenance	2	1	1	2
Vehicle fueling	4	-	-	2
Vehicle fueling infrastructure	3	1	2	-
Driver training	1	3	2	-
Maintenance staff training	1	2	3	-

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=6)

Table 39. Differences in Electrification Cost Expectations

	Costs are as Expected	Costs are Higher than Expected	Costs are Lower than Expected	Don't Know
Vehicle maintenance	2	1	-	3
Vehicle fueling	2	-	-	4
Vehicle fueling infrastructure	3	-	1	2
Driver training	5	-	-	1
Maintenance staff training	5	-	-	1

Source: Fleet Manager Survey Question E2. "Have these operational and maintenance costs been what you expected?" (n=6)

Additional Insights from Site Visits

The Cadmus team incorporated qualitative insights from site visits to supplement this data. Only one site, from the transit bus segment, mentioned an additional co-benefit: the installation of safety bollards that was part of their work through the program.

In general, the majority of operational fleets had less than one year of experience operating EVs. During site visits, the site contacts said they did not have enough data and experience to adequately assess vehicle maintenance or operational costs. Site contacts reported vehicle recalls or reliability issues. Repairs were often conducted by the vehicle manufacturer/dealer during the initial warranty period with an often unknown timeline to address the issues. Five sites discussed co-costs associated with their fleet electrification. Four of these sites said they experienced reduced flexibility with EVs compared to conventional vehicles, specifically for school buses. Two of these sites had to adjust their routes to accommodate the new buses or had to keep more conventional buses than they would have liked. Two sites reported increased maintenance costs, while one other said they lost two parking spaces due to the charging equipment.

Total Cost of Ownership

The Cadmus team conducted a TCO analysis to compare the 10-year costs of owning and operating an EV fleet to the costs of owning and operating a counterfactual (baseline) fleet. We conducted this analysis for three types of vehicle fleets (school buses, transit buses, and Class 4 package delivery trucks used for local delivery such as from a bakery, snack, or linen service). The purpose of the TCO analysis was to understand the impact of Utility programs and other available grants and incentives on fleet costs from the fleet manager perspective.

For EY2021, we conducted this TCO analysis as a scenario analysis using a mix of available primary data, secondary data, and assumptions as described in Appendix B. The scenarios were developed to understand the impact of utility incentives on the fleet TCO relative to an EV fleet with no incentives and a fleet of counterfactual petroleum vehicles.

School Bus

Figure 20 shows three TCO scenarios of 10 vehicle school bus fleets over a 10-year time span. The first scenario consisted of a fleet of all-electric school buses with no grants or incentives. As shown in Table 40, the EV fleet cost $3,260,290 more than the baseline scenario with a fleet of diesel school buses.

Figure 20. SCE School Bus Fleet TCO

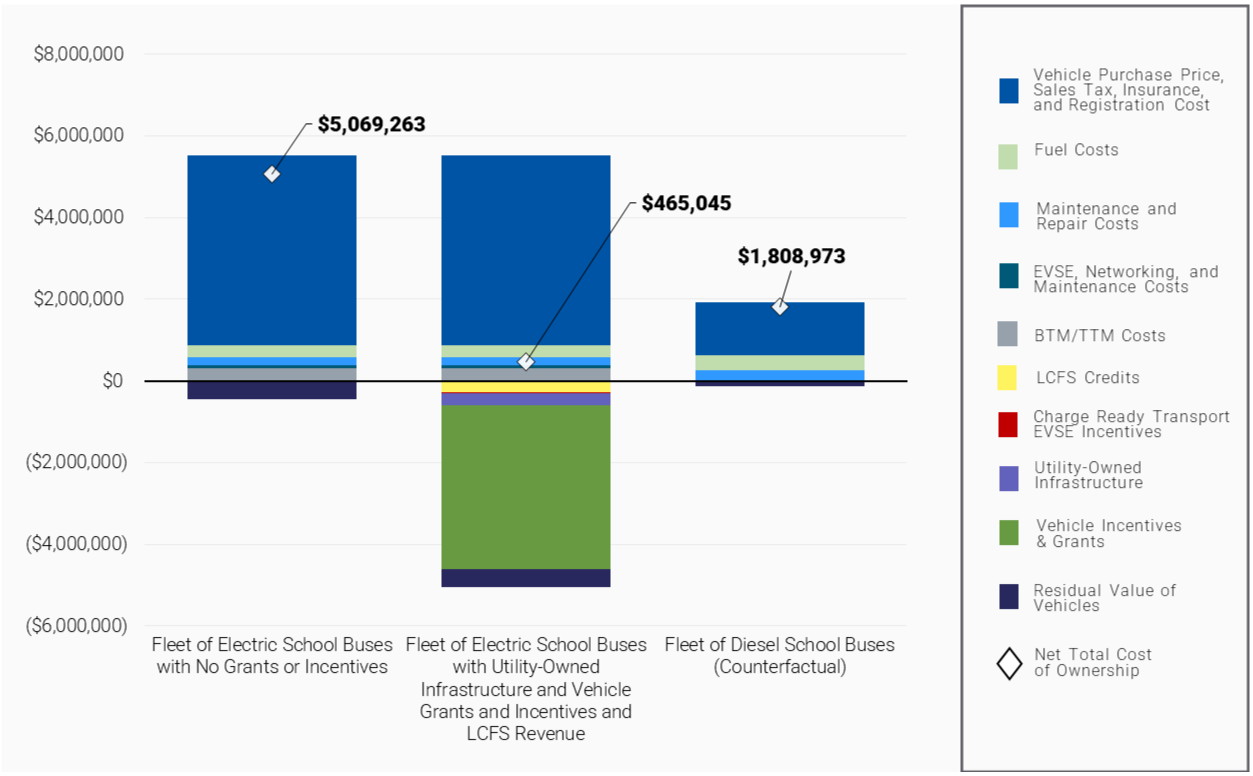


Table 40. SCE School Bus Costs in TCO Analysis

10-Year Total Cost of Ownership (NPV)	Fleet of Electric School Buses with No Grants or Incentives	Fleet of Electric School Buses with Utility-Owned Infrastructure and Incentives, Vehicle Grants, and LCFS Revenue	Fleet of Diesel School Buses (Counterfactual)
Vehicle Purchase Price, Sales Tax, Insurance, and Registration Costs	$4,653,831	$4,653,831	$1,311,394
Fuel Costs	$295,899	$295,899	$365,112
Maintenance and Repair Costs	$193,155	$193,155	$257,541
EVSE, Networking, and Maintenance Costs	$81,191	$81,191	
BTM/TTM Costs	$300,000	$300,000	
Residual Value of Vehicles	($454,814)	($454,814)	($125,074)
Vehicle incentives and Grants		($4,000,000)	
Charge Ready Transport EVSE Incentives		($15,000)	
Utility-Owned infrastructure		($300,000)	
LCFS Credits		($289,218)	
Net Total Cost of Ownership	**$5,069,263**	**$465,045**	**$1,808,973**

The second scenario resembled sites in the program based on self-report data gathered during site visits and Cadmus' estimates of utility-owned infrastructure incentives.[49] CRT projects were completed with a combination of vehicle incentives and grants, Utility-paid infrastructure upgrades (all 2021 projects included Utility-owned infrastructure), and ongoing LCFS credit revenue. By incorporating these grants and incentives, the EV fleet resulted in a net present value (NPV) of $465,045 over the 10-year period, a financial savings of $1,343,928 over the diesel school bus fleet. For the school bus fleet, average energy costs were $.33 per mile for electricity and $.40 per mile for diesel.

Transit Bus Fleets

Similar to school bus fleets, transit bus fleets rely heavily on grants for vehicle purchases; therefore, we modeled the same scenarios for transit buses as we did for school buses. We evaluated a representative 10-vehicle fleet of electric transit buses compared to the same size fleet of counterfactual transit buses. Electric transit buses cost more initially than the counterfactual vehicles (see the vehicle price in Figure 21).

For most use cases and in most geographies, EVs cost less to operate and maintain than ICE vehicles since they are more efficient, their fuel costs are lower, and they have lower vehicle maintenance and repair costs. In this analysis, the electric transit bus fleet did not have lower fuel costs than the counterfactual transit bus fleet, because they were assumed to run on CNG. While maintenance costs were lower for EV buses, fueling the EV buses cost more than fueling the CNG buses. In this scenario, the EV transit bus cost an average of $.41 per mile to fuel and the CNG transit bus cost $.32 per mile to

49 Given that only one CRT site was fully invoiced with all work orders closed for 2021, Cadmus is including estimates for utility-owned infrastructure costs in the 2021 Evaluation Report. These estimates are subject to change as additional actual cost data becomes available as more sites are completed and financially closed out in subsequent years.

fuel. As illustrated in Figure 21, the maintenance costs for the counterfactual (CNG) fleet were $3,062,418, while the maintenance costs for the EV fleet are $2,161,707, resulting in a savings of $900,711. As shown in Table 41, fuel costs for the EV fleet were $1,341,433, while fuel costs for the CNG fleet totaled $1,020,085, resulting in additional fuel expenditures of $321,349 for the EV fleet.

The NPV of the scenario in which the EV fleet received no grants or incentives was $13,767,937, or $3,366,756 more than the counterfactual CNG fleet. Based on site visit information, vehicle grants were assumed to cover the entire upfront cost of the EV transit buses. CRT was assumed to cover the cost of distribution system upgrades necessary for DCFC installation, as well as the cost of customer-side of the meter infrastructure necessary for charger installation. In addition, CRT provided EVSE incentives estimated to be $200,000 for transit fleets of this size. The combination of vehicle grants and SCE offsetting the estimated infrastructure and construction costs plus EVSE incentives brought the cost of the EV fleet to $3,299,477, a savings of $7,101,704 over the cost of the CNG fleet.

Figure 21. SCE Transit Bus Fleet 10-Year Total Cost of Ownership

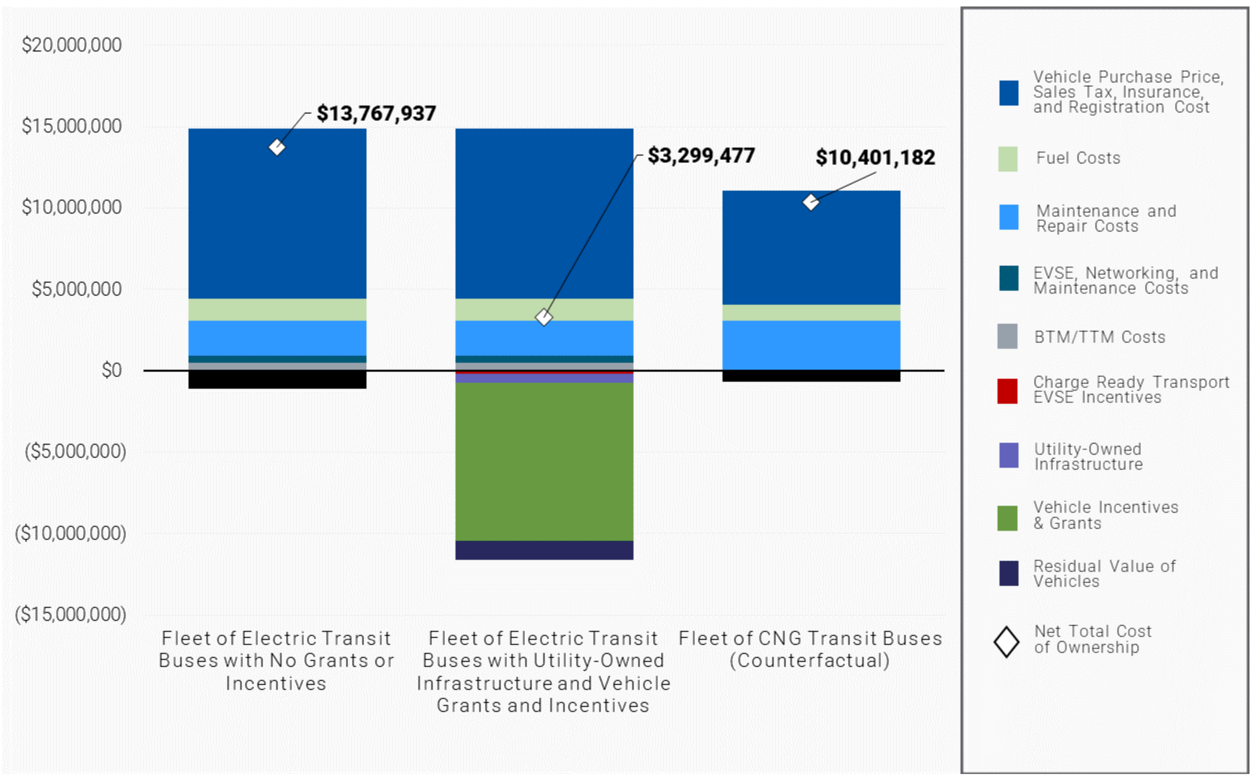


Table 41. SCE Transit Bus Fleet 10-Year Total Cost of Ownership

SCE Transit Bus Fleet 10-Year Total Cost of Ownership (NPV)	Fleet of Electric Transit Buses with No Grants or Incentives	Fleet of Electric Transit Buses with Utility-Owned Infrastructure and Vehicle Grants and Incentives	Fleet of CNG Transit Buses (Counterfactual)
Vehicle Purchase Price, Sales Tax, Insurance, and Registration Costs	$10,436,073	$10,436,073	$7,006,899
Fuel Costs	$1,341,433	$1,341,433	$1,020,085
Maintenance and Repair Costs	$2,161,707	$2,161,707	$3,062,418
EVSE, Networking, and Maintenance Costs	$439,432	$439,432	
BTM/TTM Costs	$500,000	$500,000	
Residual Value of Vehicles	($1,110,707)	($1,110,707)	($688,220)
Vehicle incentives and Grants		($9,768,460)	
Charge Ready Transport EVSE Incentives		($200,000)	
Utility-Owned infrastructure		($500,000)	
LCFS Credits			
Net Total Cost of Ownership	**$13,767,937**	**$3,299,477**	**$10,401,182**

Medium-Duty Package Delivery Trucks

The representative 10-vehicle package delivery truck fleet was the only fleet we assessed for EY2021 in which EVs did not receive enough incentives and grant funding to offset the upfront cost of the vehicle, based on research conducted on available incentives and grants for this vehicle category. Because these fleets are mostly private, there were fewer grants available to fleet owners. We incorporated the maximum available HVIP funding for this vehicle category and note that based on site visit data, other funding such as AQMD grants did support the purchase of EVs for some fleets. Based on the Cadmus team's research, the AQMD grant funding used for the fleet in EY2021 has since been exhausted, so we did not include it in the grant scenario. As shown in Figure 22, the scenario in which the EV fleet did not receive any grants or incentives cost more than twice as much as the counterfactual fleet of diesel package trucks over the 10-year period.

Table 42 illustrates that the scenario in which the EV fleet received HVIP grants, LCFS credits, and CRT infrastructure support, which reduced the NPV of the EV fleet to cost $483,535 more than the diesel fleet. Because not all MD fleets will be eligible for CRT's Charging Equipment Rebate, SCE's charger incentives were not included in the package delivery truck fleet TCO.

The upfront cost of the delivery truck fleet was higher, but the operating costs were lower. Maintenance and repair costs were forecast to save the EV fleet owner more than $56,000 over the 10 years and the per-mile fuel costs were $.37 for electricity and $.39 for diesel. Managed charging could increase this savings (as addressed in the *Managed Charging* section).

Figure 22. SCE Package Delivery Truck Fleet 10-Year Total Cost of Ownership

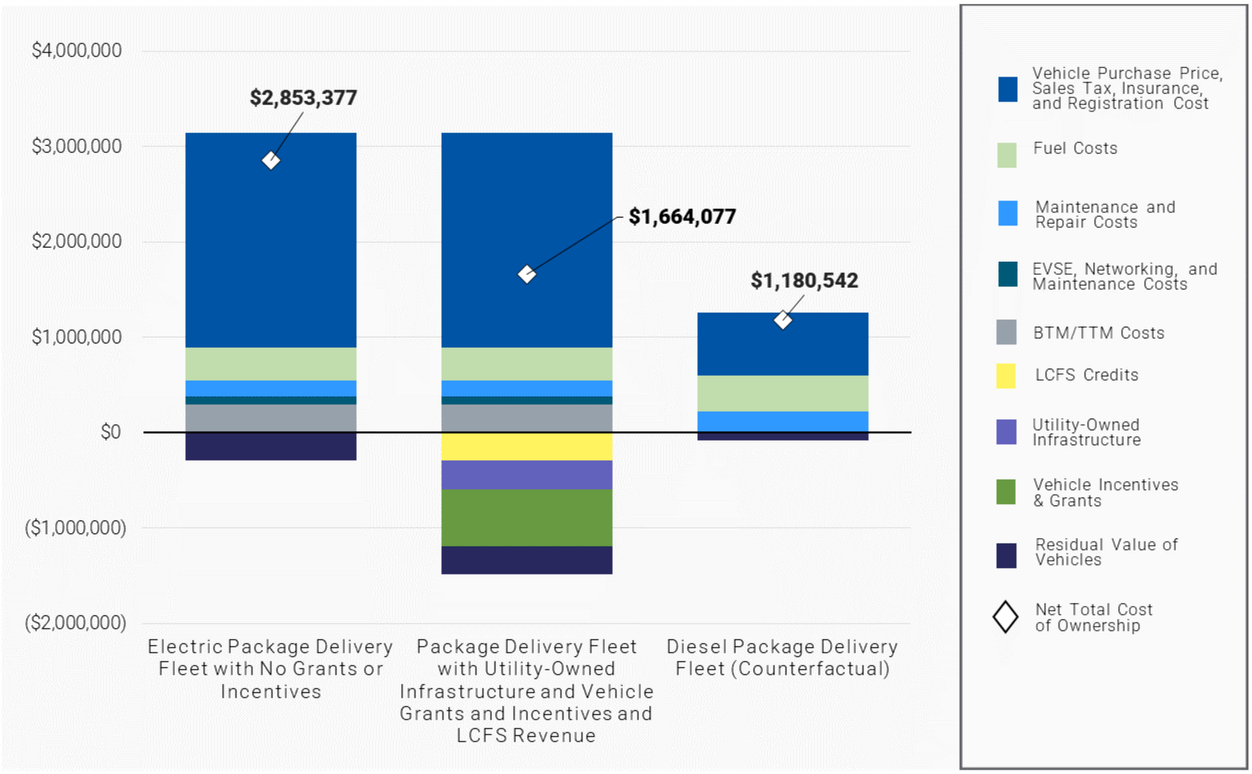


Table 42. SCE Package Delivery Truck Fleet 10-Year Total Cost of Ownership

SCE Package Delivery Truck Fleet 10-Year Total Cost of Ownership (NPV)	Electric Package Delivery Fleet with No Grants or Incentives	Package Delivery Fleet with Utility-Owned Infrastructure and Vehicle Grants and Incentives and LCFS Revenue	Diesel Package Delivery Fleet (Counterfactual)
Vehicle Purchase Price, Sales Tax, Insurance, and Registration Costs	$2,249,412	$2,249,412	$663,996
Fuel Costs	$343,231	$343,231	$370,809
Maintenance and Repair Costs	$169,364	$169,364	$225,819
EVSE, Networking, and Maintenance Costs	$81,191	$81,191	
BTM/TTM Costs	$300,000	$300,000	
Residual Value of Vehicles	($289,820)	($289,820)	($80,082)
Vehicle incentives and Grants		($600,000)	
Utility-Owned infrastructure		($300,000)	
LCFS Credits		($289,300)	
Net Total Cost of Ownership	**$2,853,377**	**$1,664,077**	**$1,180,542**

Cost Mitigation Strategies

Expert Advice

Expert advice from program staff and service from Utility personnel in designing and installing the necessary EV charging infrastructure can help reduce or avoid project costs (such as by providing information on grants and incentives or by recommending the most cost-effective locations for installing EV chargers). The expansion of sector-specific resources (such as case studies and webinars on specific fleet types) and the provision of advisory services can further support this strategy.

SCE offers Transportation Electrification Advisory Services outside of CRT to support business and fleet owners in their electrification projects. These services include EV readiness studies, assistance with identifying and applying for grants, educational webinars and workshops, and information regarding CRT for eligible fleets. As illustrated in the TCO analysis, vehicle grants are critical to making these projects financially feasible. Therefore, Utility support in conducting an EV readiness study and applying for grants adds value and has the potential to reduce vehicle electrification costs and increase the number of projects implemented.

SCE also provides an Electric Fleet Fuel Savings Calculator, which can help fleet customers estimate potential fuel cost savings over 20-years by going electric. Customers can adjust inputs such as number of vehicles, charger type, and charging schedule, among others, in estimating potential savings in fuel costs, which can further inform fleets' TCO analysis.

Managed Charging

One way fleet managers can reduce the operating costs of their electric fleets is through managed charging. The Cadmus team used participant sites' billing data to determine electricity cost assumptions for the TCO analysis. SCE provides information regarding its TOU and TOU-EV rates to each customer, and during the CRT project feasibility study phase, SCE account managers and field engineers educate and encourage customers to use off-peak charging (when electricity demand and costs are lower).

However, despite these efforts, anecdotal information gathered from site hosts during evaluation site visits indicated that most EY2021 electrified fleets were not managing charging to minimize costs and grid impacts. Fleet managers may not have been aware of electricity bills, which an administrative person responsible for all facility bills typically handles. As a result, fleet managers may not have directly seen the financial benefit of adjusting charging. Additionally, most fleet managers were not aware of EVSP's charge management features due to a lack of training and familiarity with the online portals offered by the majority of EVSPs where charging could be configured. Lastly, even if charging was delayed via EVSP's software, there is a potential challenge if EVs are not accepting a delayed charge from the EVSE to protect the vehicle's battery, which may be a feature of the battery management software.

SCE can support fleet managers participating in CRT to manage charging by ensuring fleet managers know to communicate with their administrative departments to monitor electricity costs, understand the EVSP's online portal used to configure time of charging if offered, and have selected charging infrastructure that is compatible with their vehicle acquisition plans to prevent interoperability issues. SCE may provide more thorough benefits to customers through semi-annual follow-up with their customers, both the fleet managers and contacts who receive the energy bills. Many customers share similar experiences of being unsure of electric rates and their own costs, for which SCE can act as a conduit and ensure clarity going forwards. This effort can help ensure customers attain the energy prices for their fleets that were highlighted during early planning phases.

To assess the impact of managed charging on the TCO for fleets, the Cadmus team created two scenarios analyzing an illustrative example school bus using SCE's TOU-EV-8 rate over a 10-year period. All the EV school bus fleets activated in 2021 used the TOU-EV-8 rate, which offered demand charge relief and consisted of energy charges combined with service charges. In the first scenario we modeled a fleet with unmanaged charging, which charged during times of peak energy demand. In the second scenario we modeled a fleet with managed charging, which took advantage of lower electricity prices during times of low energy demand (Table 43).

Table 43. SCE Managed Charging Scenario Inputs

TOU Period	Scenario 1: Unmanaged Charging	Scenario 2: Managed Charging
Summer On-Peak/Winter Mid-Peak	60%	-
Summer Mid-Peak/Winter Off-Peak	40%	70%
Summer Off-Peak/Winter Super Off-Peak	-	30%
Average Cost of Electricity ($/kWh)	**$0.29**	**$0.21**

Scenario 1 (unmanaged charging) resulted in $0.29 per kilowatt-hour average cost of electricity and Scenario 2 (managed charging) resulted in $0.21 per kilowatt-hour. In terms of annual electricity costs, Scenario 2 resulted in a 27% decrease in annual electricity costs for an electric school bus on the TOU-EV-8 rate. Over the total life of the vehicle, this cost decrease resulted in a 16.5% decline in the NPV for a fleet of 10 buses in the scenario where incentives and LCFS revenue were considered (Table 44).

Table 44. SCE Managed Charging Scenario Outputs

Scenario	Net Present Value [a]	Total Fuel Costs [b]
Scenario 1 – Unmanaged Charging	$467,662	$28,352
Scenario 2 – Managed Charging	$390,537	$20,639
Base Case (presented in Table 40)	$480,045	$29,316
Percent change from Scenario 1 to Scenario 2	**16.5%**	**27.2%**

[a] This table shows NPV for an example electric school bus in a fleet of 10 buses with incentives included over 10 years.

[b] This column shows discounted fuel costs over a 10-year period.

It is of note that the example school bus fleet from Table 40, based on representative billing data, had higher fuel costs than the unmanaged charging scenario. This result indicates that school bus fleets could be charging on-peak more than 60% of the time. While many cost considerations are out of a fleet manager's control, charging management is an area in which managers can reduce operating costs.

Utility Revenue

The Cadmus team primarily approached this TCO analysis from the perspective of the fleet owner, but it is important to note that one impact from these programs will be an increase in cumulative electricity sales. While many of these projects were not active until mid-year, and do not reflect what the annual revenue from these projects will be; over time, the costs of the infrastructure installed for these projects and paid for by customers will be spread out over growing energy sales. In EY2021, CRT operational projects yielded $136,510 in electricity sales. As sales accumulate, this should put downward pressure on rates and, if charging is managed, could result in a more efficient distribution system.

Conclusions

From a fleet manager perspective, the representative MDHD market segments assessed in this TCO analysis are only cost-effective today when EV grant funding, subsidized Utility infrastructure, and market-based climate policies are taken into account. Lower operating costs and preferential tax treatment also help to support the affordability of EV fleets. In particular, the example of the medium-duty package delivery truck fleet shows the importance of EV grant funding to making vehicle electrification economically feasible. Without grants to offset the higher upfront cost of the vehicles, they are not a financially attractive investment for fleet owners today. Currently, EV grant funding and Utility rebates and incentives are critical to making EV fleets economically competitive with ICE fleets.

Based on the results of the three scenarios, the analysis for fleets in each market segment resulted in three findings.

- Electric MDHD vehicles are much more expensive than ICE vehicles.
- While EVs cost less to operate and maintain than ICE vehicles, these savings do not compensate for the higher upfront cost of the EVs and the added costs of infrastructure necessary for charging.
- Without the combination vehicle grants and incentives, infrastructure support and EVSE incentives from SCE, and LCFS credits, EY2021 MDHD fleet electrification projects would be cost-prohibitive.

Grid Impacts

The team estimated grid impacts for the CRT program based on the energy consumed by operational charging stations installed through the program in EY2021, combined with charging session data from the EVSPs. Table 45 presents a summary of the estimated CRT program grid impacts through EY2021, an annual estimate, and a 10-year projection.

Table 45. SCE CRT Grid Impacts Summary

Impact Parameter	Evaluation Year 2021	Annualized Estimate [a]	10-Year Projection [a]
Operational Sites	19	16	16
Electric Energy Consumption, MWh	545.4	1,029	10,290
On-Peak MWh (4 p.m. to 9 p.m.) (and % of total)	175 (32%)	N/A	N/A
Maximum Demand, kW (with date and time)	683 (12/15/21 3:30 p.m.)	N/A	N/A
Maximum On-Peak Demand, kW (with date and time)	506 (12/15/21 4:00 p.m.)	N/A	N/A

[a] The team used 16 sites for this estimate based on annualized AMI data.

Figure 23 shows total monthly electricity consumption during EY2021 for all 19 operational sites in the CRT program (January through October data are not shown due to less than 15 operational sites for those months). There was an increase in energy consumption in fall 2021 as school bus operations increased with public school re-openings.

Figure 23. SCE CRT EY2021 Monthly Electricity Consumption

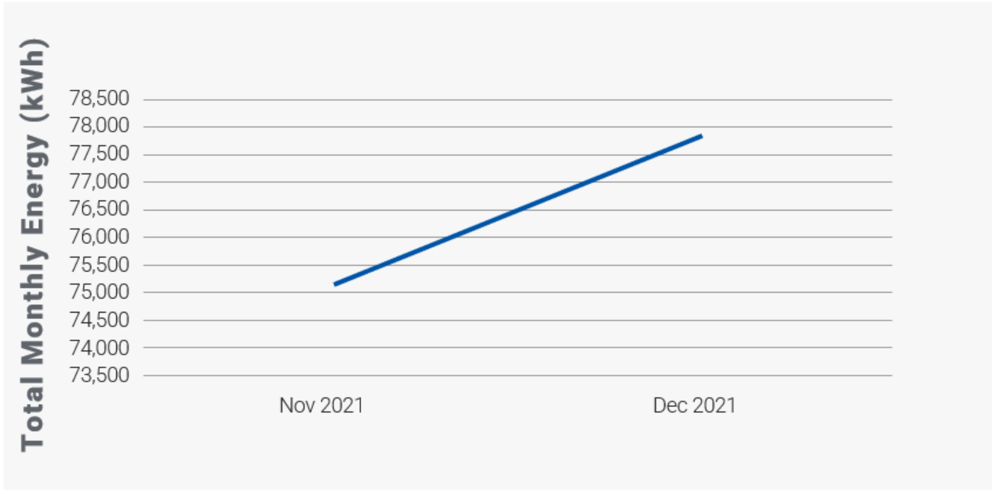
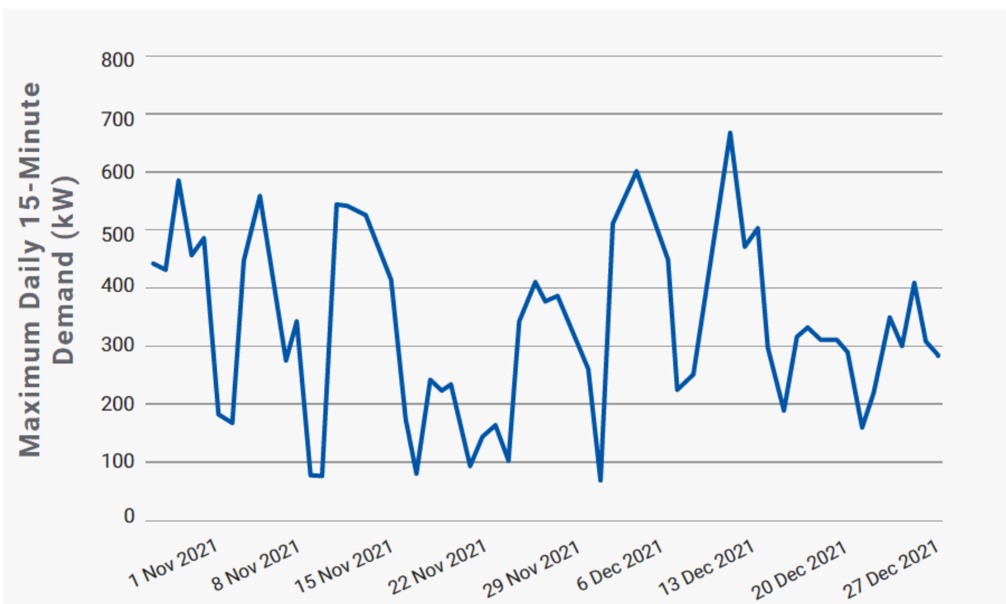


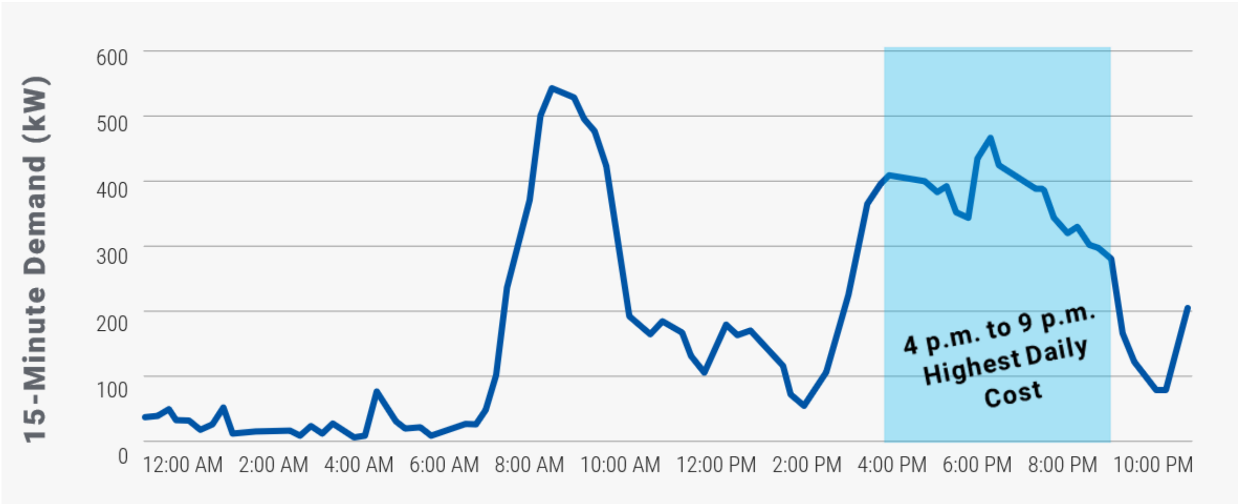
Figure 24 shows new transportation load as SCE customers began using their charging infrastructure and vehicles. The hysteresis shows weekly cycles with low marks representing reduced weekend operation.

Figure 24. SCE CRT New Transportation Load



Through the end of 2021 approximately 600 kW of new load had been added through the program. The team tracked maximum demand using AMI 15-minute interval data on a daily basis (shown above) and actual aggregate load (shown below). The overall portfolio was primarily school bus operations, which charge after routes in the mornings and late afternoons. Maximum load was exhibited on December 9, 2021. As shown in Figure 25, load peaked in the morning but was nearly as high during the highest cost period of the day (between 4 p.m. and 9 p.m.). The load shape with morning and late afternoon peaks was heavily influenced by school districts operating electric school buses, despite there being several sites representing heavy-duty trucks and transit buses. Overall, few operators charged on the weekend.

Figure 25. SCE CRT Load Curve on Tuesday, December 9, 2021



School bus operations across the state shared many characteristics, such as similar duty cycles, similar EV battery capacities, and similar parking dwell times, resulting in very similar load curves. Few if any sites regardless of market segment appeared to use load management during 2021 based on load curves and insight from site visits.

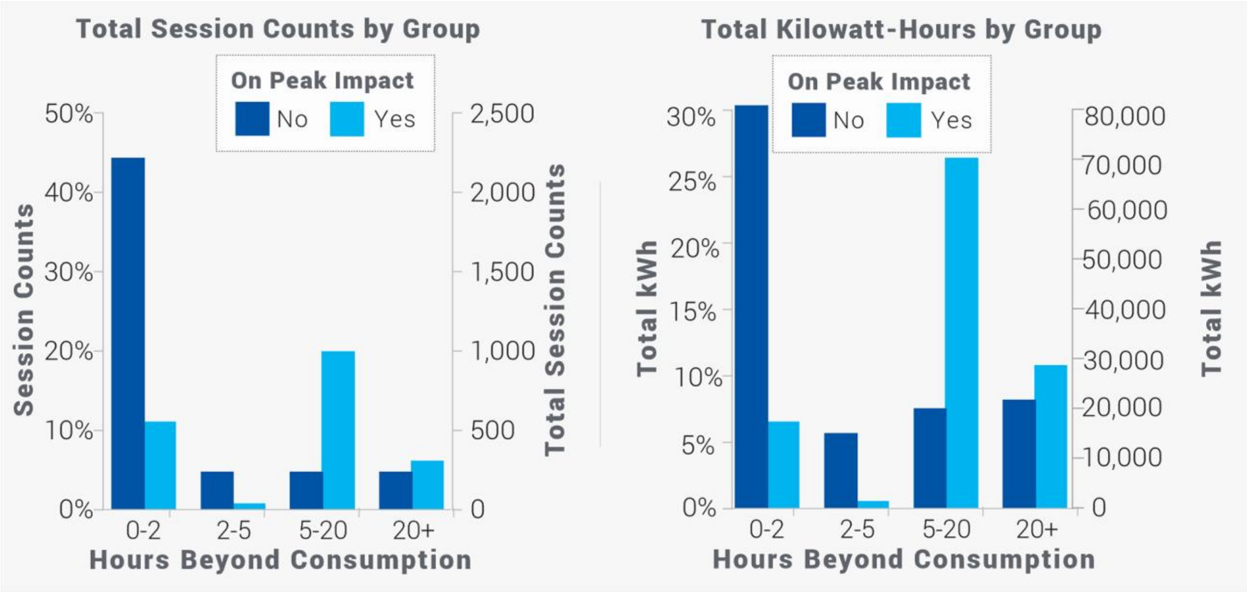
The Cadmus team used charging session summaries from EVSPs to assess potential flexibility in when charging sessions consumed energy. In our initial analysis of sessions, the team scanned for realistic durations of connection or charging and potential faults ending sessions prematurely. Flexibility is currently defined as how much time a vehicle was connected to a charging port in excess of electricity consumption.

Figure 26 highlights that nearly 40% (1,800) of all charging sessions consumed at least some energy between 4 p.m. and 9 p.m. More than a third of the total energy use (38%) that impacted that time period appears to have two hours or more of charging flexibility. This observation indicates that most energy use during this unideal time period can likely take place during a time period at reduced cost and lower emissions. Load management strategies could allow for shifting consumption to other lower cost and lower emissions time periods.

The histograms below represents 100%[50] of charging sessions while the colors indicate whether a portion of their consumption took place between 4 p.m. and 9 p.m. (on peak). The left variation is based on charging sessions while the right chart is based on energy (kilowatt-hours).

50 The team removed charging sessions with known or suspected errors from this analysis.

Figure 26. Time Connected to EVSE Beyond Consumption Indicates Potential for Load Flexibility



Petroleum Displacement

The Cadmus team determined petroleum displacement that is attributable to the vehicle electrification enabled by SCE's CRT program. We used diesel gallons equivalent (DGE) for reporting purposes. Transit buses primarily use CNG fuel, which means that we needed to convert their natural gas consumption into DGE units based on the fuel's energy content.

Table 46 summarizes petroleum displacement impacts for CRT through EY2021. More than 380,000 electric miles were driven in EY2021. This translates into the displacement of nearly 100,000 DGE on an annualized basis. The results below are reported for the four market segments represented in the program, the majority of which were school buses. Due to fewer than 15 customers for any market segment, per evaluation criteria, the EY2021 results are grouped together.

Table 46. SCE CRT Petroleum Displacement Summary

Market Segment	Evaluation Year 2021			Annualized	10-Year Projected Impact
	Total Usage (kWh)	Usage (miles)	Petroleum Displacement (DGE)	Petroleum Displacement (DGE)	Petroleum Displacement (DGE)
Heavy-Duty Vehicles, Medium-Duty Vehicles, School Buses, and Transit Buses	545,428	381,394	52,394	99,699	996,987

Based on our analysis of EY2021 operational sites, the program is on target to displace close to 1 million DGE over a 10-year period. The actual displacement will be higher as more EVs are added at existing sites. Additionally, site operations may be reasonably expected to increase to pre-pandemic levels of service. In addition to greater use at existing sites, the program will build out additional sites resulting in higher total program impacts in the months and years ahead.

Greenhouse Gas and Criteria Pollutant Impact

The Cadmus team calculated reduced emissions from displaced fossil fuel use from ICE vehicles that were not in service because of CRT. The first step was to develop ICE counterfactual equivalents for each market segment, then calculate the emissions associated with these vehicles under conditions that otherwise matched the EVs to provide 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 47 summarizes GHG impacts from CRT for three time periods: (1) EY2021 reductions, (2) estimated annualized reductions that reflect what the program would have saved in EY2021 if all activated sites had been fully operational for all 12 months, and (3) a 10-year projection based on annualized data. Similar to petroleum displacement, the largest GHG impacts are from school buses. The four market segments shown below had annualized GHG emissions reductions of 76%.

Table 47. SCE CRT GHG Reductions Summary

Market Segment	Evaluation Year 2021		Annualized	10-Year Projected Impact	% GHG Reduction
	Total Usage (kWh)	GHG Reduction (MT)	GHG Reduction (MT)	GHG Reduction (MT)	
Heavy-Duty Vehicles, Medium-Duty Vehicles, School Buses, and Transit Buses	545,428	365	723	7,230	76%

Table 48 shows the estimated reductions in local emissions from the tailpipes of ICE vehicles that were displaced through this program. The estimates of local emissions reductions are relatively small in this first year of the program, with the exception of transit buses (which have higher ROG and CO emissions due to the assumption that the displaced transit buses ran on CNG).

Table 48. SCE CRT Local Emissions Reductions Summary – EY2021

Market Segment	Evaluation Year 2021 Local Emissions Reductions			
	PM_{10} (kg)	$PM_{2.5}$ (kg)	ROG (kg)	CO (kg)
Heavy-Duty Vehicles, Medium-Duty Vehicles, School Buses, and Transit Buses	0.69	0.66	7.23	3,517.72

Table 49 shows the same information as above but on an annualized basis. In other words, it shows what the localized emissions reductions would have been if the sites were fully operational for the entire year. This annual estimate for the first year is necessary to calculate a 10-year reduction projection based on the first evaluation year results.

Table 49. SCE CRT Local Emissions Reductions – Annualized

Market Segment	Annualized Local Emissions Reductions			
	PM_{10} (kg)	$PM_{2.5}$ (kg)	ROG (kg)	CO (kg)
Heavy-Duty Vehicles, Medium-Duty Vehicles, School Buses, and Transit Buses	1.3	1.3	14.2	7,055.3

Table 50 provides an estimate of savings over the 10-year period based on annualized reduction estimates from this first evaluation year.

Table 50. SCE CRT Local Emissions Reductions Summary – 10-Year Projection

Market Segment	10-Year Local Emissions Reductions			
	PM_{10} (kg)	$PM_{2.5}$ (kg)	ROG (kg)	CO (kg)
Heavy-Duty Vehicles, Medium-Duty Vehicles, School Buses, and Transit Buses	13.2	12.5	142.4	70,552.6

Table 51 and Table 52 show annualized reductions in GHG and NO_X emissions for the CRT program. The results indicate GHG reductions of 76% and 60% reduction in NO_X from the use of EVs compared to counterfactual vehicles.

Table 51. SCE CRT Annualized GHG Reductions

Market Segment	Annualized GHG (MT)			
	Counterfactual	Utility	Reduction	% GHG Reduction
Heavy-Duty Vehicles, Medium-Duty Vehicles, School Buses, and Transit Buses	955.7	232.8	723.0	76%

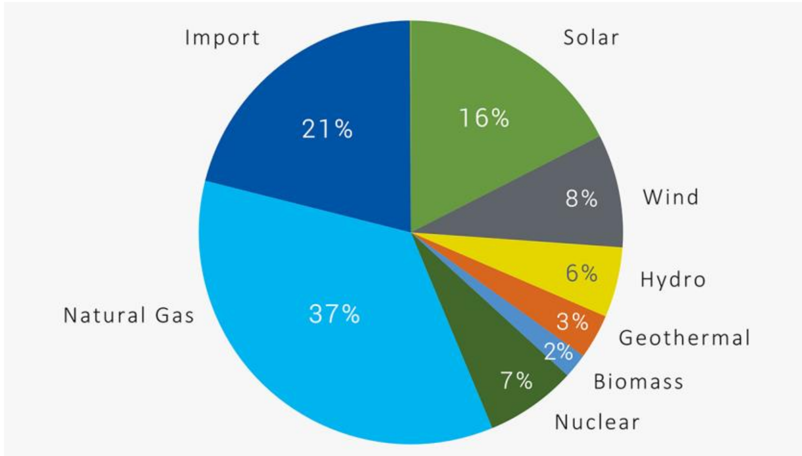
Table 52. SCE CRT Annualized NO_x Reductions

Market Segment	Annualized NO_x (kg)			
	Counterfactual	Utility	Reduction	% GHG Reduction
Heavy-Duty Vehicles, Medium-Duty Vehicles, School Buses, and Transit Buses	459.2	181.6	277.6	60%

Figure 27 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 renewables resources such as solar. At this early stage of the program, it appears that the vehicles were not charging predominantly during the peak hours of solar output. Over 20% of the grid mix is comprised of electricity imports, which are assumed to match the resource mix of the Western grid.

Based on the real-time grid conditions when the charging occurred, the overall energy mix was about 42% zero-emissions or renewable sources of electricity (including solar, wind, hydro, geothermal, biomass, and nuclear) and 37% natural gas. Emissions reductions from these sites over 10 years should increase as the grid becomes cleaner. Additionally, the increased use of managed charging, where possible, would reduce emissions by having EVs charge at times when the grid is supplied with renewable resources such as solar. Finally, emissions will decrease even more as more charging sites and EVs are added in the future evaluation years.

Figure 27. Annualized Program Net Electricity Mix for SCE CRT



Health Impacts

The team calculated health benefits related to reductions in $PM_{2.5}$ (as shown in the *Greenhouse Gas and Criteria Pollutant Impact* section) that resulted from EY2021 program activity:

- Mortality: incidence and valuation ($)
- Work loss days: reduction in days lost incidence and valuation ($)
- Emergency room visits: cardiovascular and respiratory incidence and valuation ($)
- Hospital admissions: respiratory benefits incidence and valuation ($)

As part of this analysis, we also examined the health benefits specifically within DACs, which may be disproportionately burdened by sources of pollution (including air pollution from ICE vehicles). However, the amount of $PM_{2.5}$ reduction that resulted from the EY2021 CRT program annualized activity was not substantial enough to detect a change within DACs or for the sites evaluated for this reporting period. The U.S. EPA's BenMAP, which the team used to conduct the health impacts analysis, is only capable of estimating health impacts at reductions in concentrations down to the sixth decimal place. Only 16 sites had enough activity to be included in the analysis for the first evaluation year, and a significant number of those sites' reductions were at or past the seventh digit, resulting in undetectable impacts. While some sites had $PM_{2.5}$ air concentration reductions at the sixth decimal place, the team opted to run BenMAP with a cut-off at the fifth decimal place in an attempt not to overstate potential impacts at such a low level of precision.

Net Impacts

Qualitative Assessment of Spillover

The Cadmus team asked fleet managers if their participation in the program had any impact on their procurement of EVs and charging equipment that was not directly resulting from program incentives. Among participating fleets, two fleet managers said that the program had an influence:

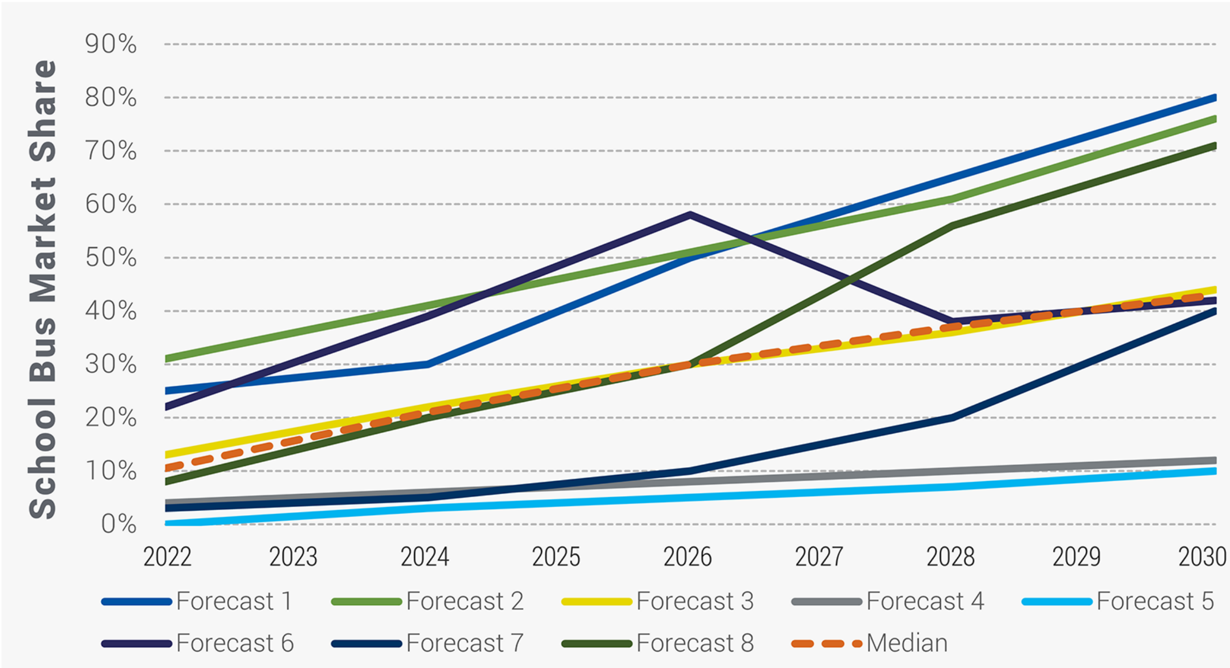
- "The savings we realized by participation in the Charge Ready Transport program enabled us to consider purchasing additional electric school buses. We had originally planned on purchasing six Blue Bird and five Lion school buses. Now we are looking at purchasing an additional eight Lion or Blue Bird school buses."
- "From the positive experience we had with Charge Ready Transport this further strengthened our commitment to transition our fleet to zero-emission as quickly as possible. Given the infrastructure that was constructed through Charge Ready Transport, the city is prepared to acquire six additional battery-electric buses within the next 24 months."

None of the fleet managers who withdrew from the program reported any influence of the program on fleet electrification.

Market Effects: School Bus Electrification Market Share Baseline

The Cadmus team developed a consensus forecast for the baseline market share of electric school buses in California through vehicle model year 2030 following two rounds of input from the Delphi process. Figure 28 shows the individual curves from the first round of input (Round 1), along with the median curve. Note that the horizontal axis indicates vehicle model year and only applies to *new vehicles*, not to the entire statewide vehicle stock.

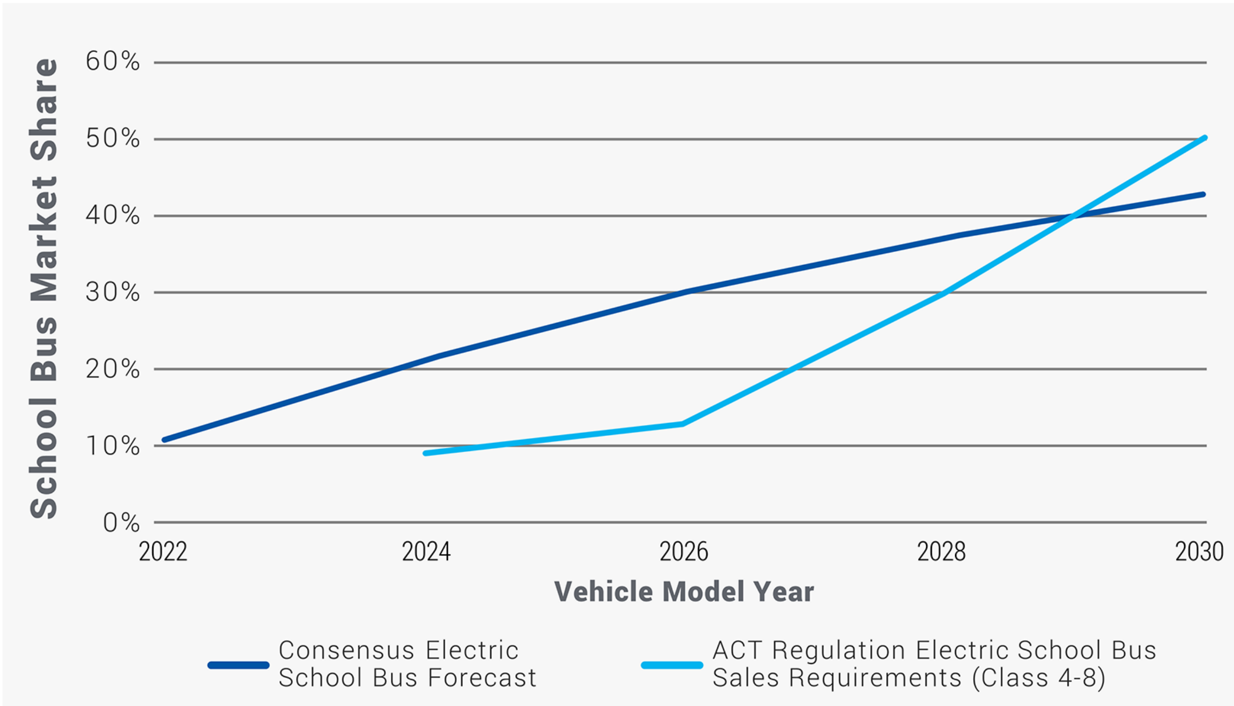
Figure 28. Round 1 Baseline Electric School Bus Adoption Forecasts



Despite the range in Round 1 forecasts, there was general agreement that the EV market share will increase over time.[51] In Round 2, five of eight panelists agreed with the median or consensus forecast, while three panelists submitted new forecasts and rationales. As over half the panelists were in agreement, the median forecast was the final consensus result. Figure 29 shows the final consensus estimate compared to the zero-emission truck sales schedule from the Advanced Clean Trucks (ACT) regulation for Class 4 through Class 8 vehicles. It shows that experts do not think the ACT regulation will drive adoption of electric school buses, possibly because the regulation allows flexibility in how manufacturers decide to meet the California sales requirements across all covered MDHD vehicles.

51 Forecast 6 is the only one that shows a temporary decline in market share between 2026 and 2028. According to the panelist, this is due to the Bipartisan Infrastructure Law and California Energy Commission grant propping up the market share of electric school buses until 2026, after which demand will drop for a few years before eventually increasing again.

Figure 29. Electric School Bus Baseline Market Share Forecast



Of the three experts who did not agree with the median, two believed that the market share will grow faster due to a tipping point in the late 2020s once EVs establish a clear TCO advantage over ICE vehicles. This shift will likely manifest as a supply- and demand-side shift wherein manufacturers and fleet managers will view ICE vehicles as financially irrational. The third expert thought the electric school bus market share will grow at a much slower rate than the median forecast due to the relative price and TCO of electric school buses, the delay in bus purchases resulting from the COVID-19 pandemic, manufacturing limitations, and the lack of sufficient funding.

The Cadmus team recognized that while deriving the consensus forecast achieved the main goal of the Delphi panel, 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.

Nearly all the panelists agreed that the availability of funding poses the greatest driver or barrier to wider school bus electrification. Experts stated that the financial standing of school districts as well as the costs for production, batteries, and overall vehicles comprise the major barriers that suppress increased adoption. These panelists referred to incentives, rebates, and other programs at the local, state, and federal levels—such as the Bipartisan Infrastructure Law, HVIP, and the U.S. EPA's Clean School Bus Program—as vital mechanisms that will alleviate the financial burden and accelerate the electric school bus market.

While panelists named funding availability, or the costs currently associated with owning and operating electric school buses, as the main deterrent, they also mentioned many other barriers to increased uptake of electric buses. For instance, panelists whose forecasts were below the median curve cited infrastructure challenges such as EVSE placement and availability, incompatible charging schedules, vehicle range, and charging rates within their supporting rationales. One panelist noted that, irrespective of cost, funding, or other advantageous changes, certain school bus routes and fleets will be difficult to electrify due to customers being resistant to change.

The final concern raised by panelists was related to vehicle or model availability being a constraint on adoption. Experts disagreed over this issue: some believed that the availability of vehicles was not a bottleneck, some were certain that supply will be insufficient to meet demand, and some thought that while the initial ramp up in supply will not be able to meet demand, vehicle availability will not suppress adoption in later years of the study period.

Experts were split between whether the ACT regulation would influence the electric school bus market. Half the panelists viewed the regulation as a “floor” or “background noise” rather than a driving force. These observations result from schools historically following bus replacement schedules regardless of any regulations, the lack of available vehicles or vehicle models, and the regulation’s classification of school buses within a broad category wherein sales of varying vehicle types can count toward the regulation’s sales requirements. The remaining half of panelists stated that the ACT regulation increased their market share baseline forecast. As previously mentioned, some panelists predict that the regulation will induce a supply-side shift, causing manufacturers to view ICE vehicle production as no longer profitable or feasible in the long term. Other experts expect the ACT regulation to indirectly support electric school bus uptake, as it will help reduce battery and other input costs for all EVs. Several experts also pointed to the emissions standards within California’s Clean Air Act (reinstated through a waiver by the U.S. EPA) as spurring a significant transition toward electric school buses in 2027.

Finally, experts provided insight into the impact that California’s electric utilities could produce on the actual adoption of EVs. Over half the experts (five of eight panelists) predict that the Utilities will shift actual adoption upward through mechanisms such as funding, EVSE and infrastructure support, education and outreach programs, and targeted charging rates.

4.1.3. Lessons Learned

The Cadmus team identified a number of lessons learned from EY2021, which are presented below with key supporting findings. Note that these lessons and findings were derived from a limited number of program participants across only four market sectors. Additional insights will be gained as more sites are completed in the coming years.

Activation timelines were longer than estimated, but participants were satisfied with program timelines.

Of the 24 activated sites spanning four market sectors in the CRT program for EY2021, the median start-to-finish timeline for site activation for these sites was 669 days (over 22 months). In its program materials, SCE estimated its process to take 11.5 months to 14.5 months. During site visits, some participants anecdotally reported that the COVID-19 pandemic had slowed the completion of their sites. Information from SCE program staff also indicated that the pandemic changed the scope of multiple projects throughout 2021, resulting in project delays and multiple projects being placed on hold for varying periods of time. As program activity increases in the various segments, the evaluation will continue to review activation timelines and factors driving them.

Despite longer-than-estimated timelines, all seven fleet manager survey respondents who answered the question on program satisfaction rated themselves as either *very satisfied* (four) or *somewhat satisfied* (three) with the installation timeline. Regarding the timeline for receiving rebates, five of the six respondents rated themselves as either *very satisfied* or *somewhat satisfied*. When asked for more details, these program participants did not share anything they would have done differently if going through the program again.

Participants were satisfied with the CRT program's services for BTM make-ready infrastructure.

Twenty three (23 of 24) activated sites chose Utility ownership of BTM infrastructure instead of customer ownership. For these sites, SCE paid to design, construct, own, and maintain all infrastructure up to the charging stations. Customers were still responsible for procuring, installing, and maintaining the charging stations. Five of seven respondents rated themselves as *very satisfied* with the level of program services received. In interviews, Utility staff said they had added site management personnel to improve program implementation, since each site required significant time and effort.

CRT addressed most of the participants' top barriers to fleet electrification, but the cost of EVs remained a barrier and requires non-Utility funding to address.

Fleet manager survey respondents said that incentives for EV charging infrastructure and vehicles were a significant motivator for transitioning to EVs, and that before participating in the program, the costs of EVs and of installing EV charging infrastructure were prohibitive. This finding was reiterated by Utility staff, who reported that the most significant costs for site hosts were vehicle and infrastructure costs. Survey respondents also listed the range limitations of EVs for their routes as a major barrier. After participating in the program, respondents noted that the cost of installing EV charging infrastructure was less of a barrier, and that the EVs and charging infrastructure supported through the program addressed some of the range anxiety they felt prior to the program. However, the cost of EVs remained a key barrier as the program is not designed to address EV acquisition.

During site visits, school fleets anecdotally reported being heavily dependent on public grant funding to mitigate EV costs. The TCO analysis also revealed that without the combination of vehicle grants and incentives, infrastructure support from SCE, and LCFS credits, MDHD fleet electrification projects would cost significantly more. Non-Utility funding to support EV procurement was therefore important in addressing the EV cost barrier.

EV charging equipment was found to be reliable, but EVs themselves were found to be less reliable.

Six of the fleet managers who provided survey responses regarding reliability, reported that they found the charging equipment to be reliable, while four of six found the EVs to be reliable. Respondents also mentioned vehicle reliability and range as key limitations of EVs when discussing EV options in their sector.

Additionally, of the 15 sites visited, five fleet operators discussed co-costs associated with their fleet electrification. These five operators noted that they experienced vehicle recalls or reliability issues that often required repairs to be conducted by the vehicle manufacturer or dealer during the initial warranty period. Four of these operators said they experienced reduced flexibility with EVs compared to conventional vehicles, specifically for school buses. Two of these operators had to adjust their routes to accommodate the new buses or had to keep more conventional buses than they would have liked. Two operators reported increased maintenance costs.

Some fleet operators anecdotally reported isolated instances of difficulty with vehicle reliability, with some sites being unable to fully operate their EV fleet due to vehicle reliability limitations. Therefore, even though the fleet manager survey found that the EVs and charging infrastructure supported through the program addressed some of the range anxiety respondents felt prior to the program, qualitative data gathered during the evaluation revealed that range and reliability still presented barriers to increased electrification.

Most fleet operators did not manage charging, resulting in increased operating costs. Flexibility in charge times provides opportunities for improved grid integration and further electrification.

While program data indicates that most of the EVs and EVSPs participating in the program have the capability to limit charging during certain hours, only one operator from the sites visited was aware of EVSPs' capability to limit charging during peak hours, and none of the 15 sites visited had a load management plan to reduce electric fuel costs and grid impacts. In addition, among operators who discussed electric fuel costs during site visits, few reported being aware of their electric fuel costs, even after several months of operation. None of these operators had been able to access or analyze data on actual ranges and fuel economies derived from vehicle logs and charging sessions. This was despite SCE account managers' and field engineers' efforts to educate and encourage customers during the project feasibility study phase to use off-peak charging when electricity demand and costs are lower. As such, most fleet managers were not managing charging and, as a result, were paying more for charging than necessary.

The grid impacts analysis revealed that nearly 40% of charging sessions impacted electricity consumption during peak hours, when rates were highest. The grid impacts analysis also showed that charging could be shifted away from peak hours (see Figure 26) based on time spent parked (but not actively charging) at chargers. Therefore, increased awareness of electric fuel costs and how to mitigate them through charge management will be important in helping fleet managers to reduce their electric fuel costs, manage grid impacts, and accommodate additional EVs.

Ongoing effects of the pandemic on fleet operations limited program impacts.

The grid impacts analysis indicated that sites began to show regular, pre-COVID levels of operation in the fall of 2021. During site visits, some participants anecdotally reported that the COVID-19 pandemic had slowed the completion of their sites and/or reduced vehicle and charger use for their fleets, especially for school buses. The slowdown in site completion that may have been due to COVID-19 and the reduced use of vehicles and chargers meant that there were fewer impacts from the program.

During site visits, some participants commented on EV utilization and expected it to increase when travel demand returns to pre-pandemic levels, vehicle reliability is addressed to support full and consistent utilization, vehicles that were ordered are delivered, vehicles are procured pending grant fulfillment, and more drivers are available to operate additional routes.

There was general agreement among market experts that the EV market share for the school bus segment will increase over time.

Nearly all the Delphi panel experts on school bus electrification agreed that the availability of funding poses the greatest driver or barrier to wider school bus electrification. They cited the various government funding programs as vital mechanisms that will alleviate the financial burden and accelerate the electric school bus market. They noted that the financial standing of school districts as well as the costs for production, batteries, and overall vehicles comprise the major barriers that suppress increased adoption.

Half the market experts did not believe the ACT regulation would be the main driving force in electrification of the school bus market, citing factors such as bus replacement patterns, lack of available vehicles, or the flexibility within the regulation that allows for sales of different types of vehicles to count toward compliance. The remaining half of panelists said the ACT regulation increased their baseline market forecast. Some panelists predict that the regulation will induce a supply-side shift, causing manufacturers to view ICE vehicle production as no longer profitable or feasible in the long term. Other experts expect the ACT regulation to indirectly support electric school bus uptake, as it will help reduce battery and other input costs for all EVs.

4.2. Schools and Parks Pilots

4.2.1. Overview

This overview provides a detailed description of the SCE Schools and Parks Pilots as well as summaries of the Pilot implementation process; marketing, education, and outreach (ME&O) activities; EY2021 sites; budget status; and a major milestone timeline. Following the overview, we present the EY2021 findings and lessons learned.

Pilot Description

Schools Pilot: Per Decision 19-11-017, SCE's Schools Pilot offers the direct installation of and incentives for installing approximately 250 L1 and L2 charging stations at 40 K–12 schools. SCE staff designed the Pilot to enable K–12 schools to offer public charging, which would support not only school staff, but also the communities in which the schools are located.

Schools Pilot Targets

- 250 L1 and L2 charging stations
- 40 K–12 schools
- 40% in DAC locations

Participating schools can opt for SCE-owned EVSE or to own the EVSE itself. In cases where 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. In cases where 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 for SCE to own the EVSE. This adjustment maintains a static cost for the EVSE, but also considers the required agreement to operate and maintain the equipment and 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 also plan to offer customers an option to manage and pay for the qualified state-licensed labor to install customer-side infrastructure, for which SCE will provide a rebate of up to 100% of the installation cost. Participating schools also commit to providing charging equipment usage 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.

Finally, through the Pilot SCE staff will deploy a K–12 Campus EV Awareness Campaign aimed at empowering administration, faculty, students, and parents to become EV ambassadors in their communities. This Campaign will provide grade-level-specific material to increase awareness of EV ownership, repair, and maintenance skills; a faculty education program leveraging calls to action, signage, new web content, and the launch of an educator EV proponent network; and an EV economic education program to promote online self-service tools to help educators estimate the total cost of EV ownership, access lower-income resource support and information, and promote alternatives to new EV purchases, including previously owned EVs, leases, and ride-sharing.

Parks Pilot: Per Decision 19-11-017, SCE offers the direct installation of approximately 120 L2 chargers, 10 DCFC, and an optional 15 mobile chargers across 27 state parks and beaches. SCE staff designed the Parks Pilot to encourage state parks and beaches to charge their own EV fleets as well as offering charging services to staff and patrons of light-duty vehicles.

Parks Pilot Targets

- 120 L2, 10 DCFC, and 15 mobile charging stations
- 27 state parks and beaches
- 40% in DAC locations

SCE owns, builds, and operates the EVSE and contracts 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 being passed to the 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 light-duty vehicles.

In addition to EVSE, SCE staff will deploy a customer marketing campaign to publicize the availability of EV charging stations, aiming to reduce range anxiety, facilitate EV adoption, and encourage park patrons to drive EVs to the parks or beaches.

Implementation

In preparation to launch the Pilot, and prior to reaching out to potential site hosts, SCE staff set up internal processes to track applications, draft common agreement language, and conduct similar administrative tasks to ensure smooth implementation of the Schools and Parks Pilots over time. SCE identified key eligibility considerations for each site:

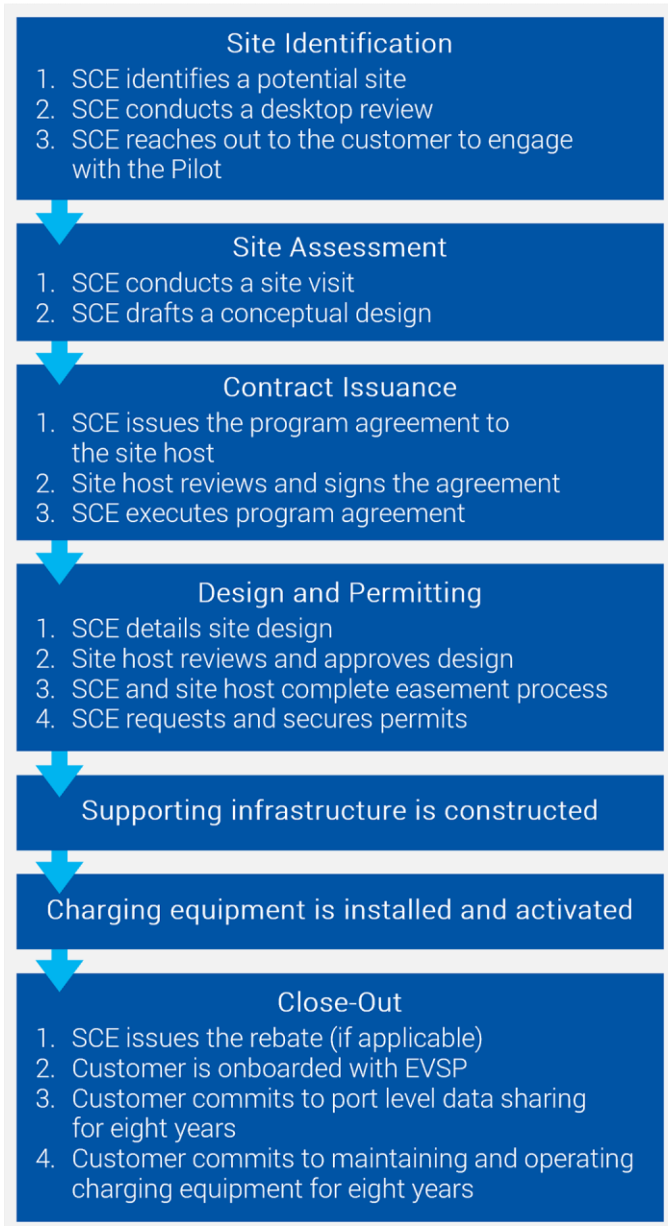
- The anticipated timing of EVSEs to be installed at the site
- DAC potential
- The overall complexity and cost of the project
- Topographic features (such as having no significant incline)
- Length of trenching needed
- Degree of construction needed to meet the Americans with Disabilities Act (ADA) requirements
- High vehicle population
- Proximity/access to appropriate electrical infrastructure
- Agree to all program terms and conditions including easements

Additionally, SCE staff began to review proposals for a third-party partner to develop educational materials for the Schools Pilot, including the curriculum for schools to use. Staff have not begun to develop ME&O for the Parks Pilot, but are planning to develop these materials once sites are underway. Further details on ME&O activities completed in EY2021 can be found in *ME&O Summary* section.

Figure 30 shows the implementation process for the Schools and Parks Pilots. Note that the Customer Agreement step is slightly different for the Parks Pilot, since the California Department of Parks and

Recreation anticipates approving a master participation agreement that will apply 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 30. Schools Pilot and Parks Pilot Implementation Process



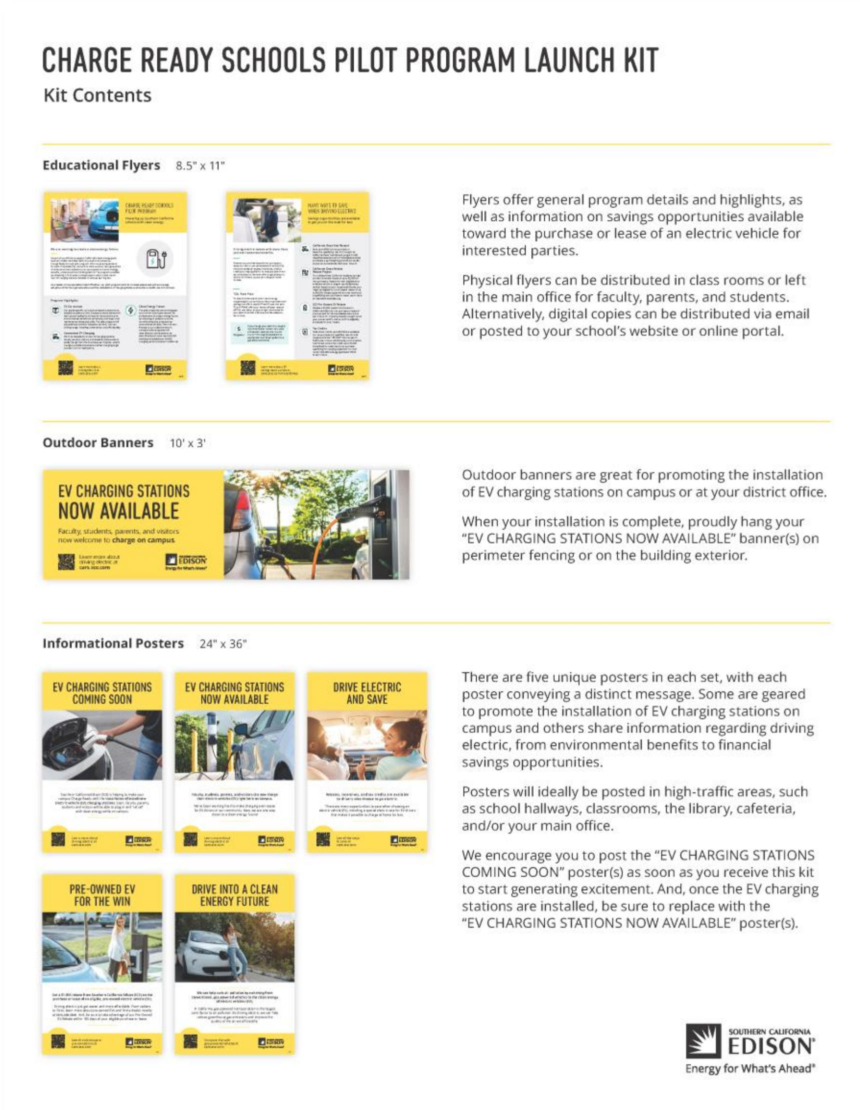
ME&O Summary

Schools Pilot and Parks Pilot: Because SCE identified potential sites for both the Schools Pilot and Parks Pilot prior to launch, the primary outreach activity for EY2021 was the Schools and Parks Pilots' manager or the Account Manager reaching out to individual potential sites directly. Initially SCE maintained a web page, https://www.sce.com/helpcenter/pilot-programs, that provided some detail of the Pilots;

however, when SCE reached full subscription for both Pilots, they updated the web page to reflect full subscription status.[52] The Cadmus team conducted a high-level review of SCE's AB web page and our findings are presented in the *Utility Web Page Insights* section.

Schools Pilot: To support the Pilot managers with direct outreach, staff developed support materials for the Schools Pilot: a summary of the welcome kit provided to participating sites, a fact sheet about the program overall, and educational flyer. Figure 31 shows an example page from the welcome kit.

Figure 31. Example of SCE Schools Pilot Welcome Kit Summary Page


CHARGE READY SCHOOLS PILOT PROGRAM LAUNCH KIT

Kit Contents

Educational Flyers 8.5" x 11"

Flyers offer general program details and highlights, as well as information on savings opportunities available toward the purchase or lease of an electric vehicle for interested parties.

Physical flyers can be distributed in class rooms or left in the main office for faculty, parents, and students. Alternatively, digital copies can be distributed via email or posted to your school's website or online portal.

Outdoor Banners 10' x 3'

Outdoor banners are great for promoting the installation of EV charging stations on campus or at your district office.

When your installation is complete, proudly hang your "EV CHARGING STATIONS NOW AVAILABLE" banner(s) on perimeter fencing or on the building exterior.

Informational Posters 24" x 36"

There are five unique posters in each set, with each poster conveying a distinct message. Some are geared to promote the installation of EV charging stations on campus and others share information regarding driving electric, from environmental benefits to financial savings opportunities.

Posters will ideally be posted in high-traffic areas, such as school hallways, classrooms, the library, cafeteria, and/or your main office.

We encourage you to post the "EV CHARGING STATIONS COMING SOON" poster(s) as soon as you receive this kit to start generating excitement. And, once the EV charging stations are installed, be sure to replace with the "EV CHARGING STATIONS NOW AVAILABLE" poster(s).

SOUTHERN CALIFORNIA EDISON
Energy for What's Ahead

52 Full subscription reflects the pipeline, not active and operational.

SCE staff planned to begin designing the Schools Pilot curriculum in 2021; however, the third-party vendor originally contracted was unable to meet the needs of the Pilot so SCE began the process of procuring a different vendor. Currently, the curriculum is planned to provide grade-level-specific material to increase awareness of EV ownership, repair, and maintenance skills; a faculty education program leveraging calls to action, signage, new web content, and the launch of an educator EV proponent network; and an EV economic education program to promote online self-service tools to help educators estimate the total cost of EV ownership, access lower-income resource support and information, and promote alternatives to new EV purchases, including previously owned EVs, leases, and ride-sharing.

SCE completed additional outreach as the Pilots progressed. In November 2021, SCE published an article highlighting their first site installation in the Pilot in an effort to increase awareness and participation. The first school to benefit from the Schools pilot installed 12 EV charging stations and was the first site in SCE's service territory's efforts to lower carbon emissions and transition to zero-emission new car fleet goals by 2035 set by the state of California. The charging stations, which will be owned and operated by SCE, will be available to staff, students, and campus visitors.

As of the end of EY2021, one school has received and used marketing materials from the CRT Program Launch Kit, which includes educational flyers, posters, and outdoor banners designed to help school staff generate interest and awareness of the newly installed EV charging stations on their campuses.

Parks Pilot: SCE did not conduct any Parks Pilot–specific ME&O activities in EY2021.

Site Summary

For EY2021, the Pilot data included the number of sites by Pilot, location of sites, DAC status of sites, and days by application phase; the team will continue to work with the Utilities to expand our collection of Pilot data for future evaluation years.

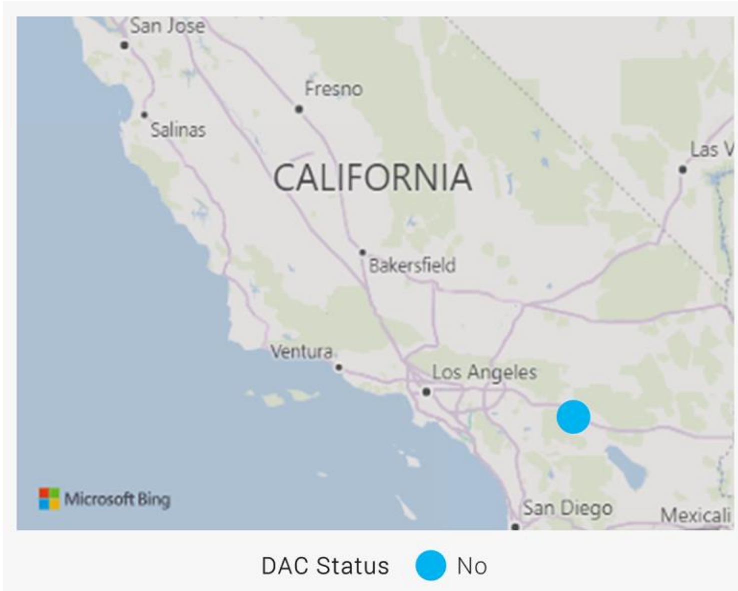
Schools Pilot: Table 53 provides the count of construction complete sites in SCE's Schools Pilot by completion status.

Table 53. EY2021 Schools Pilot Complete Site Count by Status

Site Status	EY2021
Utility Construction Complete	1
Activated	1
Operational	0
Closed Out	0

As shown above, by the end of EY2021, the Schools Pilot had secured one activated site, outside of a DAC (shown in Figure 32). This site include 12 installed ports. However, as the site became active in late December 2021, it was not operational in time for inclusion in the impact analyses for EY2021.

Figure 32. EY2021 Schools Pilot Site Location



The one activated Schools Pilot site finished the full phase cycle in 656 days, from the application reviewal through activation. The longest phase was for design and permitting, at 321 days, while the shortest phase was for activation, at zero days. Table 54 shows the median number of days by phase.

Table 54. Median Number of Days by Phase for the Schools Pilot

Phase Status	Median Number of Days
Application Reviewal	63
Site Assessment	44
Contract Issuance	48
Design and Permitting	321
Construction Complete	75
Activation	0 [a]

[a] SCE counts the end date of the construction complete phase as the activation date; therefore there is no days within the activation phase.

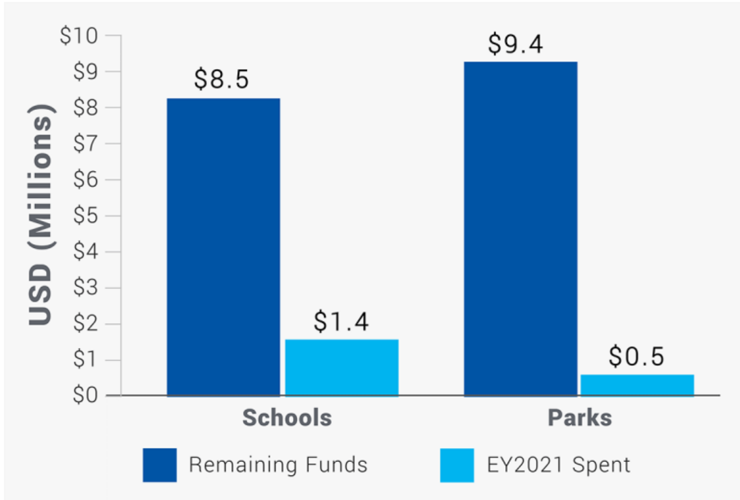
Parks Pilot: SCE did not have any Parks Pilot sites activated or constructed in EY2021.

Budget Summary

As shown in Figure 33, through the end of 2021 SCE spent $1,420,649 (de-escalated costs) of $9.89M on the Schools Pilot and $513,040 (de-escalated costs) of $9.89M on the Parks Pilot.[53]

[53] De-escalated dollars.

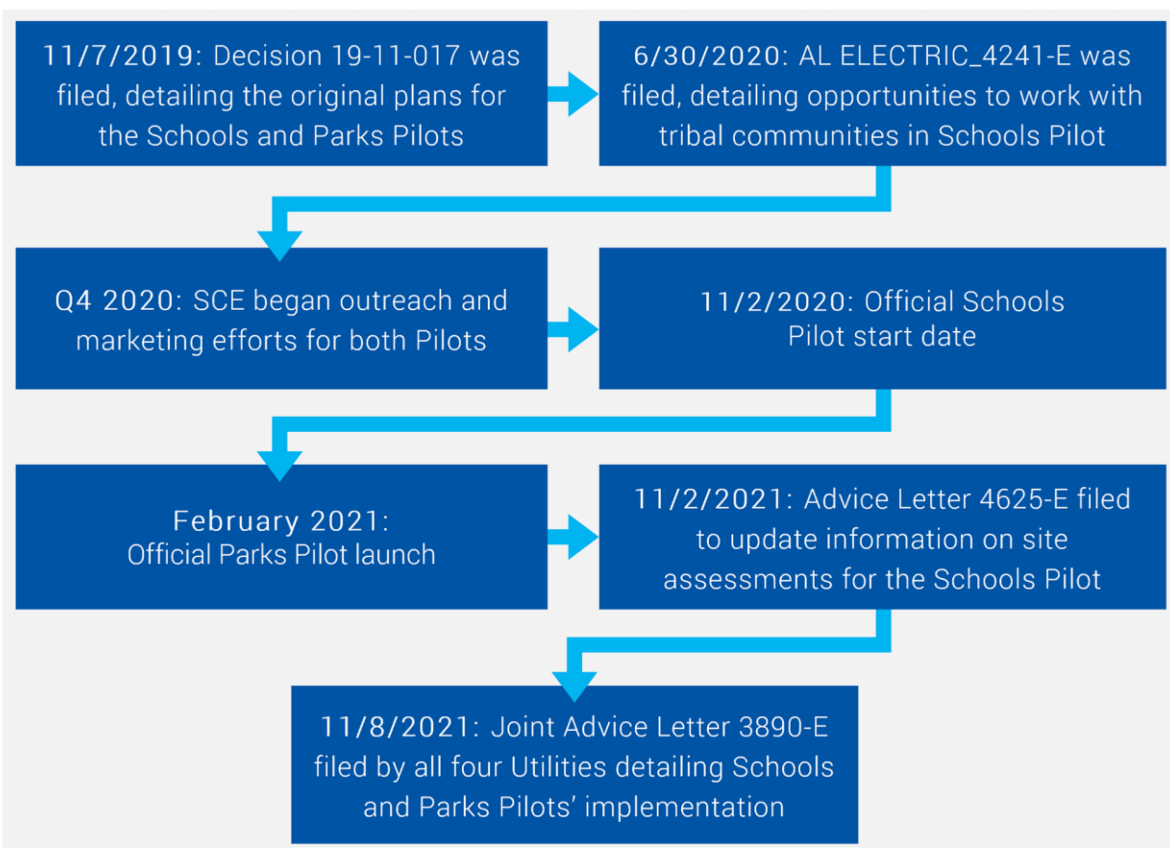
Figure 33. Budget Remaining versus Spending through 2021



Timeline

Since the inception of the Schools and Parks Pilots in 2018, there have been several milestones, as shown in Figure 34.

Figure 34. Key Schools Pilot and Parks Pilot Milestones



4.2.2. Findings

As discussed in the *Overview* section, neither the SCE Schools Pilot nor the Parks Pilot secured operational sites for EY2021.[54] As a result, the Cadmus team did not complete any visual site visits in 2021 and will complete the first round of impacts including incremental EV adoptions, petroleum displacement, GHG and criteria pollutant reductions, health impacts, and grid impact as part of the EY2022 analysis and reporting. This report provides limited insights based on analyses completed for 2021 including TCO contextual analysis, a Utility website review, and staff interviews. These findings are provided below.

Total Cost of Ownership

The Cadmus team analyzed key industry cost trends for public charging due to the limitations of the EY2021 cost data and to set the stage for EY2022 TCO analysis. This section provides context to the financial costs associated with installing EV infrastructure.

Infrastructure costs include BTM and TTM costs, as well as the cost for the charger and related materials. As shown in Table 55, these cost categories vary in the degree of variance, with BTM and TTM costs typically being the most significant cost driver and having the largest degree of variance on a per-site basis.

Table 55. Infrastructure Costs

Category	Degree of Cost Variance	Context and Rationale
Behind-the-Meter Costs	High	BTM includes site excavation for service line extensions to connect charging stations to the relevant meter. Costs may vary depending on lengths for trenching and cabling. BTM costs are also impacted by the cost of labor and any relevant supply chain and labor shortages. [a]
To-the-Meter Costs	High	TTM costs may vary depending on current capacity available for site hosts and, particularly, if a new transformer is required to supply power for EV charging. Costs may also vary depending on lengths for trenching and cabling. TTM costs are also impacted by the cost of labor and any relevant supply chain and labor shortages. [a]
Charger Costs	Moderate	Per-unit charger costs may decline with greater deployment of chargers per site. However, there are potential impacts from supply chain constraints and costs that may vary by charger power level. With current supply chain constraints, charger manufacturing costs may be affected, possibly increasing overall costs. [b]
Material Costs	Moderate	Material costs may include the cost of panels, meters, and the cabling required to connect the charger to the Utility distribution system. Similar to the cost of the charger, material costs are subject to supply chain constraints and may increase overall costs. [c]

[a] PG&E. February 2022. "Program Advisory Council Meeting Q4 2021." Presentation.

[b] California Energy Commission. Accessed March 2022. "CALeVIP DC Fast Chargers, Average Rebate, Unit Cost, and Total Project Cost per Charger." and California Energy Commission. Accessed March 2022. "CALeVIP Level 2, Average Rebate, Unit Cost, and Total Project Cost Per Connector Installed."

[c] PG&E. February 2022. "Program Advisory Council Meeting Q4 2021." Presentation.

54 As noted in the program overview section, one Schools Pilot site was active in 2021, but did not become fully operational for this evaluation year.

Significant TTM costs include transformer upgrades and costs related to upgrading and maintaining the distribution system.[55] Significant BTM costs can include trenching, site excavation for service line extensions, and cabling requirements to connect charging stations to the relevant meter. In the context of the Utility-sponsored public charging programs, Utility staff across programs noted higher-than-expected infrastructure costs, occurring both BTM and TTM. Specifically, Utility staff noted significant variable costs such as the need for transformer upgrades and longer-than-anticipated lengths for trenching, as well as for ensuring compliance with the ADA.[56]

Material costs for charging stations are rising at least in part to the ongoing COVID-19 pandemic and global disruptions on supply chains.[57] This increase was noted during a PAC meeting in which stakeholders mentioned that significant increases in material costs (such as copper wire and panels) are impacting contractors' ability to hold pricing past three to six months.[58] Related to material costs, the cost of the charger itself is subject to price volatility with global supply chain constraints disrupting manufacturing processes.[59] In addition, in California, the shortage in labor supply and high labor rates in the construction industry can create additional costs for EV charging deployment.[60] In addition, it can be difficult to quantify the supply chain impacts to material and labor costs, as revealing these costs may be detrimental to vendors' competitive advantage, allowing for competitors to adjust their prices accordingly.[61]

> Ongoing supply chain constraints and labor shortages will increase infrastructure costs.

In addition to infrastructure costs, the installation of EV chargers also includes a number of soft costs with a range of impact on the site development. Soft costs can also be difficult to quantify, as some cost categories may apply across a Utility program as opposed to a single site location. As shown in Table 56, potential site delays and opportunity costs have the largest degree of variability for soft costs related to EV charging deployment.

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55 PG&E. February 2022. "Program Advisory Council Meeting Q4 2021." Presentation.

56 PG&E. February 2022. "Program Advisory Council Meeting Q4 2021." Presentation.

57 White House (Helper, Susan, and Evan Soltas). June 2021. "Why the Pandemic has Disrupted Supply Chains."

58 SCE. March 18, 2022."SCE Transportation Electrification Program Advisory Council." Presentation.

59 Note: Because SCE bid out contracts early on in program EVSE costs were fixed.

60 Public Policy Institute of California (Johnson, Hans). March 2022. "Who's Leaving California-and Who's Moving In?"

61 Rocky Mountain Institute (Nelder, Chris, and Emily Rogers). 2019. "Reducing EV Charging Infrastructure Costs."

Table 56. Summary of Soft Costs

Category	Degree of Cost Variance	Rationale
Site Delays	High	Delays in building out EV charging are difficult to predict and the financial impact of such delays can be difficult to quantify. A delay may increase site costs as it may require extending the timeline for BTM and/or TTM construction and result in an increased labor cost. [a]
Opportunity Costs	High	Utilities implementing transportation electrification programs invest time to engage site hosts in the program process, conduct site visits, and so on. Utilities will need to coordinate with property owners and key decision-makers, and this coordination effort is specific to each site. There is a time cost associated with the uncertainty of the permitting process and delays, as well as multiple revisions and meeting schedules which can result in extending the timeline for approval across sites. For instance, Utility staff noted that certain site schedules have to adhere to school board or city council meeting timelines to receive the relevant approvals to move sites forward. [b] This time could be spent on other sites. Opportunity costs are critical to consider and difficult to quantify, particularly as costs may vary by site based on the level of complexity. [c]
Permitting	Moderate	Permitting costs can vary as unexpected permits from cities and/or counties have been required.
Site Design	Moderate	Sites may ask for multiple iterations to refine the site design, change the location of charging stations, and/or to change the number of ports. These adjustments may require additional site visits.
Taxes	Low	Taxes are a relatively fixed cost.
Operations and Maintenance	Low	Operations and maintenance costs occur on a routine basis and are relatively fixed to the type of charger installed.
Communication/ Networking	Low	Networking costs are built into the cost of installing the charging infrastructure and are billed on a fixed reoccurring basis.
Marketing and Customer Outreach Costs	Low	Marketing and outreach costs are considered in Utility cost methodologies. However, marketing costs are commonly applied across programs and may be difficult to link with a single site location. [d]

[a] PG&E. July 2021. "Program Advisory Council Meeting Q2 2021." Presentation.
[b] SCE. March 18, 2022. "SCE Transportation Electrification Program Advisory Council." Presentation.
[c] Rocky Mountain Institute (Nelder, Chris, and Emily Rogers). 2019. "Reducing EV Charging Infrastructure Costs."
[d] PG&E, SCE, and SDG&E. Report Filed on March 31, 2022. "Joint IOU Electric Vehicle Load Research and Charging Infrastructure Cost Report 10th."

Our research indicates that soft costs can contribute significantly to the overall cost of public charging stations, particularly for public DCFC sites, which have high levels of energy demand and can be more complex installations.[62] Soft costs are difficult to consider on a per-site basis. Utilities often quantify soft costs such as program management and ME&O on a program level, yet more fixed soft costs are quantifiable on a site level (such as site design costs, taxes, permitting, operations, maintenance, networking and communication costs).

However, complex sites will require a greater investment of time and resources, thus increasing the site-related soft costs. This level of complexity will depend on variable factors including the decision-makers

[62] Rocky Mountain Institute (Nelder, Chris, and Emily Rogers). 2019. "Reducing EV Charging Infrastructure Costs."

involved, the power level of the installed charging, the number of chargers per site, and any site delays. Related to this investment of time and resources, there is a high degree of variability in opportunity costs for Utilities engaged in transportation electrification programs. These technologies are relatively nascent and Utilities expend effort to engage site hosts, conduct site visits, and make adjustments to improve these programs. This time could be spent on other Utility activities.

EV charger site costs vary as the result of uncertainties in both infrastructure and soft costs. Additionally, an increase in soft costs can compound infrastructure costs.

Soft costs are interrelated to infrastructure costs. In the context of Utility-sponsored public charging programs, Utility staff have specifically noted that BTM labor costs can be complicated by site host BTM construction delays. Reasons for these delays can include RFP challenges, internal decision-making related to paying for BTM work, and lack of familiarity with BTM construction. These BTM delays are a common driver of overall site completion delays.[63] As sites are delayed, other costs may accumulate without the financial impacts being readily quantified. Current supply chain constraints may increase the costs of infrastructure while also increasing soft costs due to resulting delays.

Per-unit charger costs will likely decline with greater numbers of chargers per site. Unlike per-unit costs, total costs per charger may not decline with a greater number of chargers per site.

In addition to considering the EV infrastructure and soft costs discussed above, the team also examined a cost case study based on the California Electric Vehicle Infrastructure Project (CALeVIP). CALeVIP offers incentives to acquire and install EV charging infrastructure at publicly accessible sites throughout California. The 2021 CALeVIP data on L2 costs (Figure 35) and DCFC costs (Figure 36) showcases the decline in per-unit costs (shown in blue) and the variance in total per charger costs (shown in gray).[64] Based on CALeVIP data shown in Figure 35), L2 per-unit costs decrease in sites with a greater number of chargers per site. Similar to L2 data, DCFC per-unit costs decrease in sites with a greater number of chargers per site (Figure 36). However, for both DCFC and L2 charging, the soft costs and remaining infrastructure costs—beyond the charger itself—(shown as the *average additional costs* in the gray bars) do not reflect a direct relationship between the number of chargers per site and the total cost per charger per site.

63 PG&E. July 2021. “Program Advisory Council Meeting Q2 2021.” Presentation.

64 California Energy Commission. Accessed March 2022. “CALeVIP DC Fast Chargers, Average Rebate, Unit Cost, and Total Project Cost per Charger.” and California Energy Commission. Accessed March 2022. “CALeVIP Level 2, Average Rebate, Unit Cost, and Total Project Cost Per Connector Installed.”

Figure 35. CALeVIP Level 2 Charger Costs

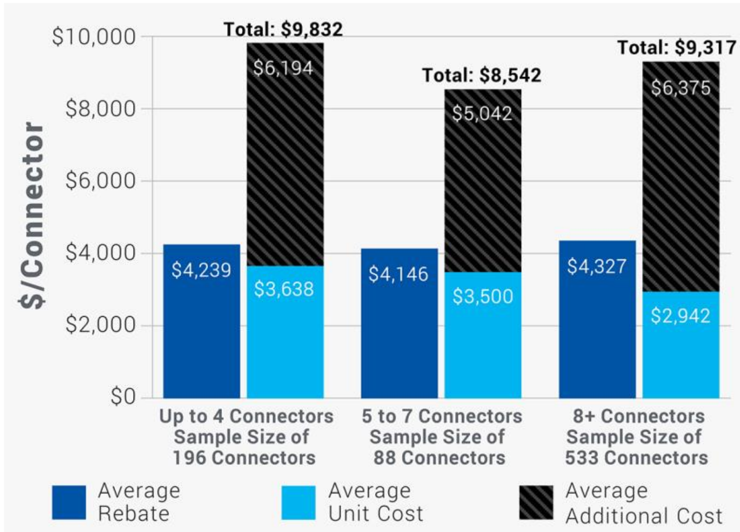
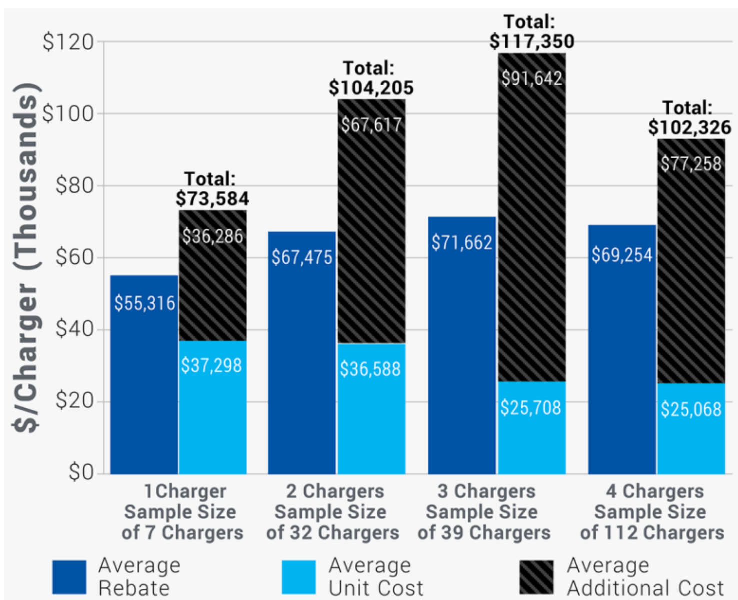


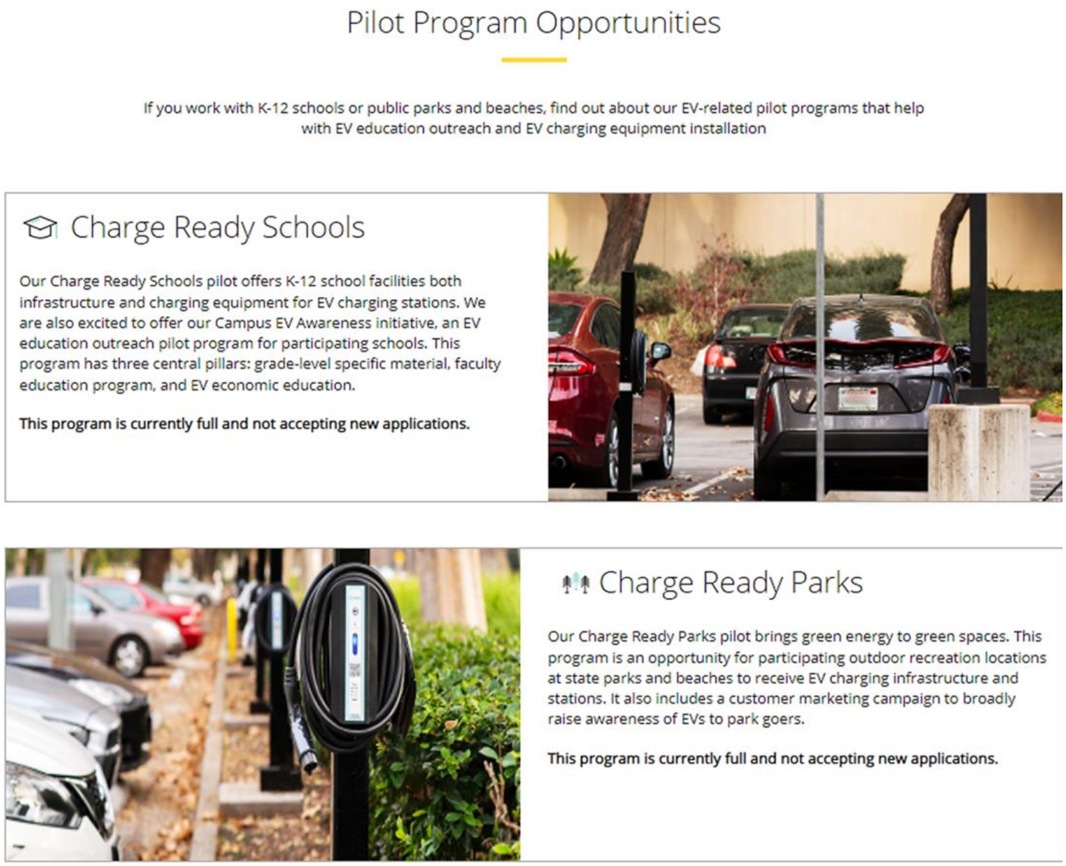
Figure 36. CALeVIP DCFC Costs



Utility Web Page Insights

The team conducted a high-level review of SCE's web page, "Pilot Program Opportunities," in April 2022 to identify what information was available regarding the Schools and Parks Pilots. Overall, the web page was clean, attractive, and easy to skim, though the page title was vague (even though the page only referenced the Schools Pilot and the Parks Pilot). At the time of the review, SCE considered both Pilots to be fully subscribed, and appropriately updated the page to clearly reflect the Pilots' status (Figure 37).

Figure 37. SCE Web Page Information for Schools and Parks Pilots



Utility Staff Insights

Over the course of EY2021, the Cadmus team interviewed SCE program staff for SCE's Schools and Parks Pilots twice (once in September 2021 and again in March 2022) in addition to monthly check-ins about the status of the Pilots and quarterly joint Utility calls regarding the Schools Pilot and the Parks Pilot. Through these conversations, SCE staff identified key insights from what they experienced in 2021.

Schools Pilot and Parks Pilot

Before rolling out the Pilots, SCE staff reported setting up procedures to coordinate with other internal departments within SCE. By leveraging the expertise of internal staff across several departments (the Transmission and Distribution Group, the Business Customer Division, and Marketing), staff were able to efficiently prepare for the roll out. For example, staff reported working to develop the necessary Pilot documentation (such as common agreement and easement language) as well activity portals to be customized to fit the Pilots' needs. Staff also recalled designing expected Pilot participation flows from the perspective of the customer and the steps they would need to take internally and with their contractors (such as EVSPs).[65]

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65 See the *Implementation* section above for further detail on the implementation process.

Staff reported that when completing preliminary work to identify prospective sites for both Pilots to target for enrollment, they focused on three main priorities for site selection: anticipated costs to install the chargers (which includes consideration of physical features of the sites), potential utilization, and DAC status. Staff reflected that completing preliminary work to identify these sites was successful, as they were able to target sites that were within DACs (14 of 29 sites).[66] Additionally, staff were able to move quickly onto another potential site if an eligible site host was not interested due to this preliminary site identification work. Though SCE only activated one site (for the Schools Pilot), by the end of EY2021 both Pilots were fully subscribed.

When moving forward with implementation, SCE staff reported that while interest was high, conflicting site host priorities made it difficult to move site hosts through the application process and into the construction phase. For example, at the time of the Schools Pilot roll out, schools were dealing with the impacts and uncertainty caused by COVID-19. Staff noted that the priority of ensuring school staff and student health and safety limited the schools' capacities to work with SCE on getting the EV charging infrastructure installed. To a certain extent, staff have had this same issue with the Parks Pilot, as State Parks Department staff also had competing priorities that took their attention away from the Pilots—including COVID-19 implications for parks and beaches.

Schools Pilot

SCE Pilot staff emphasized a key and unique barrier to participation for the Schools Pilot: the layers of approval that are required before a school can enroll in the Pilot. Though SCE staff noted that they typically first connect with a school staff member who works at the potential site, their contact may not have been the ultimate decision-maker. Staff found that even though the contact would pass on the agreement, easement, and other Pilot documents to the decision-makers, there are still additional layers of approval needed. For example, many school districts required board approval for sites of this scale. Another struggle SCE staff reported was figuring out the approval requirements for different district hosts, as not all schools have the same requirements. For example, some schools require specific personnel approval, and many require board approval, while others also require putting the site out for public comment. SCE staff expressed that due to these varying level of decision-making and approval, it is hard to estimate how long it might take to get a given site host through the application process. In addition to having to navigate the approval processes along these different steps, some schools would request changes to the proposal (such as different site locations, a different port count, or completely different school sites). These requests necessitated back-and-forth conversations between the potential site host and SCE, resulting in additional budget being spent on these sites.

Additionally, the lack of clarity around the layers of approval occasionally inhibits SCE staff from being able to help site hosts through their concerns about participating in the Pilot. For example, if agreement and easement language get rejected further up the approval process than SCE's primary contact at the potential site, SCE staff occasionally did not receive clear information as to why the decision-makers decided not to move forward with the program despite repeatedly asking for feedback. While staff

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66 Per Advice Letter 4635-E, filed November 8, 2021.

attempted to reach out and understand why initially interested sites ultimately decide to not participate, they were often met with vague details. For example, several sites simply told staff that the school board would not approve easement language but provided no further detail. In addition to increased back-and-forth burning Pilot budget, staff reported other reasons why the expected cost for each site was higher than anticipated. In particular, staff noted that opportunity costs had been trending significantly higher. Staff also reflected that construction labor and material costs had increased as inflation has been rising and COVID-19 has disrupted supply chains and the labor force. In addition, although permitting costs were expected, construction costs to meet ADA and safety requirements were unexpectedly high; for example, existing parking lots did not always provide easy access and accessibility without adversely impacting additional parking stalls. There were also delays in permitting processes SCE had not previously encountered, particularly when multiple Authority Having Jurisdictions (for example, Building & Safety, Electrical, and Fire Department Planning) must review and approve the permit.

As previously noted, staffing issues within the potential school site hosts were compounded by COVID-19. Direct outreach efforts (such as email or phone calls) to engage with key contacts were ineffective due to district officials and school administrators having overwhelming workloads as a result of COVID-19. Even when key contacts were engaged in the process, it still proved difficult to coordinate meetings with busy officials since they were overwhelmed.

Staff found that there was one primary challenge when working with K-12 schools specifically to install public charging infrastructure: many schools were concerned about student safety if chargers were always accessible to the public. Staff noted that initially interested schools with this concern ultimately opted out of enrollment, despite being allowed to make the final decision about whether sites were open to the general public. Finally, SCE staff noticed that most schools enrolling in the Pilot were opting for SCE-owned and operated EVSE due to the site host's inexperience with EVSE, EVSE installation, and managing such equipment. Staff reported that schools typically indicated that they were unable to bring on new staff with the necessary experience (often due to funding) or did not have the bandwidth to educate current staff. In response, SCE is requiring the EVSP to provide multiple training sessions to site host staff, both pre- and post-installation of charging stations, facilitated by SCE with the EVSP.

Parks Pilot

Though the Parks Pilot had limited activity through 2021, SCE staff's work on the Pilot still resulted in a few preliminary insights. Mainly, staff identified that the limitation of only being able to serve state parks may have contributed to delays in Pilot activity. For example, the design stipulation of serving only state parks and beaches limits SCE's ability to serve parks and beaches within DACs. Staff reported that due to these repeated delays, and in conjunction with the Parks Pilot managers at PG&E and SDG&E,[67] they have engaged the California Department of Parks and Recreation to determine participation agreement language. However, staff noted that, likely due to multiple staff changes at the California

67 Though Liberty is also implementing a Parks Pilot, the three major Utilities are leading the coordination with the California Department of Parks and Recreation.

Department of Parks and Recreation, SCE and their Utility colleagues have had trouble keeping the participation agreement moving through the Department approval process. When Department staff transitions occurred, SCE staff and their Utility colleagues often have to re-orient the new staff member on the purpose of the Pilot, all steps completed to date, and next steps needed.

4.2.3. Lessons Learned

The team identified a number of lessons learned from EY2021. These lessons, presented below with key supporting findings and recommendations, may be applied to future Pilot years and to other similar efforts.

Schools Pilot and Parks Pilot

Staffing constraints contributed to conflicting priorities from site hosts, which resulted in site delays or withdraws.

Participating in either the Schools or Parks Pilot requires the site host to make a commitment that often spans several months. Site hosts must not only be willing to install EVSE on their property, but—at a minimum—they must also work with SCE to coordinate site walks, approve site designs, and review and approve agreements, easements, and other critical documents. SCE staff experienced that many site hosts of both the Schools Pilot and the Parks Pilot had staffing constraints that either delayed or ultimately prevented participation.

In EY2021, SCE's Parks Pilot was most influenced by staff turnover at the California Department of Parks and Recreation. When Department staff transitions occur, Utility staff must often re-orient the new staff member to the purpose of the Parks Pilot, all the steps completed to date, and next steps.

The Schools Pilot was also influenced by staff constraints. While turnover was less of an issue with the Schools Pilot than with the Parks Pilot, SCE staff did notice that Schools Pilot site host staff were constrained by the available bandwidth of current staff, which was exasperated by COVID-19. Since the Pilot began, schools have been burdened with making ever-changing decisions regarding virtual versus on-site learning, mask mandates, and similar choices. SCE staff noted that the priority of ensuring school staff and student health and safety limited the schools' capacities to work with SCE on getting the EV charging infrastructure installed.

Highly prescriptive Pilot designs may be more susceptible to significant delays in achieving desired targets.

SCE's Schools and Parks Pilots have very specific, targeted market segments to serve. SCE's Schools Pilot must provide publicly available chargers to K–12 schools within its service territory. However, SCE staff encountered barriers that are unique to K–12 schools, such as safety concerns for underage students. The design of the Schools Pilot limits SCE's ability to address that barrier, and ultimately schools that were not comfortable with fully public chargers opted out of enrollment. Because there are only so many K–12 schools in its service territory, SCE staff may need to assess sites that were previously considered cost-prohibitive in order to fill in gaps and meet participation targets.

Additionally, the prescriptive language in the Parks Pilot mandating that SCE must work with state parks and beaches limited the extent to which SCE could engage with sites in its service territory. While SCE could scout potential sites or engage with regional managers, the decision to participate—and the language included in a participation agreement—must be approved by state-level offices. Given the delays that SCE experienced with the California Department of Parks and Recreation in EY2021, the Parks Pilot has been in a holding pattern, awaiting participation agreement approval.

The strong internal processes SCE developed prior to launching the Pilot were key to smooth internal implementation and coordination. Before rolling out the Pilots, SCE staff set up procedures to coordinate with other internal departments. By leveraging the expertise of internal staff across several departments, SCE was able to efficiently prepare for the Pilot roll out. For example, staff developed the necessary Pilot documentation (such as common agreement and easement language) and built out customized application and activity portals to fit the Pilots' needs. Having established these processes and pre-familiarized internal departments with the Schools and Parks Pilots, SCE can now easily leverage the expertise of these departments if Pilot issues arise.

Schools Pilot Only

K–12 schools experience unique barriers to installing public EVSE.

The intent of the Schools Pilot is to install publicly available chargers at K–12 schools to increase charging available to staff, students, parents, and the greater community. However, SCE staff reported that several of the schools they tried to recruit for the Pilot expressed concern about student safety if the chargers were accessible to the public 24/7. Despite having the final decision on whether to make chargers publicly accessible and the potential interest in installing EV charging infrastructure, those schools ultimately opted out of enrollment.

Additionally, staff found that public K–12 schools often need multiple layers of approval before signing an agreement and easement for sites like those designed under the Schools Pilot. Often, approval must come from the school board (which, in some cases, means the site may be open to scrutiny and public comment) or from specific personnel who may not work at the site. These multiple layers add complication and time to enrollment and implementation processes.

Initial contacts at interested Schools Pilot sites were not necessarily the ultimate decision-makers, which resulted in site delays and sometimes withdraws.

SCE staff tried to account for multiple layers of approval at the beginning of the Schools Pilot enrollment process by providing their primary site contact with example agreement and easement language to share with decision-makers. However, the lack of clarity around the layers of approval occasionally inhibited SCE staff from being able to help site hosts through the decision-makers' Pilot participation concerns. For example, if agreement and easement language got rejected by someone further up the approval process than SCE's primary site contact, SCE staff occasionally did not receive clear information as to why the decision-makers decided not to move forward with the Pilot, despite repeatedly asking for feedback. While SCE staff continued to engage with the primary contact to ask for more detail about the concerns that led them to elect out of Pilot participation, unclear higher-level concerns caused delays in the approval process and sometimes extended their expected timeline. In the worst cases, the primary site contact was unable to facilitate any sort of problem-solving and the site ultimately opted out of enrollment.

Unexpected market impacts, site design requirements, and permitting process requirements resulted in higher-than-expected site costs and limited participation.

SCE began the Schools Pilot during the COVID-19 pandemic. COVID-19 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 SCE had created for Decision 19-11-017 (which mandated the Schools Pilot at its determined funding level) did not reflect the actual costs for implementation. Though SCE staff conducted research ahead of Pilot design, these expenses were then compounded by inadvertent inaccuracies in Pilot design estimations. For example, while designing actual sites, more construction is needed than what was estimated to meet ADA permit requirements. Additionally, some sites needed permitting from Authority Having Jurisdictions that required approval from multiple departments, resulting in delays and additional project costs; in some cases, permit timeframes were simply longer than expected (such as for Division of the State Architect approval).

5. PG&E Transportation Electrification Programs

This section provides process and impact evaluation findings and lessons learned for PG&E's EV Fleet program, Schools and Parks Pilots, and the EV Fast Charge program.

5.1. EV Fleet Program

5.1.1. Overview

Per Decision 18-05-040, PG&E designed the EV Fleet program to provide infrastructure for fleet electrification. The program launched in June 2019 and encompasses incentives and rebates, site design and permitting, construction and activation, and maintenance and upgrades. The program goals are to assist fleets to install EV charging easily and cost-effectively, saving money, eliminating tailpipe emissions, and simplifying maintenance.[68] PG&E's EV Fleet has a budget of $236.3 million and a program-specific goal to support fleet electrification for 700 sites supporting 6,500 MDHD EVs that are procured or converted. As of the end of 2021, EV Fleet had signed contracts with 88 sites that can support 1,514 MDHD EVs, and had 28 activated sites that can support 301 MDHD EVs. These numbers exclude any contracts that were withdrawn or canceled as of December 31, 2021.[69] Through the EV Fleet program, PG&E will construct all to-the-meter (TTM) infrastructure and, depending on the cost-effectiveness of each site, will cover behind-the-meter (BTM) infrastructure. Otherwise, fleet operators will design, build, own, operate, and maintain BTM infrastructure. PG&E provides rebates for BTM infrastructure based on the vehicle types 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 Fortune 1000 companies.

EV Fleet Goal

Achieve minimum of 700 sites supporting 6,500 MDHD EVs.

To participate in the EV Fleet program, fleets must meet specific criteria. The 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 site looking to procure two or more MDHD vehicles. Additionally, fleets must own or lease the property on which the chargers are installed, must operate and maintain the infrastructure for 10 years, must provide data related to EV usage for five years, and must use EVSE vendors that meet 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 EV Fleet. The infrastructure budget is to be spent with a minimum of 15% for transit agencies, maximum of 10% for forklifts, and minimum of 25% on installations in DACs in PG&E's territory.

EV Fleet Update

1. Signed 88 contracts, supporting 1,454 MDHD EVs
2. 28 activated sites supporting 301 MDHD EVs (as of December 31, 2021)

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[68] PG&E. Accessed April 28, 2022. "EV Fleet Program."

[69] PG&E. "Program Advisory Council Meeting Q4 2021." PowerPoint presentation.

Implementation and Timeline

Customers participating in the EV Fleet program initially enter the Preliminary Design phase, which is estimated to take three to five months. In this initial phase, the customer submits an application through the online application portal and designs the BTM infrastructure, then PG&E provides the initial design and estimates for TTM infrastructure and the contract is signed. The second phase is the Final Design and Execution phase, which is estimated to take about 10 to 14 months. In this phase, the customer begins the BTM permitting process and PG&E finalizes the TTM design. If the customer opted to own and build the BTM, the customer then constructs the BTM infrastructure, PG&E constructs the TTM infrastructure, PG&E turns on service, the customer commissions the EVSE, then PG&E issues the relevant rebates.[70]

Site Summary

Participating sites in the PG&E EV Fleet program were reviewed and analyzed by program status. Table 57 provides the count of sites in the PG&E EV Fleet program by completion status.[71]

Table 57. EY2021 PG&E EV Fleet Complete Site Count By Status

Site Status	EY2021
Utility Construction Complete	28
Activated	28
Operational	26
Closed Out	23

ME&O Summary

The Cadmus team reviewed available program-related materials, such as program websites, marketing materials, Decisions, Advice Letters, and Program Advisory Committee (PAC) presentations. The program material review was important to establish a foundational understanding of the program design intent, to track changes in design over time, and to understand implementation progress. In the program materials review process for EV Fleet, the team assessed the level of accessibility for program web pages, presentation and navigation, overall layout and design, efficacy of the materials to establish trust and credibility, content clarity, how materials engaged eligible customers, and how the materials set program expectations and aided in decision-making.

Budget Summary

The CPUC Decision approving PG&E's EV Fleet program granted PG&E a budget of $236,324,661 and the right to recover program costs through rates that were in effect prior to the CPUC's evaluation of the

[70] PG&E. Accessed April 2022. "Take Charge: A Guidebook to Fleet Electrification and Infrastructure." p. 42.

[71] Note that these numbers are not additive; for example, by the end of 2021, 28 of the 28 completed sites in the program were activated, 26 of the 28 activated sites were operational, and 23 of the 26 operational sites were closed out.

program, provided the program met *per se reasonableness* requirements. PG&E also reports on these *per se reasonable measures* in Appendix B of its annual SB 350 report to the CPUC.

As of the end of Q4 2021, PG&E had spent roughly $25.4 million of its total program budget and had executed contracts with 88 make-ready installations (13% of *per se reasonable* installation goal) for 1,454 MDHD EVs (22% of *per se reasonable* vehicle goal). Based on these figures, PG&E has used roughly 10.7% of its total budget. While PG&E's program spending has been in accordance with the specific transit agency, forklift, and DAC budget requirements, high upfront costs resulted in the administration spending exceeding the required 10% of the infrastructure budget spent in EY2021. However, this does not mean that PG&E exceeded 10% of the total authorized administration budget. According to PG&E, administrative spending will decline as the Utility activates more make-ready sites, ultimately reducing this budget category below the 10% threshold.

PG&E released summarized costs data pertaining to 23 closed out (fully invoiced) sites within the EV Fleet program that support 235 MDHD EVs. Given the quantity of school bus sites (15), PG&E delineated site costs related to school buses from those derived from other market sectors.

Under the EV Fleet program, TTM costs comprised the majority of the known make-ready total, as the Utility specified no BTM costs and other costs were unreported.[72] Average TTM site trenching and excavation costs are higher for school bus sites than for the aggregate of other market sectors. Despite the higher construction costs for school bus sites in the EV Fleet program, these sites receive less in EVSE and customer-side infrastructure rebates on average than other types of sites.

The small number of fully invoiced sites located in a DAC, as shown in Table 58, limits the degree of analysis that could be conducted on the cost-related information required by SB 350.

[72] PG&E has not conducted BTM construction for any Utility construction complete EV Fleet program sites.

Table 58. PG&E EV Fleet Cost Summary

Cost Summary	School Bus	Other
Reporting date	December 31, 2021	
Utility program	PG&E EV Fleet	
Count of (fully invoiced) sites	15	8
Count of ports energized	101	58
Count of (fully invoiced) sites in DAC	3	6
Average site design cost	$13,165	$10,676
Average site permits cost	$112	$109
Average separate meter cost	$800	$1,011
Average cost for site trenching and excavation	$49,094	$30,361
Average make-ready cost of infrastructure on the Utility side of the meter (TTM)	$171,152	$135,113
Average make-ready cost of infrastructure on the customer side of the meter (BTM)	$0	$0
Average projected ongoing maintenance costs for infrastructure	$856	$676
Average rebate amount applied for EVSE [a]	$143,333	$156,875
Average rebate amount applied for customer-side infrastructure [b]	$36,359	$52,157
Average cost for site management and labor	$25,151	$18,957
Average cost of EVSE [c]	$0	$0

[a] This average includes the maximum planned EVSE rebates for sites that may not have yet applied for or been provided with a rebate.

[b] This average includes the maximum infrastructure rebate amounts for sites that may not have yet applied for or been provided with a rebate.

[c] PG&E does not incur the cost of the charger and instead offers EVSE rebates to customers that are schools or transit agencies or that reside in DAC and are not Fortune 1000.

Program Updates

On October 21, 2021, PG&E and SCE staff hosted a joint Program Advisory Council (PAC) meeting to review their proposal to file a Tier 3 Advice Letter, pursuant to Ordering Paragraph 2 of Decision 18-05-040. In this meeting, PG&E and SCE (the Joint Utilities) proposed several adjustments to program budgets and metrics used to determine *per se* reasonableness:

- **Extend the program through 2026.** The Joint Utilities noted that COVID-19 has contributed to business slowdowns, reduced capital and expenditures, delayed manufacturing, shifted site scopes, and slowed permitting review and issuance, resulting in slower uptick in the early years of both programs. A two-year extension would allow for the programs to support MDHD electrification as the market evolves. In these two years, PG&E and SCE noted that more vehicles will become available, upfront costs will continue to decline, and both programs will be able to support fleet customers as they develop and implement their electrification plans.
- **Emphasize and prioritize program vehicle goals.** The Joint Utilities suggested focusing on supporting increased EV adoption versus balancing site and vehicle goals. They note that there is a trade-off when balancing site and vehicle goals while remaining within their approved budgets. Sites that support a greater number of vehicles tend to be more cost-effective on a per-vehicle basis; however, the programs are currently significantly limited in the number of large sites they can support without compromising their site goals. Sites with fewer vehicles

tend to be more costly on a per-vehicle basis, and supporting a greater number of sites with lower vehicle counts, while aiming to remain within budget, places the vehicle goal at risk.

- **Adjust infrastructure budget category requirements to support customer, versus technology or vehicle type, electrification readiness.** The Joint Utilities initially suggested this adjustment to build more flexibility into the infrastructure budget category requirements specifically for transit agencies. This proposal has since been removed from the Joint Utilities' Advice Letter.[73]

Following their joint-PAC presentation, PG&E and SCE reviewed and incorporated stakeholder feedback into their proposals through December 2021 in preparation to file their formal proposal in 2022.

5.1.2. Findings

This section provides evaluation findings for PG&E's EV Fleet program. Table 59 summarizes key impact parameters for EY2021 and Table 60 provides key impacts by market segment.

Table 59. PG&E EV Fleet EY2021 Impacts Summary

Impact Parameter	Annual Estimate [a]	Percentage in DAC
Population of Activated Sites (#)	28	39%
Sites included in analysis (#) [b]	24	42%
Charging Ports Installed (#)	197	57%
Electric Vehicles Supported (#) [c]	265	55%
Electric Energy Consumption (MWh)	2,806.68	65%
Petroleum Displacement (DGE)	306,260	73%
GHG Emission Reduction (MT GHG) [d]	2,655	75%
NO_x Reduction (kg)	1,625	66%
PM_{10} Reduction (kg)	32.9	95%
$PM_{2.5}$ Reduction (kg)	29.5	95%
ROG Reduction (kg)	236.0	97%
CO Reduction (kg)	12,946	97%

[a] Energy consumption, petroleum displacement, emission reductions, and health benefits are based on annualized data.
[b] The number of sites included in analysis differs from the population of activated sites because some sites were only activated for a short period during 2021 (such as one or two months).
[c] The team derived the EVs supported value from applicants' vehicle acquisition plans. This value represents the maximum number of vehicles expected to be supported by the charging infrastructure.
[d] GHGs include CO_2, CH_4, and N_2O multiplied by their respective GWP as defined by IPCC AR5 (see the Methodology section for more details).

[73] PG&E and SCE. October 2021. "SB 350 Tier 3 Advice Letter Overview." Presentation.

Table 60. PG&E EV Fleet EY2021 Impact Estimates by Market Segment

Impact Parameter	Market Segment		
	School Bus	Transit Bus, Heavy-Duty Vehicles, Medium-Duty Vehicles, Forklifts	Total
Population of Activated Sites (#)	19	9	**28**
Sites included in analysis (#) [a]	17	7	**24**
Ports Installed (#)	141	56	**197**
Electric Vehicles Supported (#) [b]	189	76	**265**
Annual Electric Energy Consumption, MWh	1,340.6	1,466.1	**2,806.7**
Total Peak Demand, MW	0.73	-	**-**
Petroleum Displacement, DGE	113,886	192,374	**306,260**
GHG Reductions (MT) [c]	905	1,750	**2,655**
NO_x Reductions (kg)	812	813	**1,625**
PM_{10} Reduction (kg)	2.26	30.64	**32.9**
$PM_{2.5}$ Reductions (kg)	2.17	27.30	**29.5**
ROG Reduction (kg)	10.14	225.81	**236**
CO Reduction (kg)	401	12,544	**12,946**

Note: Energy consumption, petroleum displacement, emission reductions, and health benefits are based on annualized data.
[a] The number of sites included in analysis differs from the population of activated sites because some sites were only activated for a short period during 2021 (such as one or two months).
[b] The team derived the EVs supported value from applicants' vehicle acquisition plans. 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 the Methodology section for more details).

Program Performance Metrics

As of December 31, 2021, PG&E's EV Fleet program had received 201 applications, signed contracts with 88 of these sites that can support almost 1,500 MDHD EVs, and activated 28 sites to support 301 MDHD EVs. As Table 61 displays, the EV Fleet program has 39% or 11 of its 28 activated sites located in DACs.

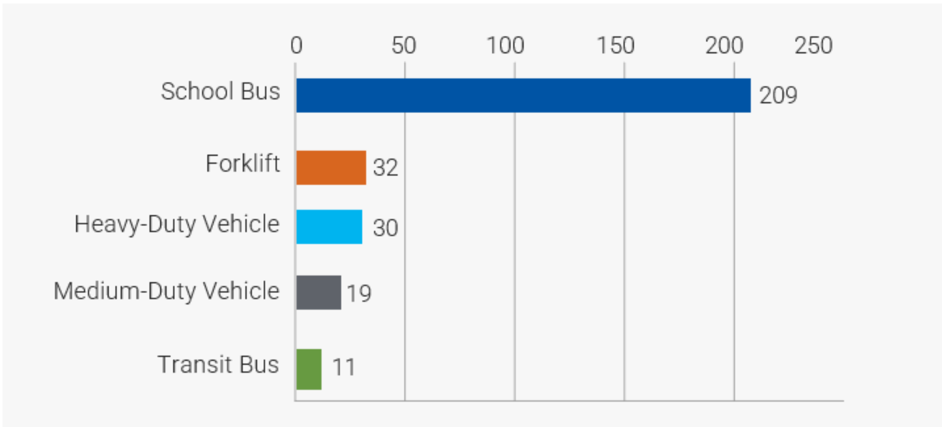
Table 61. PG&E EV Fleet Active Site Summary by Market Segment

Market Sector	Number of Activated Sites in DAC	Number of Activated Sites in Non-DAC
Heavy-Duty Vehicle	1	0
Forklift	2	1
Medium-Duty Vehicle	2	1
School Bus	5	14
Transit Bus	1	1
Total	**11**	**17**

PG&E's EV Fleet program had the most participation from school bus fleets, which comprised over two-thirds (68%) of activated sites. Forklift and medium-duty vehicle sites are the next most common market segment, each representing 11% of the EV Fleet program's activated sites. The transit bus market segments had two activated sites, while the heavy-duty vehicle market segment had only one activated site as of the end of December 31, 2021.

As shown in Figure 38, the EV Fleet program currently supports 301 MDHD EVs across five different market segments. Mirroring the composition of activated sites, school buses represent the majority (69%) of all MDHD vehicles electrified within the program. The next most commonly electrified MDHD vehicles are forklifts (11%) and heavy-duty vehicles (10%), followed by medium-duty vehicles (6.0%) and transit buses (3.5%).

Figure 38. EV Fleet Program's Number of Vehicles Supported by Market Segment



The CPUC established six phases in program timelines per the SB 350 reporting template. As shown in Table 62, the EV Fleet program had issued and signed contracts with 88 applicants, representing 13% of the program's *per se reasonableness* installation goal of 700 sites. The associated quantity of MDHD EVs, 1,500, comprises over 23% of the program's *per se reasonableness* goal of 6,500 vehicles electrified.

Table 62. EV Fleet Sites and Vehicles by Program Phase

Program Phase	Number of Sites	Total Number of EVs Supported [a]
Applications Received [b]	**201**	**-**
Application Reviewal	-	-
Site Assessment	-	-
Contract Issuance [c]	88	1,500
Design and Permitting	62	737
Construction Complete	28	322
Activation	28	301

[a] Vehicle counts derived from applications' vehicle acquisition plans. Totals include applications without vehicles' market sector(s) specified.

[b] This includes applications that were rejected, cancelled, or put on hold.

[c] Viable contracts exclude contracts that were rejected or withdrawn.

Table 63 displays the median durations per program phase (measured in calendar days) based on the experience of the 28 activated sites. The first and last stages of the program, application reviewal and activation, typically take applicants the shortest time to complete. The fourth and fifth program phases take the longest time to complete, with median durations exceeding 100 calendar days. Note that these median durations vary by market sector. For instance, heavy-duty vehicle applications in the application reviewal phase took a median of 93 calendar days to complete. Similarly, customer applications in medium-duty vehicle market segment experienced significantly greater times in the contract issuance phase compared to the overall median duration, with a median of 166 calendar days in the third program phase.

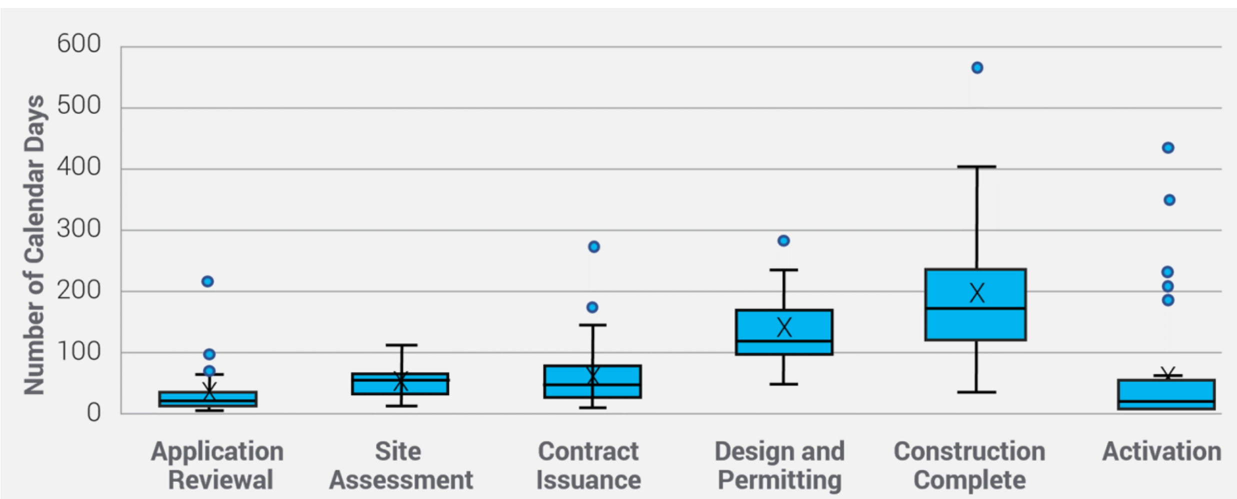
Table 63. Median Calendar Days Per Phase for PG&E's EV Fleet Program

Program Phase	Calendar Days (Median)
Application Reviewal	19
Site Assessment	51
Contract Issuance	42
Design and Permitting	116
Construction Complete	169
Activation	16

Note: This table only includes data for activated sites.

Figure 39 broadens the discussion of program phase completion to display the average calendar days (denoted by X), as well as 1st quartile (bottom of square), 3rd quartile (top of square), minimum (bottom tail), maximum (top tail), and outliers (dots). The distribution of calendar days per phase appears positively (right) skewed across program phases, which is evident by the average calendar days per phase exceeding the median number of calendar days per phase. This trend likely derives from the high quantity of severe outliers, meaning that several sites take an abnormally long time to complete a given program phase. Based on Figure 39, program customer applications can expect wider variances in the amount of time taken to complete the contract issuance, design and permitting, and construction complete stages.

Figure 39. PG&E EV Fleet Summary of Calendar Days per Phase



Note: This data only represents activated sites.

By the end of 2021, PG&E's EV Fleet program had processed customer applications from start-to-finish for five market sectors. Table 64 summarizes the number of calendar days taken from application reviewal to activation for the 28 sites activated by December 31, 2021. Heavy-duty vehicles customer applications experience the shortest median start-to-finish site activation, followed by forklift and transit bus customer applications. The median start-to-finish durations for customer applications in the school bus market segment exceeded 500 calendar days, while site activation took the longest for medium-duty vehicle applications, whose median start-to-finish activation exceeded 600 calendar days.

Table 64. EV Fleet Median Duration for Site Activation, by Market Segment

Market Sector	Median Duration Start-to-Finish Site Activation (Calendar Days)	Number of Activated Sites
Heavy-Duty Vehicle	364	1
Forklift	405	3
Transit Bus	409	2
School Bus	507	19
Medium-Duty Vehicle	615	3

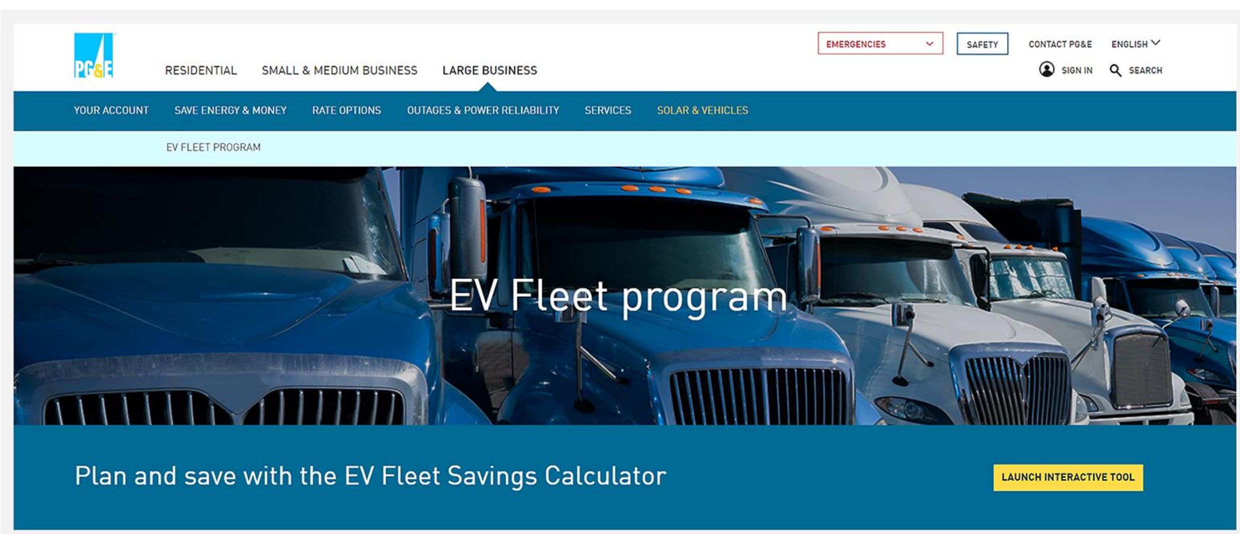
Program Materials Review

The program materials review was important to establish foundational insight into program design intent, changes, and implementation progress. Because the broad accessibility of program web pages makes them a core element of customer-facing communications and their non-static nature enables them to reflect current phases of the implementation process, we find them to be an insightful element within the materials review.

PG&E MDHD Program Web Page Assessment Findings

In April 2022, the Cadmus team reviewed PG&E's program web page "PG&E fleet program for electric vehicles" (shown in Figure 40), subpages ("EV fleet program for distribution & delivery fleets," "EV fleet program for shuttle bus fleets," "EV Fleet program for public school fleets," and "EV Fleet program for public transit fleets"), and the online interest submission form.

Figure 40. Screenshot of PG&E's Fleet Program for Electric Vehicles Web Page



The team used an assessment template that grouped assessment criteria into seven areas. The first four areas addressed navigation, design, credibility, and content clarity. The last three areas guided our review of how the pages supported the primary page objectives. Based on the current implementation stage and web page content, we determined that these pages' objective criteria were to drive qualified program leads, set program expectations, and aid in decision-making about fleet electrification.

Navigation and Information Architecture

PG&E's EV Fleet program web pages have a clear and intuitive structure that makes them easy to navigate. The most sought-after information is identified in navigation tabs at the top of the main program page (shown in Figure 41) and navigation labels are accurate, succinct, and descriptive. Pages load quickly and site searches return relevant program pages.

Figure 41. Navigation Tabs at Top of PG&E's Main EV Fleet Program Page

A potential detractor from a positive user experience is that the navigation tabs are not distinct pages, nor do they have anchors within their URLs to enable viewers to use forward and back browser navigation to move between tabs. If a user clicks a link that leads to a different page, then clicks back, they always return to the first tab.

Layout and Design

The pages have an attractive, easy-to-digest layout and design. The page structure is consistent from page to page; the content balances text, images, and whitespace; and images and icons support the text they accompany. The site is responsive to screen size, maintaining functionality and legibility when viewed on a mobile device.

All the program pages have a clear title; however, when pages initially load, the first element that shows under the page title is a button that leads to the EV Fleet Savings Calculator, which could distract and lead users away from learning about the EV Fleet program.

Trust and Credibility

The program pages come across as a trustworthy and credible source of information. They are hosted within the core PG&E website, www.pge.com, use the same template and branding as the rest of the Utility site, and provide relevant information that is free of typographical or other surface-level errors.

Content Clarity

PG&E's EV Fleet program web pages provide clear and concise information. The text is brief and to-the-point and uses tables and lists in place of paragraphs, where applicable. Titles and subtitles effectively introduce page sections, visual elements complement rather than duplicate text, and information is not repeated within the same page.

Drive Qualified Leads

The EV Fleet program web pages prompt users to submit an interest form in multiple places; however, most of these call-to-action prompts are at the bottom of the page. Moving or adding an "submit an interest form" button to the top of the page could help drive additional submissions. The interest form itself is brief and easy to complete, increasing the likelihood that eligible users will complete and submit the form once they reach that page.

Set Program Expectations

The program pages provide high-level information about what to expect but lack detail about steps to participate and how the program staff support participants throughout the life cycle of a site. Some of this information is available within program guides and factsheets in PDF format or recorded webinars hosted on the website, but information in these formats can be more challenging to find and access than web page content. Adding web page content with clearly listed steps to participate, an example site timeline, and additional information about support services provided by the program staff could help set clearer program expectations.

Aid Decision-Making

The web pages offer information about the benefits of electrifying vehicle fleets and provide tools to help fleet owners and operators understand what electrification might mean to them. Tools include fuel savings and total cost of ownership (TCO) calculators, fact sheets and case studies tailored to different types of fleets, an approved vendor list, information about rate options, and guidebooks and recorded webinars with additional information. Many of these resources are provided as PDFs, which may not be as easy to access, especially from a mobile device. Some of the most sought-after information to aid decision making, such as steps involved in converting a fleet to electric, could be helpful page content.

Utility Staff Insights

Through speaking with PG&E program staff, the Cadmus team sought to better understand the program's design and operations, barriers to transportation electrification, and ways that PG&E planned to overcome those barriers.

PG&E program staff identified several customer-focused barriers to increased transportation electrification. One of the more significant barriers for customers was difficulty understanding the streams of costs and incentives over time and how they contribute to a project's financial viability. To address this, program staff developed the EV Fleet Savings Calculator, a tool to help potential partners understand the financial implications, costs, and benefits of electrification.[74] Another barrier was that many of customers had trouble navigating the installation process for BTM infrastructure. This identified barrier was especially true for schools, who had little experience with RFPs and other procedural steps involved in the installation of BTM infrastructure. Program staff sought to support customers in these situations by providing more guidance to facilitate the BTM process. PG&E also implemented a process

[74] This tool is available in the "Program Overview" section on the program website: https://www.pge.com/en_US/large-business/solar-and-vehicles/clean-vehicles/ev-fleet-program/ev-fleet-program.page

that requires sites to conduct some BTM work before PG&E completes its work on the site, to ensure that site hosts follow through with construction of BTM infrastructure. Additionally, PG&E program staff included a claw-back clause in contracts, allowing them to recoup funds spent on sites that are not completed due to the customers' inability to move the site forward.

To streamline and improve the onboarding process, PG&E program staff switched to having customers work with an onboarding specialist, then with a site manager. Previously, they had a construction site manager involved with onboarding. Also, based on their experience with recruiting site partners, program staff determined that they needed to take a sales pitch approach to attract sites, rather than the original equipment manufacturer recruitment strategy they had initially planned.

PG&E program staff believed the program's guidelines around site approval and the numerical site goals were hindering program progress because sites with more EVs (and their associated chargers) have better economies of scale than sites with few EVs. They reported that with additional flexibility around site guidelines and goals, program staff could exceed the vehicle goals. As of the time of the interview, PG&E had 1,500 vehicles out of the target of 6,500, but only 83 sites out of the target of 700. For PG&E program staff, the most significant costs had been trenching, transformers, and other upstream costs such as the interrupter and the junction box. Trenching, transformers, and upstream costs also contributed significantly to cost variations, and they were some of the largest costs to the Utility.

PG&E program staff said the vehicles and segments with the most potential for electrification were school buses and forklifts. They indicated that trucking was further behind because of the complexities involved in determining how to sufficiently electrify truck stops. There were also very few EV models for agricultural use, preventing electrification in the agricultural sector in the near future.

Survey Results

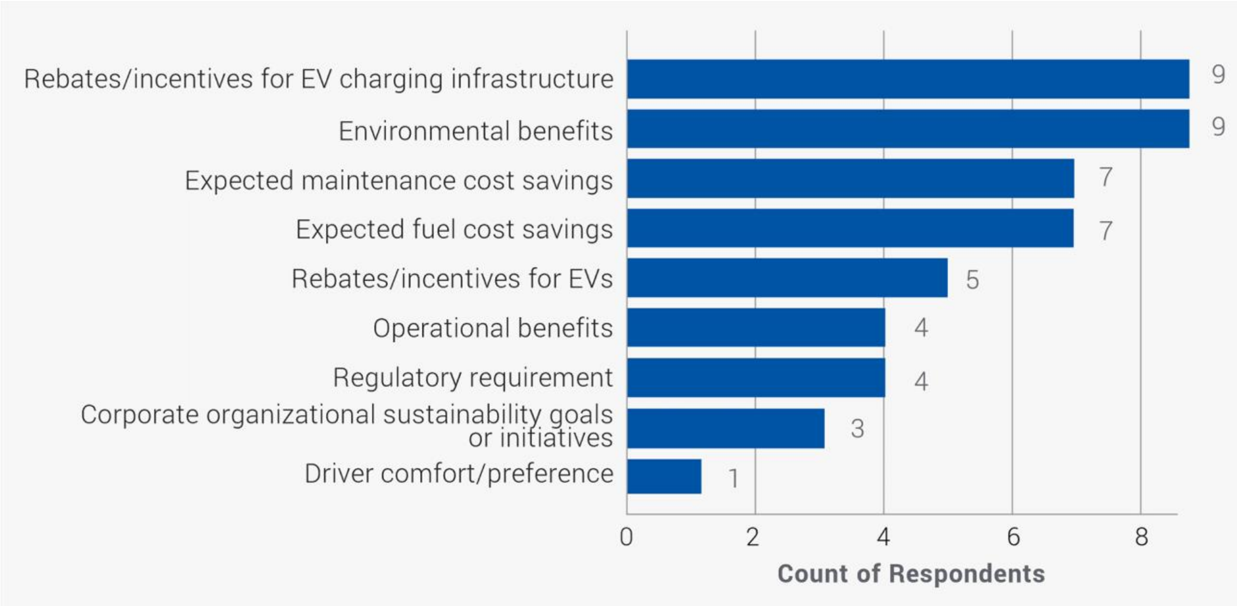
The Cadmus team surveyed 13 fleet managers[75] who participated in PG&E's EV Fleet program (known as program participants) about their motivations for and barriers to electrification, satisfaction and experience with the program, experience with EVs and charging infrastructure, the impact of the program on fleet electrification, and their perspective on the industry.

Electrification Motivators and Barriers

The Cadmus team asked PG&E program participants about their decision to transition to EVs. The top three motivators were the rebates/incentives for EV charging infrastructure (nine mentions), environmental benefits (nine mentions), and expected maintenance and fuel cost savings (seven mentions each; Figure 42). The fact that these four reasons are distinct shows that there is not one single motivator for fleet electrification.

[75] In some cases, the number of responses to a question is greater or less than 13. 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.

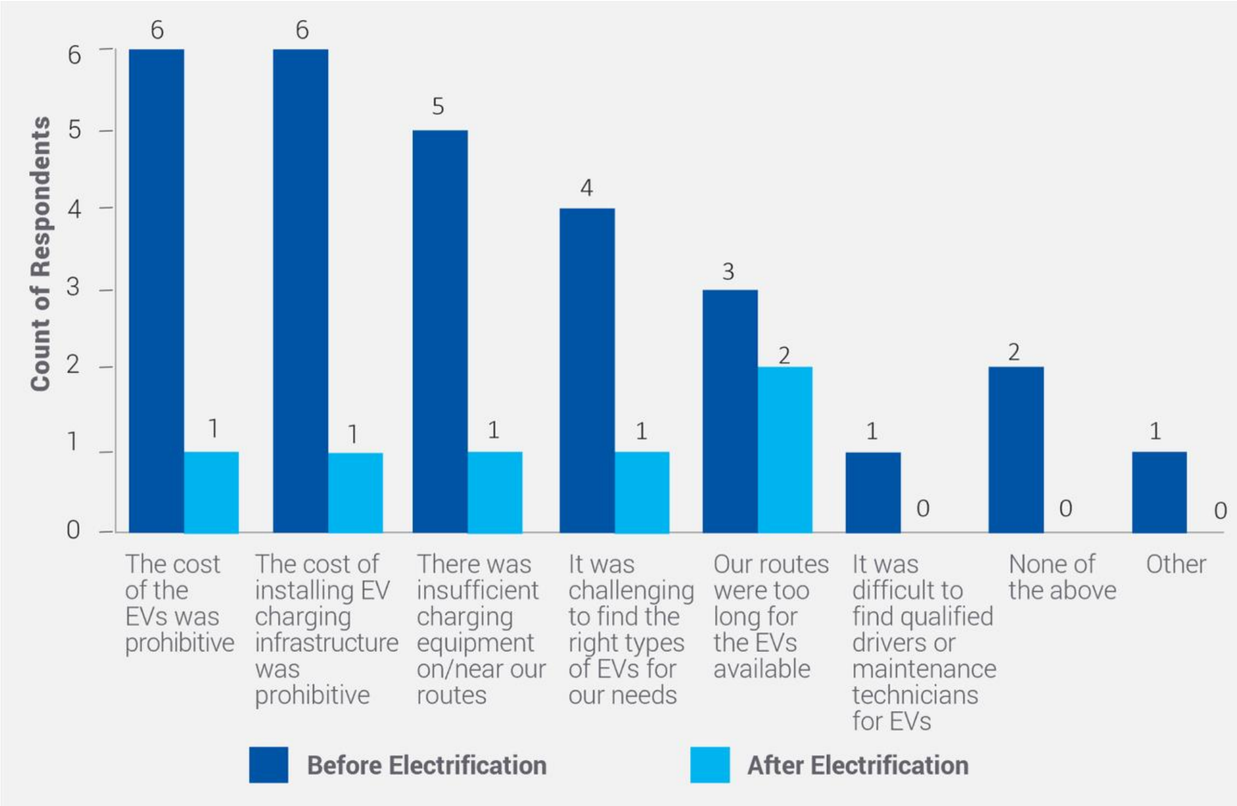
Figure 42. Motivators for Electrification among Program Participants



Source: Fleet Manager Survey Question C1. "Why did your fleet decide to transition to EVs? Select all that apply." (n=13, multiple responses accepted)

Prior to participating in the EV Fleet program, participants said that the cost of EVs (six mentions), the cost installing EV charging infrastructure (six mentions), and insufficient charging equipment along routes (five mentions) were the biggest barriers to electrification. Only six program participants indicated that barriers still existed after participating in the program, as shown in Figure 43. The most prevalent remaining barrier was the length of routes, which remained a barrier for two program participants. These results show that major barriers to electrification such as costs and availability of equipment along routes were significantly reduced for participants after their experience in the EV Fleet program.

Figure 43. Barriers to Electrification among Program Participants



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=13) 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=11)

Program Satisfaction and Desired Changes

When asked about how likely participants were to recommend EV Fleet to another company, all program participants said they already have or were extremely likely to recommend the program, resulting in a net promoter score of +100 (the highest possible value).

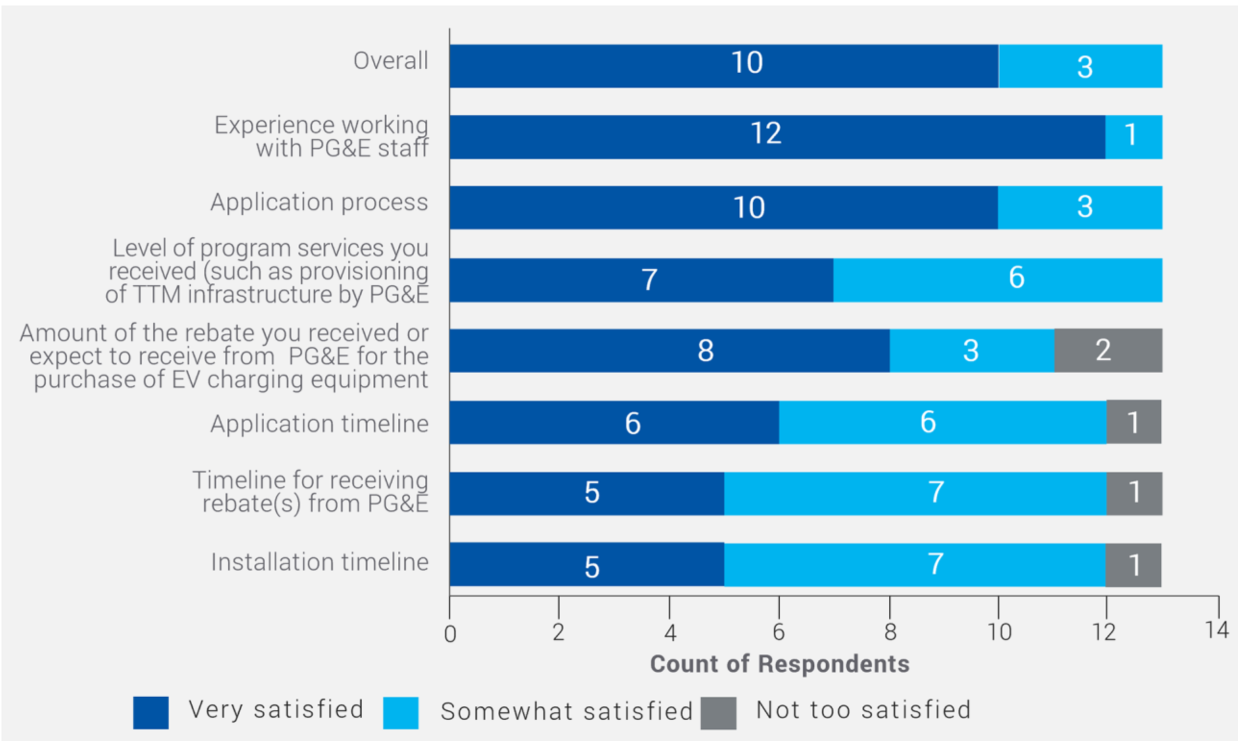
Figure 44 shows satisfaction with the EV Fleet program. Overall, PG&E participants were highly satisfied with their experience, with all program participants rating themselves as *very satisfied* (10 respondents) or *somewhat satisfied* (three respondents). Participants were most satisfied with working with PG&E staff and the application process. Other aspects of high participants satisfaction were the site manager, cleanliness, staff flexibility, and engineering coordination. Some included additional comments about their positive experience and high regard for PG&E staff:

- "The PG&E employees are always courteous and helpful when I need assistance."
- "Support was wonderful, very informational."
- "PG&E staff were very easy to work with, informative, and cooperative. Overall, the entire process went well."

Elements that received the lowest satisfaction ratings were the installation timeline, timeline to receive rebates, and application timeline. While 10 of 13 program participants were satisfied with the rebate amount received, two participants rated themselves as *not too satisfied*. Some participants provided additional comments about their dissatisfaction:

- "The final contract was frustrating as we followed PG&E directions throughout the process, and we were not able to add two additional buses because the 'project took too long.'"
- "The new chargers were given the minimum amount of power from the newly installed transformer so we will have to upgrade [the] transformer in order to add more power to service more buses."

Figure 44. Satisfaction with Program Elements



Source: Fleet Manager Survey Question B1. "Thinking about your experience with the EV Fleet program, how satisfied are you with the following?" (n=13)
Note: No respondents provided a rating of *not at all satisfied* for any element.

The Cadmus team asked program participants about what they would have done differently if they were to go through fleet electrification again. Four program participants had issues with charging: these fleet managers would have found a better charging solution, made sure the power source and chargers were more powerful than what was required, had a larger power supply brought in, and considered solar panels with storage batteries to supplement high demand during peak times to reduce costs and grid impacts. Other changes program participants would have made include putting in a bigger service for expansion and managing expectations regarding the installation timeline.

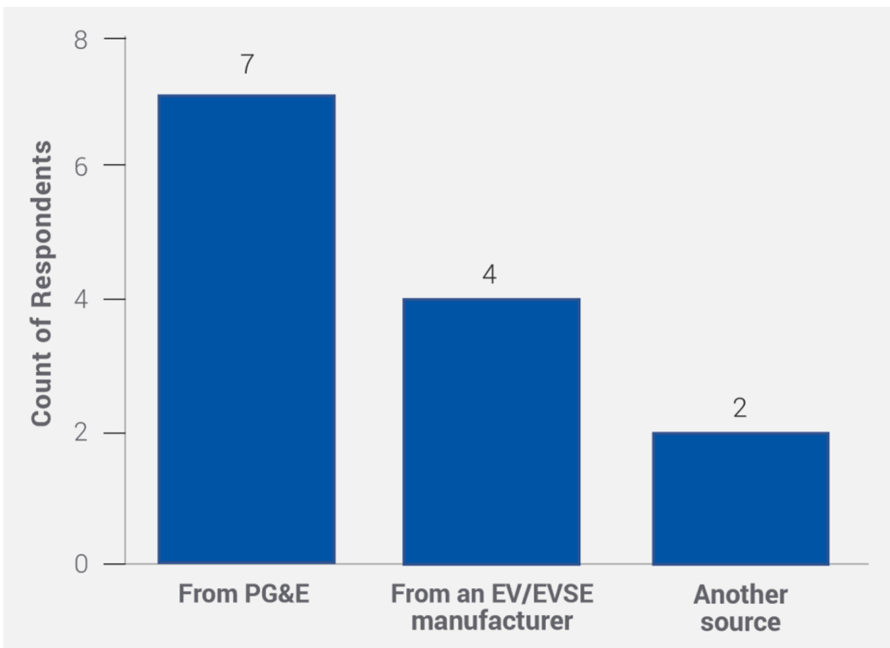
Some participants provided additional comments and changes:

- "I would [have] had all parties check that the amp gear box installed matched the plans. They did not and the wrong amps were installed. I will not have enough amps to charge all 12 buses in the future."
- "The grant process was done piecemeal. There were years where we were awarded one bus, another two, etc... it was difficult to plan the entire project and costs."

Program Experience

The Cadmus team asked program participants how they first learned about the EV Fleet program. Seven of 13 participants learned about the program directly from PG&E and four learned about the program from an EV/EVSE manufacturer. Figure 45 shows the importance of indirect sources such as EV/EVSE manufacturers and others in spreading awareness of the program.

Figure 45. Awareness of EV Fleet Program



Source: Fleet Manager Survey Question C2. "How did you first learn about the EV Fleet program? If there were multiple sources, please select the primary source." (n=13)
Note: "Another source" responses includes "Bus Sales" and "Past Director."

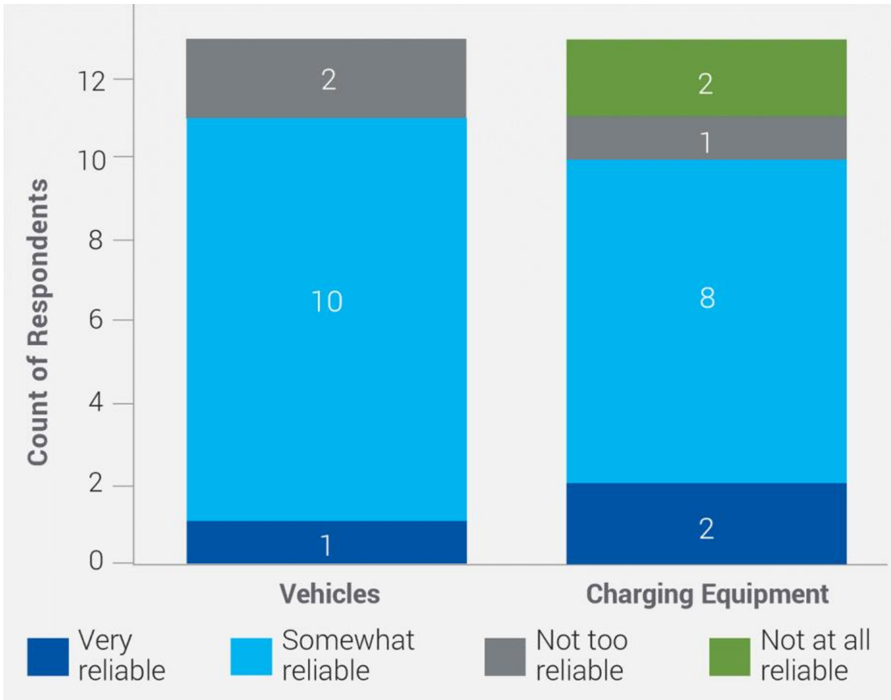
When asked whether they knew if upgrades to the electrical infrastructure were needed to charge EVs prior to joining the program, nine of 13 participants said they were aware, indicating that most participants working for a company that owns the EV charging infrastructure on the site have knowledge of upgrade requirements prior to participation.

Experience with EVs and Charging Infrastructure

The Cadmus team asked program participants about the reliability of the EVs and charging equipment in their fleet: 11 of 13 respondents said the EVs are reliable. Overall, EV charging equipment received positive reliability ratings (from 10 of 13 program participants), as shown in Figure 46. Two participants rated the charging equipment as *not at all reliable*, while two others rated it as *very reliable*, which indicates inconsistent experiences with the equipment.

Three program participants experienced some challenges with EV charging equipment due to regular failures. One of these participants believed chargers were not sized properly for school buses and failures were due to the limited amps provided.

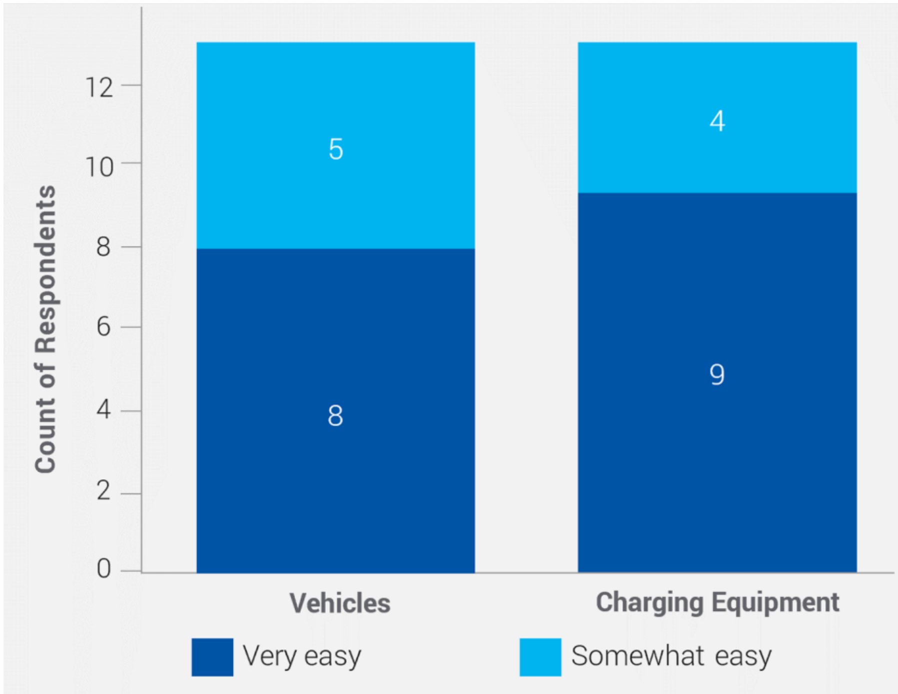
Figure 46. Reliability of Vehicles and Charging Equipment



Source: Fleet Manager Survey Questions C3 and C5. "How would you rate the reliability of the electric vehicles that are part of your fleet?" (n=13) and "How would you rate the reliability of the electric vehicle charging equipment?" (n=13)

As shown in Figure 47, all 13 participants found it easy for their drivers to operate EVs and use charging equipment. Eight rated operating EVs as *very easy* and nine rated using the charging equipment as *very easy*.

Figure 47. Ease of Operating Vehicles and Charging Equipment



Source: Fleet Manager Survey Questions C4 and C7. "How would you rate the ease with which your drivers operate the electric vehicles?" (n=13) and "How would you rate the ease with using the electric vehicle charging equipment?" (n=13)

Impact of Program on Fleet Electrification

The Cadmus team asked program participants about their plans to accelerate their procurement of EVs and related equipment because of their experience with the program. Of 13 participants, 10 had no plans to further accelerate procurement in the future, suggesting that the EV Fleet program participation did not influence ongoing procurement changes. One participant planned to slow procurement and one planned to accelerate procurement but did not provide specific aspects of the program that impacted that decision.

While most participants did not plan to accelerate EV procurement because of their experience with the program, participants still planned to acquire more EVs. Ten program participants said they had electrification plans for the next 10 years. School buses were the most mentioned vehicle type, with six different participants planning to secure 30 total vehicles. Another participant plans to acquire 500 port cargo trucks. Other types of vehicles/equipment mentioned that were part of electrification plans were lawn moving equipment, loaders, warehouse delivery vehicles, food service delivery trucks, yard tractors, gantry cranes, and top loaders. One participant mentioned plans to acquire four additional transit buses. Nine of 13 program participants said that participating in the EV Fleet program changed the number of EVs that they acquired or planned to acquire in the future. Of these participants, funding through the program was the top reason behind electrification plans.

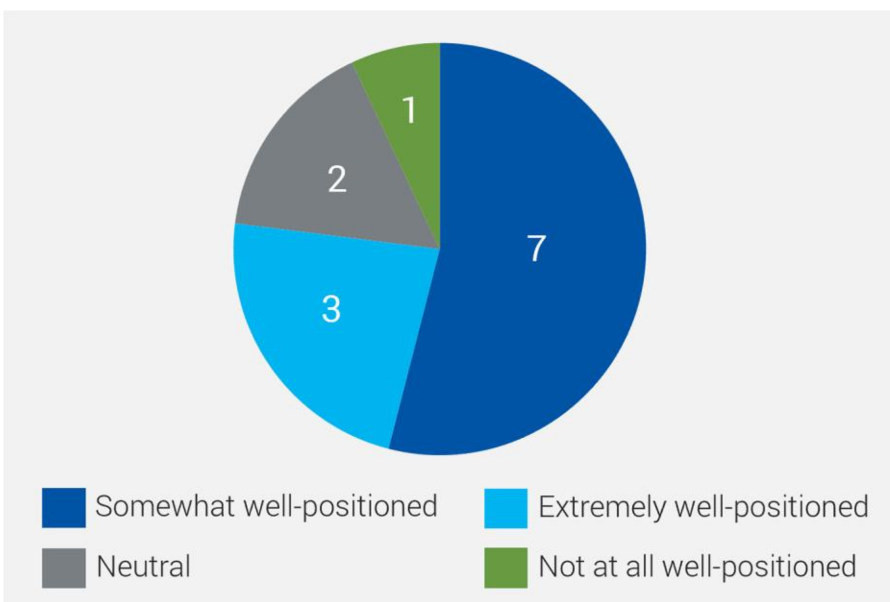
Industry Perspective

The program participants surveyed by the Cadmus team represented the school bus (nine respondents), transit bus (two respondents), forklift (one respondent), and other heavy-duty (one respondent) market segments. The Cadmus team asked these participants for their thoughts on how well their industry or sector is positioned for electrification. Ten of 13 participants rated their industry as *somewhat well-positioned* or *extremely well-positioned* (Figure 48; one did not answer this question). These fleet managers said their industry is well-positioned for electrification because of grant funding, the strong need for transit, local support, and an increasing need for cleaner air/environment. However, mileage limitations, charging delays, lack of vehicle storage, and reliability obstacles still exist. One program participant who rated their industry as *somewhat well-positioned* said:

> “I think the school bus industry is a great market for EV. However, I think advancements in equipment reliability and charging station oversite/control is needed before it can be fully functional on a large scale. I know these issues are being worked through but for now, I think we are still in somewhat of a learning curve. Also, I think more will need to be done in the area of power source/supply. Bus yards are going to need significant power supplied to the yards along with smart charging software controls before large EV bus fleets can become the normal means of transportation in this industry.”

The one program participant who rated their industry as *not at all well-positioned* at all said at least 150 miles per charge is needed to be effective.

Figure 48. Position for Electrification



Source: Fleet Manager Survey Question F1. “How well-positioned do you think your industry/sector is for electrification?” (n=13)

Seven of 13 program participants were satisfied with the current EV options on the market for their sector. When asked about the limitations of current EV options in their sector, the availability of chargers and range was the top limitation (seven mentions). Participants also mentioned the limitations of cost, availability of larger equipment, and fact that most EVs are not yet ready for the market and cannot be delivered in a timely manner.

When asked about their perspectives on risk, six program participants said diesel trucks seem like a riskier purchase while five said electric trucks seemed risker in the next three years (n=11). In the next 10 years, eight program participants said diesel trucks seemed riskier and four said electric trucks seemed like a risker purchase (n=12). Though some still have perceived risk, most participants believe that electric trucks will be the safer purchasing decision in the future.

Withdrawn Fleet Managers

In addition to the program participants, the Cadmus team surveyed three fleet managers who withdrew from the program (known as withdrawn fleet managers). Among fleets that withdrew from the program, rebates and incentives for EVs were the top reason why these fleets initially intended to transition to EVs (two mentions). Other motivators, listed by one withdrawn fleet manager each, were better technology than conventional vehicles, incentives for EV charging infrastructure, expected maintenance cost savings, expected fuel cost savings, and corporate sustainability goals or initiatives.

When asked about why they withdrew from the program, one fleet manager said the main reason was due to the lack of availability of EV models and a lack of service and program support from PG&E. This respondent also said that they would have liked higher rebates for charging infrastructure along with "more customer support from PG&E," and that these features would have increased the likelihood that they stayed in the program.

Another withdrawn fleet manager said battery technology was a barrier and believes it has not advanced enough for their organization to completely electrify. However, this fleet manager said the primary reason for program withdrawal was due to issues securing approval from city government officials:

> "Interference by our city electrical department made proceeding with PG&E impossible. If it was up to me, we would have completed the site with PG&E. Because we fell within the city limit, there was a question of whether we were required to do business with the city. While my organization would have liked to have the site completed by PG&E, it was decided that the political fallout from fighting it was not worth the gain."

The Cadmus team also asked the withdrawn fleet managers about their level of satisfaction with various aspects of the program. One fleet manager rated themselves as *very satisfied* with all aspects of the program. This withdrawn fleet manager was particularly satisfied with the application timeline and with their experience working with their PG&E site organizer, who provided "invaluable" assistance and knowledge. In contrast, another withdrawn fleet manager was *not at all satisfied* with the program overall. This respondent was unaware of the level of program services and the amount of the rebates offered.

In response to questions about additional support they would have liked, one withdrawn fleet manager would like to see increased "customer-side make-ready infrastructure support." When asked about the types of costs that the program rebates should apply to, withdrawn fleet managers believe that EVSE costs (two mentions), vehicle costs (one mention), and construction costs (one mention) should also be eligible for rebates.

After withdrawal from the program, one respondent still installed EV charging equipment without the program rebates and received grants from an air quality district to cover some of the equipment cost. This respondent proceeded with EV charging outside the program and built the site as intended. One respondent did not make installations without the offered rebates. All respondents who withdrew from the program believed their experience with EV Fleet was an important factor to their decisions to build EV charging infrastructure outside the program.

Site Visit Findings

The Cadmus team conducted site visits to 25 PG&E EV Fleet sites, using the opportunity to verify aspects such as chargers installed, EVSPs used, types of EVs used or to be delivered, and influences of site design. Table 65 presents a summary of visited site characteristics by market segment. Notable is the charging capacity for school bus market segment nearing 3 megawatts due to 17 sites.

Table 65. PG&E EV Fleet Site Visit Summary

Market Segment	Number of Sites	Number of DCFC Ports	Number of L2 Ports	Charger Power (kW)	Total Charging Capacity (kW)
School Buses	17	6	137	L2: 12, 19.2 DCFC: 50	2,887
Transit Buses, Medium-Duty Vehicles, Heavy-Duty Vehicles, and Forklifts	8	31	23	L2: 10, 12, 15.6, 19.2 DCFC: 50	1,947

Most operators discussed influences from the pandemic and vehicle reliability that limited their EV usage. Several sites experienced chronic vehicle reliability challenges and never operated their full EV fleet consistently. Similar to vehicle reliability, some operators commented on a learning curve that drivers experienced. Several operators reported instances of nearly running out of charge in addition to a lack of granularity on fuel and range gauges. Analysis of vehicle logs and charging sessions may help to assess actual ranges and fuel economies, but operators generally mentioned an inability to assess this so far. Many schools had both large and small buses as part of their initial EV purchases. Transit operators typically had either heavy-duty or medium-duty vehicles. The reliability of charging was high overall, with only a few sites highlighting this as a limitation.

Two of the sites used a load management plan to reduce their electricity costs. Most but not all the sites we visited have an EVSP network that, in theory, could enable this function to reduce vehicle charging during times that adversely impact operational costs and emissions.

Few of the fleet operators were the one within their organizations to receive the electric Utility bills and were unaware of fuel costs even several months into operation. These two points align with findings from the *Grid Impacts* section that over 35% of energy used was during the highest cost time-of-use period each day. One of the sites with load management mentioned several experiences of vehicles failing to charge after their software-based 4 p.m. to 9 p.m. daily lockout period ended, requiring them to use their conventionally fueled vehicles the next day.

School Bus

School districts expressed a heavy reliance on public funding through the local air districts, the California Energy Commission, and CARB's Hybrid & Electric Truck & Bus Voucher Incentive Project. Most school districts are willing to continue expanding their fleet as funding becomes available; one operator was told there is only internal funding for EVs and not for conventional vehicles.

However, in many cases, this funding was contingent on the disposal of conventional ICE buses, which school districts needed to accommodate longer trips. Operators noted that while their EVs were suitable for most regular school bus route schedules, their current range and charging needs discouraged (or made fleet managers uncomfortable with) the use of EVs for extracurricular activities such as field trips and sports competitions at other schools. Therefore, school bus fleets needed to maintain some conventional buses.

Although interest in expansion was noted, some sites reported only having charging capacity for the near term. Sites that built larger than their near-term vehicle acquisition plan resulted from two influences: (1) including additional charging ports to reduce the per-port costs and (2) planning so that operators can claim rebates for charging stations now without the risk of having to do additional work later. Several forms of expandability were noted including using remaining circuit breaker space in a service panel, using hand-holes to continue trenching in the future, and having full make-ready infrastructure with conduit and concrete pads ready for EVSE to be installed.

Operationally, most schools appeared to have buses return to base midday, which is a benefit especially for larger districts with longer routes and could enable more charging during off-peak pricing times when more renewable electricity is on the grid. However, most school bus sites charged their buses between 4 p.m. to 9 p.m., the highest cost and often highest emissions period of any day.

One operator mentioned that operations required more than one EV for each conventional vehicle replaced. The same operator discussed their experience showing that building more space between equipment could have helped it run cooler and potentially more reliably in the future.

Many of the school districts we contacted between October 2021 and April 2022 described that their operations have not returned to pre-pandemic levels. In some cases, driver shortages limited the number of routes that could be operated, in turn increasing passenger loads. One district said their new EVs had fewer seats, which limited usage due to increased loads and therefore the buses may not be put into service until summer school. Expandability currently appears modest, with some fleets having more intention than others. During in-person site visits, the Cadmus team connected with site representatives, who provided insight to the past, present, and future of these projects. The overarching takeaways from the process suggest that utilization is likely to increase based on several factors:

- Newer generations of EVs will operate more reliably, which will allow for more consistent use
- As fleets become more knowledgeable about their EV operation, they will likely increase EV use
- Not all fleet EV purchase orders and vehicle acquisition plans have been fulfilled completely

- Additional EV acquisition for some fleets requires public funding that has not yet been secured
- Some sites incorporated expandability through spare electrical capacity on transformers, service panels, and make-ready construction (such as pre-plumbed electrical conduits and mounting for EVSE)

Figure 49 shows one of only a few instances of BTM not requiring any trenching as the electrical wiring to power the charging stations is installed in a metal conduit on the side and the ceiling of the semi-enclosed parking garage.

Figure 49. Low-Cost Level 2 Installations, Indoor with Surface-Mounted Conduit

Figure 50 shows one of three school bus examples where both L2 charging and DCFC was installed. While most charging can be accomplished overnight and midday, the DCFC provides a backup option. Some districts said they are considering using their charging to support other schools visiting for sports and other events.

Figure 50. DCFC (left) and L2 (right) Charging with a Solar Canopy

Forklifts

The Cadmus team visited two PG&E sites in the forklift market segment. Figure 51 shows three gray chargers that have been typical of the forklift industry for decades that support smaller equipment and two orange L2 EVSEs used for new large 36,000-pound forklifts.

Figure 51. Forklift Charging Using a Mix of Legacy and New Equipment

Figure 52 shows the two types of forklifts in their open-air enclosure.

Figure 52. 36,000-Pound (left) and 10,000-Pound (right) Electric Forklifts

Co-Benefits and Co-Costs

Through surveys and site visits, the Cadmus team identified a number of co-benefits and co-costs associated with the program's vehicle electrification projects. Table 66 shows that all survey respondents (known as program participants) believed that benefits will be realized for their community or fleet because of electrifying. Most program participants believe that improved air quality/health and the reduction of noise pollution are the most significant benefits (nine of 13). Eleven of 13 program participants agreed that some benefits to driver comfort and convenience will be realized, although these benefits are not as significant. Other benefits mentioned include maintenance cost savings, good public relations, and fleet modernization.

Six program participants said they are thinking about their agency's charging needs and future EV usage. One participant installed two additional pull boxes during initial construction. One participant created designated parking for future electric school buses. Two program participants installed DCFCs to help with range anxiety. Additionally, two program participants said they are considering solar interconnection and energy storage for resiliency.

Table 66. Benefits Expected from Electrification

	Significant Benefits	Some Benefits	No Benefits
Improved air quality/health	9	4	0
Improved driver comfort/convenience	2	11	0
Reduction in noise pollution	9	4	0

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=13)

Table 67 shows the changes in costs associated with operating and maintaining EV fleets. Program participants saw the most instances of lowered costs with maintenance and fueling (eight and nine respondents, respectively). Most participants (n=10) also said that training costs stayed relatively equal, which means that there were little additional costs associated with EV maintenance training and driver training. Other costs mentioned were labor due to load balancing and developing schedules, towing due to driver error, and the overall costs of unreliability.

Table 67. Cost Change Since Electrification

	Costs are Lower	Costs are Relatively Equal	Costs are Higher	Don't Know
Vehicle maintenance	8	1	1	3
Vehicle fueling	9	3	1	0
Vehicle fueling infrastructure	5	2	4	2
Driver training	3	10	0	0
Maintenance staff training	1	8	2	2

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=13)

Most respondents said that all operational and maintenance costs were what they expected, as shown in Table 68. However, program participants' experiences with vehicle fueling and vehicle fueling infrastructure costs were the most likely to be higher than expected, reported by four and five respondents, respectively. This suggests that making fueling and infrastructure changes was a unique experience for many participants.

Five program participants agreed that there is a need to train drivers, operators, and fleet managers in EV maintenance and EV driving. Other training mentioned included charge management and energy management.

Table 68. Differences in Electrification Cost Expectations

	Costs Were as Expected	Costs Were Lower than Expected	Costs Were Higher than Expected	Don't Know
Vehicle maintenance	8	2	2	0
Vehicle fueling	7	2	4	0
Vehicle fueling infrastructure	6	1	5	1
Driver training	12	1	0	0
Maintenance staff training	10	1	1	1

Source: Fleet Manager Survey Question E2. "Have these operational and maintenance costs been what you expected?" (n=13)

Site Visit Insights

The Cadmus team incorporated qualitative insights from site visits to supplement the data. Out of 25 PG&E fleet sites visited, only two participants said they are tracking vehicle mileage, cost per mile, electricity usage from Utility bills, and vehicle activity via GPS to meet grant reporting requirements and reduce the administrative burden on fleet managers. Another two participants used their participation in the EV Fleet program to comply with Americans with Disabilities Act (ADA) requirements. Two participants mentioned co-costs. One said they lost a parking space to make room for the charging equipment while another said they have increased their time on maintenance of the solar canopy that they installed with the chargers due to the panels getting dirty.

Total Cost of Ownership

The Cadmus team conducted a TCO analysis to compare the 10-year costs of owning and operating an EV fleet with the costs of owning and operating a counterfactual fleet. We conducted the analysis for three vehicle fleet types (school buses, transit buses, and Class 4 package delivery trucks used for local delivery such as a bakery, snack, or linen delivery service). The purpose of the TCO analysis was to understand the impact of Utility programs and other grants and incentives on fleet costs from the fleet manager perspective.

For EY2021, we conducted this TCO analysis as a scenario analysis using a mix of primary data, secondary data, and assumptions as described in Appendix B. We developed the scenarios to understand the impact of Utility programs on the TCO of an EV fleet with and without incentives and a fleet of counterfactual vehicles.

School Bus

Figure 53 shows three scenarios of a 10-vehicle school bus fleet over a 10-year time span. The first scenario consisted of a fleet of all-electric school buses with no grants or incentives. As shown in Table 69, the EV fleet cost $3,267,884 more than the counterfactual scenario of a fleet of diesel school buses.

The second scenario resembles sites in the program based on data gathered during site visits. PG&E EV Fleet projects were completed with a combination of vehicle incentives and grants, Utility-paid distribution upgrades and incentives for customer-facing infrastructure upgrades, and LCFS credit revenue. By incorporating these grants and incentives, the EV fleet had a net present value of $577,071 over the 10-year period, compared to $1,807,051 for the diesel school bus fleet (as shown in Table 69).

Figure 53. PG&E School Bus Fleet Total Cost of Ownership

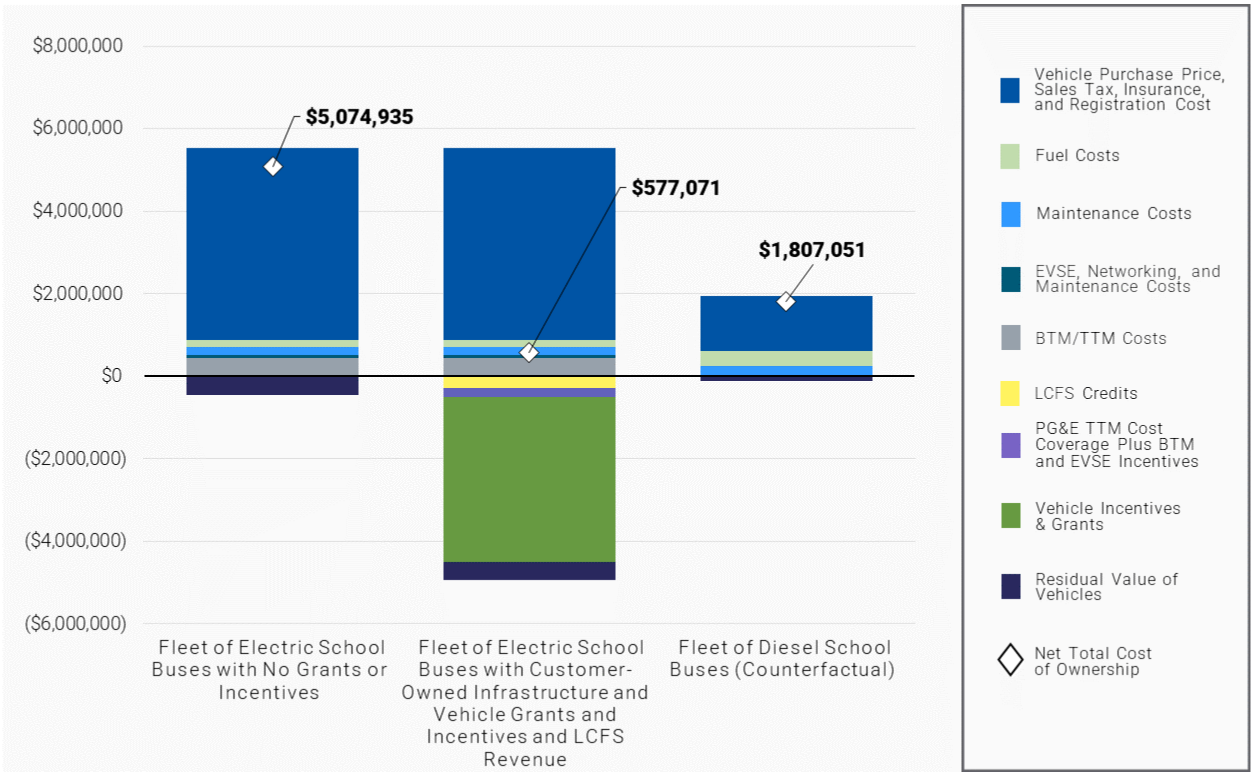


Table 69. PG&E School Bus Fleet Total Cost of Ownership

School Bus Fleet 10-Year Total Cost of Ownership (NPV)	Fleet of Electric School Buses with No Grants or Incentives	Fleet of Electric School Buses with Customer-Owned Infrastructure and Vehicle Grants and Incentives and LCFS Revenue	Fleet of Diesel School Buses (Counterfactual)
Vehicle Purchase Price, Sales Tax, Insurance, and Registration Costs	$4,652,732	$4,652,732	$1,310,990
Fuel Costs	$170,873	$170,873	$363,374
Repair and Maintenance Costs	$192,195	$192,195	$256,261
EVSE, Networking, and Maintenance Costs	$78,493	$78,493	
BTM/TTM Costs	$430,000	$430,000	
Residual Value of Vehicles	($449,359)	($449,359)	($123,574)
Vehicle incentives and Grants		($4,000,000)	
PG&E TTM cost coverage plus BTM and EVSE Incentives		($210,000)	
LCFS Credits		($287,863)	
Net Total Cost of Ownership	**$5,074,935**	**$577,071**	**$1,807,051**

Transit Fleets

Similar to school bus fleets, transit bus fleets rely heavily on grants for vehicle purchases; therefore we modeled the same scenarios for transit buses as we did for school buses. The counterfactual vehicle for transit buses was a CNG vehicle as described in Appendix B. The reduced costs of maintenance are expected to result in significant savings over the 10-year period. The maintenance costs shown in Table 70 for the counterfactual (CNG) fleet are $3,047,197, while the maintenance costs for the EV fleet are $2,150,962—a savings of $896,235.

Figure 54. PG&E Transit Bus Fleet 10-Year Total Cost of Ownership

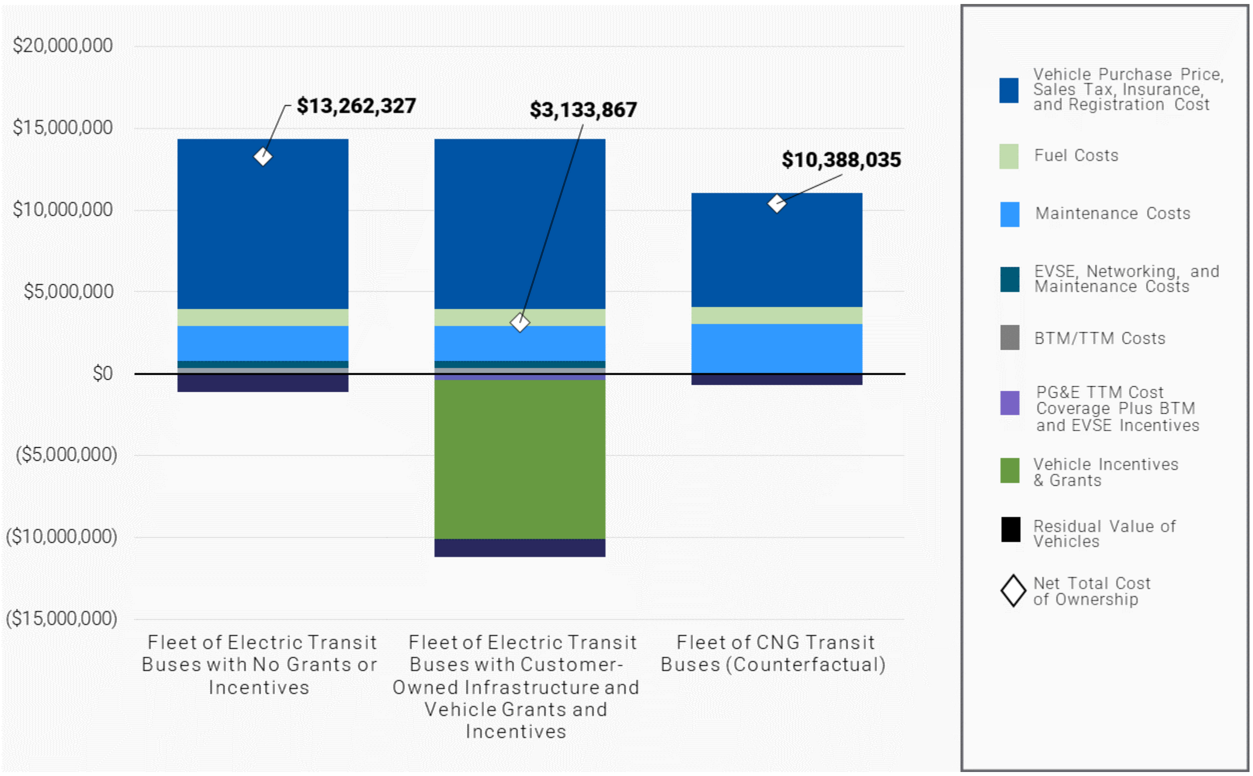


Table 70. PG&E Transit Bus Fleet 10-Year Total Cost of Ownership

Transit Bus Fleet 10-Year Total Cost of Ownership (NPV)	Fleet of Electric Transit Buses with No Grants or Incentives	Fleet of Electric Transit Buses with Customer-Owned Infrastructure and Vehicle Grants and Incentives	Fleet of CNG Transit Buses (Counterfactual)
Vehicle Purchase Price, Sales Tax, Insurance, and Registration Costs	$10,433,977	$10,433,977	$7,005,516
Fuel Costs	$994,477	$994,477	$1,015,288
Maintenance Costs	$2,150,962	$2,150,962	$3,047,197
EVSE, Networking, and Maintenance Costs	$430,298	$430,298	--
BTM/TTM Costs	$350,000	$350,000	--
Residual Value of Vehicles	($1,097,387)	($1,097,387)	($679,966)
Vehicle incentives and Grants	--	($9,768,460)	--
PG&E TTM cost coverage plus BTM and EVSE Incentives	--	($360,000)	--
LCFS Credits	--	--	--
Net Total Cost of Ownership	**$13,262,327**	**$3,133,867**	**$10,388,035**

As illustrated in Figure 54, the net present value of the EV fleet with no grants or incentives scenario was $13,262,327. This was $2,874,292 more than the counterfactual CNG fleet. Based on information from site visits, site hosts relied on vehicle grants to cover the entire cost of the EV transit buses and PG&E's EV Fleet program covered the cost of distribution system upgrades necessary for DCFC installation, as well as a significant portion of customer-facing infrastructure necessary for charger installation. The combination of vehicle grants and incentives brought the cost of the EV fleet to $3,133,867, a savings of $7,254,168 over the cost of the CNG fleet.

Medium-Duty Package Delivery Trucks

The representative package delivery truck fleet was the only fleet we assessed for EY2021 in which EVs did not receive enough incentives and grant funding to offset the upfront cost of the vehicle, based on research conducted on available incentives and grants for this vehicle category. Because these fleets are mostly private, there were fewer grants available to fleet owners. We incorporated the maximum available HVIP funding for this vehicle category, and note that based on site visit data, other funding such as AQMD grants did support the purchase of EVs for some fleets. Based on the Cadmus team's research, the AQMD grant funding used for the fleet in EY2021 has since been exhausted, so we did not include it in the grant scenario. As shown in Figure 55, the scenario in which the EV fleet did not receive any grants or incentives cost more than twice as much as the counterfactual fleet of diesel package trucks over the 10-year period. As Table 71 illustrates, the scenario in which the EV fleet received HVIP grants, LCFS credits, and PG&E's TTM upgrades and BTM incentives reduced the NPV of the EV fleet by over $1 million. The EV fleet with grants and incentives had a NPV of $544,113 more than the diesel fleet.

Figure 55. PG&E Package Delivery Truck Fleet 10-Year Total Cost of Ownership

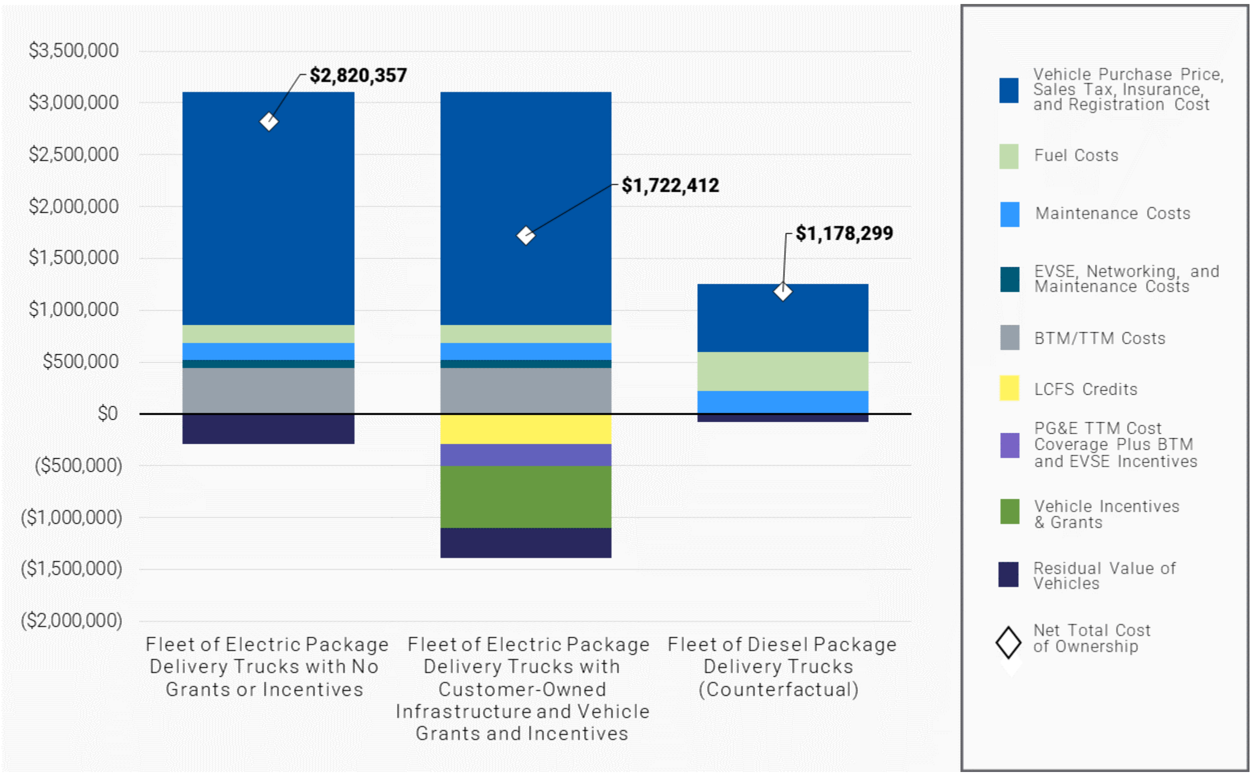


Table 71. PG&E Package Delivery Truck Fleet 10-Year Total Cost of Ownership

Package Delivery Truck Fleet 10-Year Total Cost of Ownership (NPV)	Fleet of Electric Package Delivery Trucks with No Grants or Incentives	Fleet of Electric Package Delivery Trucks with Customer-Owned Infrastructure and Vehicle Grants and Incentives	Fleet of Diesel Package Delivery Trucks (Counterfactual)
Vehicle Purchase Price, Sales Tax, Insurance, and Registration Costs	$2,248,764	$2,248,764	$663,680
Fuel Costs	$170,922	$170,922	$369,044
Maintenance Costs	$168,522	$168,522	$224,696
EVSE, Networking, and Maintenance Costs	$78,493	$78,493	
BTM/TTM Costs	$440,000	$440,000	
Residual Value of Vehicles	($286,344)	($286,344)	($79,121)
Vehicle incentives and Grants		($600,000)	
PG&E TTM cost coverage plus BTM and EVSE Incentives		($210,000)	
LCFS Credits		($287,945)	
Net Total Cost of Ownership	**$2,820,357**	**$1,722,412**	**$1,178,299**

Cost Mitigation Strategies

Expert Advice

Expert advice from program staff and service from Utility personnel in designing and installing the necessary EV charging infrastructure can help reduce or avoid transportation electrification costs (such as by providing information on grants and incentives, or by recommending the most cost-effective locations for installing EV chargers). The expansion of sector-specific resources (such as for public school fleets or transit fleets) and the provision of advisory services can further support this strategy.

Managed Charging

One way fleet managers can reduce the operating costs of their electric fleets is through managed charging. The Cadmus team relied on actual billing data to determine electricity cost assumptions for the TCO analysis. However, site visit feedback indicated that most EY2021 electrified fleets were not managing charging to minimize costs and grid impacts. However, information gathered from site hosts during evaluation site visits indicated that most EY2021 electrified fleets are not managing charging to minimize costs and grid impacts. Fleet managers may not be aware of electricity bills, which an administrative person responsible for all facility bills typically handles. As a result, fleet managers may not directly see the financial benefit of adjusting charging. Additionally, most fleet managers are not aware of EVSP's charge management features due to a lack of training and lack of familiarity with EVSP's online portals where charging could be configured. These online portals are offered by the majority of EVSPs. Lastly, even if charging were delayed via EVSP's software, there is a potential challenge if EVs do not accept a delayed charge from EVSE to protect the vehicle's battery, which may be a feature of the battery management software.

To assess the impact of managed charging on the TCO for fleets, the Cadmus team created two scenarios analyzing an illustrative example school bus enrolled in PG&E's BEV-1 rate over a 10-year period. The majority of school bus fleets were enrolled in the BEV-1 rate in EY2021.[76] In the first scenario we modeled a fleet with unmanaged charging, which charged during times of peak energy demand. In the second scenario we modeled a fleet with managed charging, which took advantage of lower electricity prices during times of low energy demand (Table 72).

Table 72. PG&E Managed Charging Scenario Inputs

TOU Period	Scenario 1: Unmanaged Charging	Scenario 2: Managed Charging
On-Peak	60%	--
Off-Peak	40%	70%
Super Off-Peak	--	30%
Average Cost of Electricity ($/kWh)	$0.30	$0.18

76 BEV-1 is used for customers with usage below 100 kW of demand.

Table 73. PG&E Managed Charging Scenario Outputs

Scenario	Net Present Value [a]	Total Fuel Costs [b]
Scenario 1 – Unmanaged Charging	$697,968	$29,177
Scenario 2 – Managed Charging	$582,822	$17,662
Base Case (presented in Table 69)	$577,071	$17,087
Percentage change from Scenario 1 to Scenario 2	**16.5%**	**39.5%**

[a] This table shows NPV for an example electric school bus in a fleet of 10 buses with incentives included over 10 years.

[b] This column represents discounted fuel costs over a 10-year period.

Scenario 1 (unmanaged charging) resulted in a $0.30 per kilowatt-hour average cost of electricity and Scenario 2 (managed charging) resulted in $0.18 per kilowatt-hour. In terms of annual electricity costs, Scenario 2 resulted in a 40% decrease in annual electricity costs for an electric school bus on the BEV-1 rate. Over the total life of the vehicle, this decrease in operating costs resulted in a 17% decline in the NPV for an electric school bus in a fleet of 10 buses in the scenario where incentives and LCFS revenue were taken into account. It is of note that the example school bus fleet from Table 73, based on representative billing data, had lower fuel costs than the managed charging scenario. This result indicates that school bus fleets could be charging off-peak more than 70% of the time. While many cost considerations are out of a fleet manager's control, charging management is an area in which managers have some ability to reduce operating costs.

Utility Revenue

The Cadmus team primarily approached this TCO analysis from the perspective of the fleet owner, but it is important to note that one impact from these programs will be an increase in money collected by PG&E through rates. In EY2021, revenue generated from EV Fleet operational projects totaled $377,795. Many of these projects were not activated until mid-year, so this value does not reflect the annual revenue from these projects, but the actual revenue based on billing data since project activation. Over time, the costs of the infrastructure installed for these projects and paid for by ratepayers will be spread out over cumulative electricity sales. As sales grow, this should put downward pressure on rates and, if charging is managed, could result in a more efficient distribution system.

Conclusions

From a fleet manager perspective, the representative MDHD market segments assessed in this TCO analysis are only cost-effective when EV grant funding, subsidized Utility infrastructure, and market-based climate policies are taken into account. Lower operating costs and preferential tax treatment also help to support the affordability of EV fleets. In particular, the example of the medium-duty package delivery truck fleet shows the importance of EV grant funding to making vehicle electrification economically feasible. Without grants to offset the higher upfront cost of the vehicles, they are not a financially attractive investment for fleet owners. Currently, EV grant funding and Utility rebates and incentives are critical to making EV fleets economically competitive with ICE fleets.

Based on the results of the three scenarios, the analysis for fleets in each market segment resulted in three findings:

- Electric MDHD vehicles cost much more than ICE vehicles.
- While EVs cost less to operate and maintain than ICE vehicles, these savings do not compensate for the higher upfront cost of the EVs and the added costs of infrastructure necessary for charging.
- Without the combination of vehicle grants and incentives, infrastructure support from PG&E, and LCFS credits, EY2021 MDHD fleet electrification projects would be cost-prohibitive.

EV Fleet Infrastructure Support Analysis

The Cadmus team examined the magnitude and variance of costs per site, per vehicle supported, and per kilowatt in PG&E's EV Fleet program. Across PG&E's 23 fully invoiced EV Fleet sites in EY2021, there were 15 school bus sites and eight other MDHD vehicle sites. The other vehicle category consists of a combination of other heavy-duty Class 8 vehicles, transit buses, medium-duty vehicles, and forklifts. All costs presented in this analysis are specific to the financial support PG&E provides for site construction, including constructing the TTM infrastructure and providing a rebate to the customer for a portion of BTM costs. Note that this analysis reflects sites constructed through EY2021 and does not necessarily reflect the costs of constructing sites in the future.

Individual site cost analysis is inclusive of the actual TTM costs PG&E incurred to support the sites in EY2021 and the estimated BTM rebates PG&E will distribute to customers. BTM rebate estimates reflect the eligibility of BTM infrastructure support. BTM rebate estimates are not reflective of the total BTM costs customers may incur. EVSE rebates are not included in this analysis, as the maximum eligible rebate may not accurately map to actual rebates distributed. As an example, a 19.2 kW L2 charger would be eligible for up to 50% of the cost of the EV charger, up to $15,000 (Table 74). For current data reporting purposes, the eligible rebate is listed as $15,000 when the actual rebate may more likely provide about $2,000 to cover 50% of the cost of the L2 charger. Customers who are eligible to receive these EVSE rebates include participants operating school buses, transit buses, and participants installing chargers in DACs. Fortune 1000 companies are not eligible to receive an EVSE rebate. EVSE rebates are distributed from a separate non-infrastructure budget, which means they are not considered a part of the infrastructure costs for the program.

Table 74. EV Fleet EVSE Rebate Levels

EV Charger Power	Rebate for Eligible Customers per Charger
Up to 50 kW	50% of the cost of EV charger, up to $15,000
50.1 kW to 149.9 kW	50% of the cost of EV charger, up to $25,000
150 kW and above	50% of the cost of EV charger, up to $42,000

When analyzing individual site costs, it is important to consider the power level of charging installed. School bus sites primarily used L2 charging with a few sites installing both DCFC and L2 charging. Other vehicle sites consisted of several vehicle types with varying charging power requirements, in which some sites have installed L2 charging while others have installed high-powered DCFC. While charger power level will be a key factor for overall site costs, it is not the only factor. Increases in length of trenching and cabling can result in higher TTM and BTM costs. Soft costs related to delays in construction, permitting, and design may incur additional project costs. Please see the *Total Cost of Ownership* section on EV Fast Charge TCO for a literature review on cost variance for EV charging deployment. For PG&E EV Fleet school bus and other MDHD vehicle sites fully invoiced in EY2021, Table 75 and Table 76 show the magnitude and variation in per site, per vehicle supported, and per kilowatt costs, broken down by TTM support and estimated BTM rebate support.

Table 75. School Bus and Other Vehicle Sites TTM Cost Analysis

School Buses	$/site	$/vehicle supported	$/kW
Mean	$171,152	$21,425	$1,163
Minimum	$133,482	$6,233	$371
Maximum	$263,985	$34,296	$2,002
Other Vehicle Sites	**$/site**	**$/vehicle supported**	**$/kW**
Mean	$135,113	$15,816	$527
Minimum	$14,092	$2,818	$147
Maximum	$213,407	$27,182	$1,262

Table 76. School Bus and Other Vehicle Sites BTM Rebate Cost Analysis

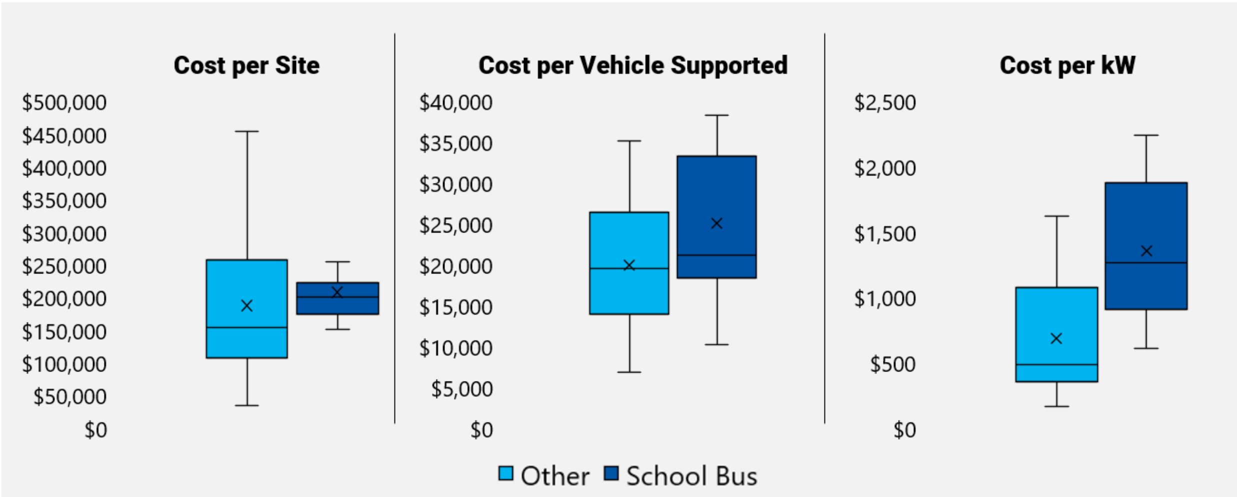
School Buses	$/site	$/vehicle supported	$/kW
Mean	$36,359	$3,635	$194
Minimum	$7,528	$1,506	$90
Maximum	$120,000	$4,000	$239
Other Vehicle Sites	**$/site**	**$/vehicle supported**	**$/kW**
Mean	$52,157	$4,124	$158
Minimum	$9,965	$1,329	$10
Maximum	$240,000	$8,000	$357

For school bus sites, PG&E's EV Fleet program provided on average $171,152 for TTM infrastructure deployment and is estimated to provide $36,359 for BTM rebates. For other vehicle sites, PG&E provided an average of $135,113 for TTM infrastructure deployment and is estimated to provide $52,157 in BTM rebates. Overall, school bus sites received a higher mean level of TTM infrastructure support in EY2021 and are estimated to receive a lower mean level of BTM rebates than other vehicle sites.

The mean cost for PG&E EV Fleet school bus sites, which includes actual TTM costs and estimated BTM rebate amounts, was $20,000 higher than the mean cost for other vehicle sites. As noted, the other vehicle category consists of a variety of vehicle types and charger power levels and, accordingly, the costs per site varied greatly across the other vehicle sites category. This high level of variance can be seen in the cost per site analysis, in which the maximum cost for other sites exceeds the maximum cost of school bus sites by about $150,000 and minimum cost for other vehicle sites is about $115,000 less than the average minimum cost for school bus sites.

In terms of estimated BTM rebate support, the maximum cost per vehicle supported align with the maximum allowable rebates PG&E provides for school buses and other vehicles. On average, school bus sites are estimated to receive 91% of the maximum BTM rebate. School bus sites are overall installing less expensive, lower power charging than the other vehicle sites. Due to providing lower power charging, when considered on a cost per kilowatt installed basis, school bus sites cost twice as much per kilowatt than other vehicle sites using higher powered charging (Figure 56).

Figure 56. PG&E EV Fleet Infrastructure TTM and BTM Rebate Cost Analysis



Grid Impacts

The Cadmus team estimated grid impacts for the EV Fleet program based on the energy consumed by the operational charging stations installed through the program in EY2021, combined with charging session data from the EVSPs. Table 77 presents a summary of the estimated EV Fleet grid impacts through EY2021, an annual estimate, and a 10-year forecast.

Table 77. PG&E EV Fleet EY2021 Grid Impacts Summary

Impact Parameter	Evaluation Year 2021	Annual Estimate [a]	10-Year Projection [a]
Operational Sites	26	24	24
Electric Energy Consumption, MWh	2,013	2,807	28,067
On-Peak MWh (4 p.m. to 9 p.m.) (and % of total)	598 (30%)	N/A	N/A
Maximum Demand, kW (with date and time)	1,493 (9/28/21 5:45 p.m.)	N/A	N/A
Maximum On-Peak Demand, kW (with date and time)	1,493 (9/28/21 5:45 p.m.)	N/A	N/A

[a] Twenty-four sites were used for this estimate.

Figure 57 shows total monthly consumption of electricity for operational sites during EY2021 for the EV Fleet program. A steep increase in energy consumption is observed over summer 2021 as vehicles were received and entered service. This time period also reflects school bus operations resuming as pandemic-related closures ended.

Figure 57. PG&E EV Fleet EY2021 Monthly Electricity Consumption

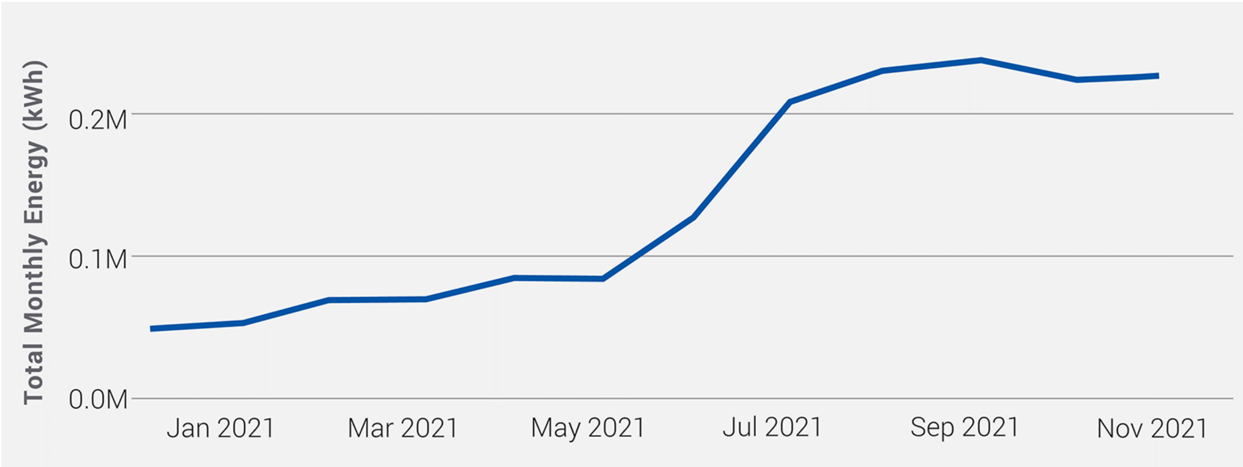
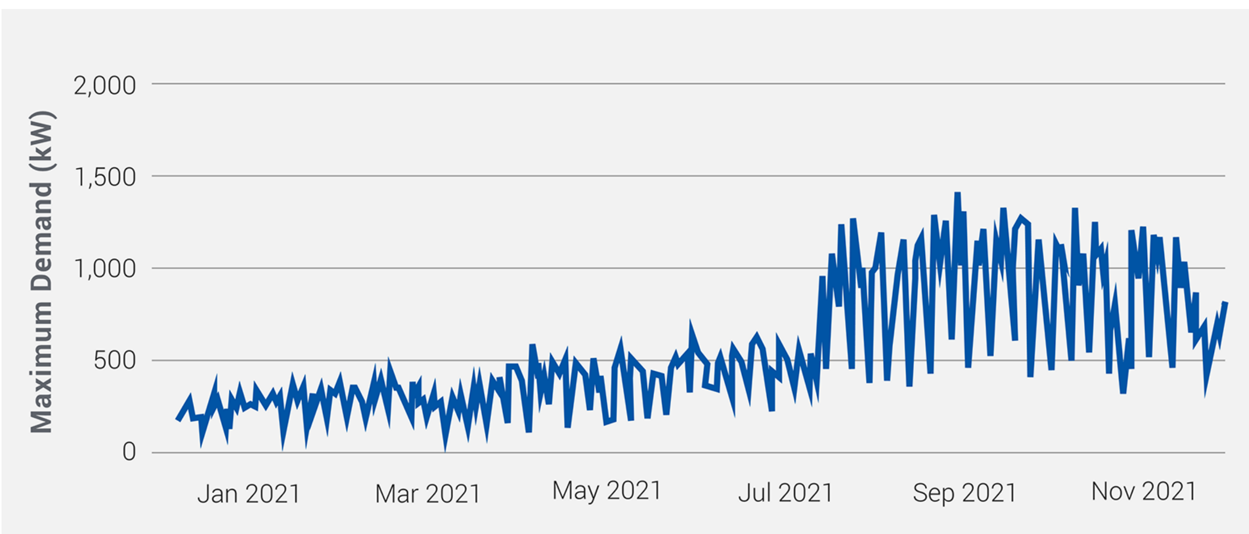


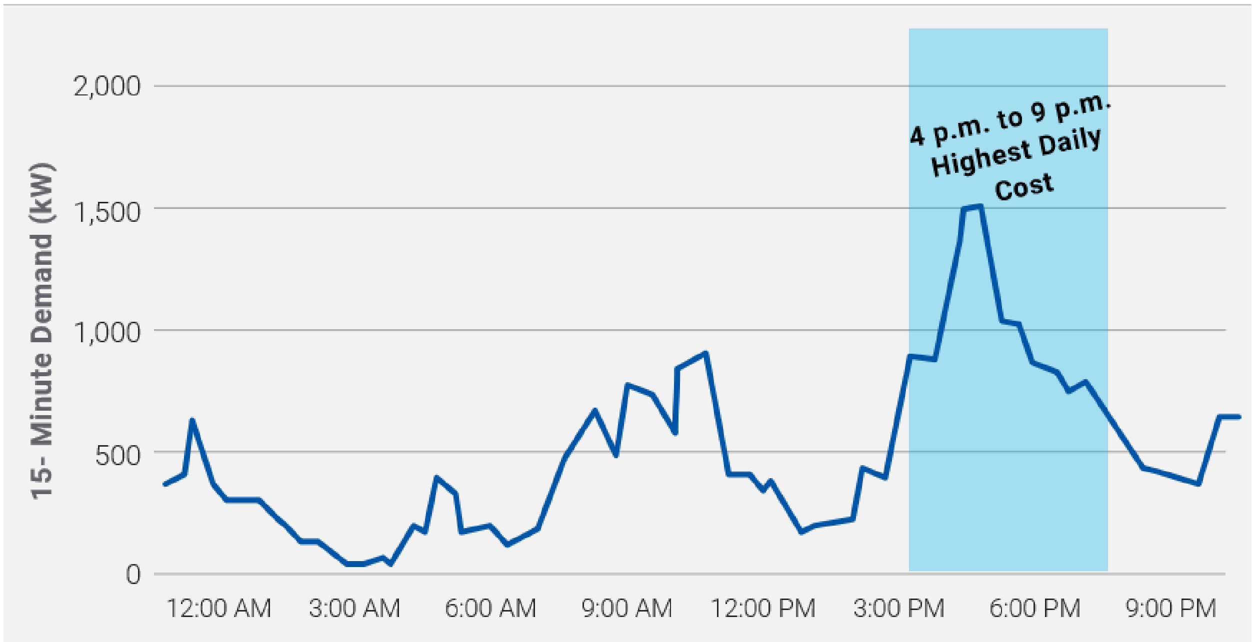
Figure 58 shows new transportation load as PG&E customers began using their charging infrastructure and vehicles. The hysteresis shows weekly cycles with the valleys representing weekends.

Figure 58. PG&E EV Fleet New Transportation Load



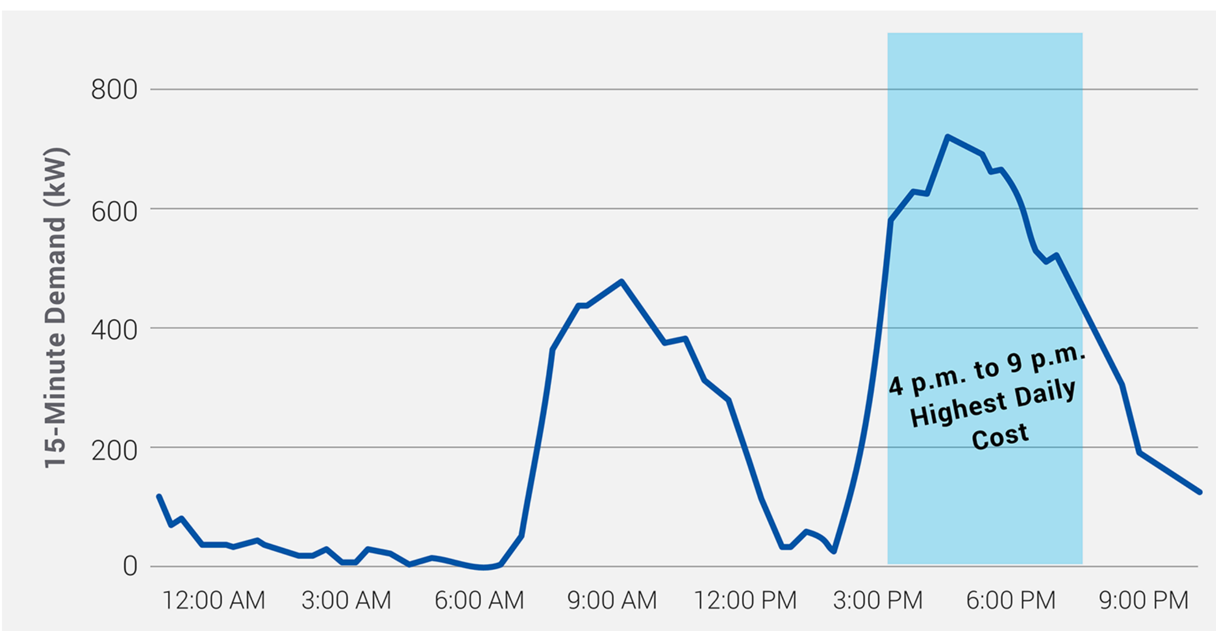
Through the end of 2021, approximately 1,500 kW of new load was added through the program, compared to approximately 9,000 kW of total installed charging capacity, which was verified through site visits. The portfolio was primarily composed of school bus operations, which charge after routes in the morning and late afternoon, and heavy-duty vehicles, which charge between shifts and during breaks. Significant new demand has largely aligned with the peak period of 4 p.m. to 9 p.m. The maximum load of 1,500 kW occurred on September 28, 2021, as shown in Figure 59.

Figure 59. PG&E EV Fleet Load Curve on September 28, 2021



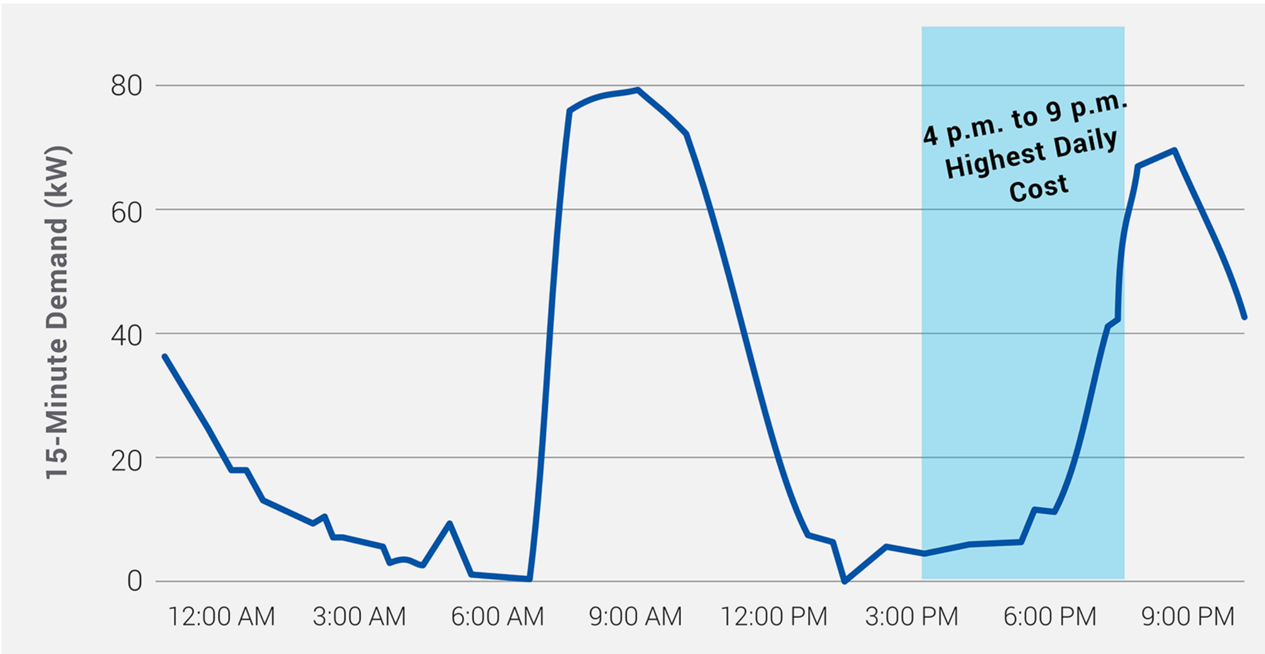
The load shape is heavily influenced by school districts operating electric school buses, which is shown in Figure 60. The school bus–only load curve shows charging directly after morning and afternoon routes. Afternoon charging is particularly significant, with more than 40% of consumption by school bus fleets taking place between 4 p.m. and 9 p.m. during most months.

Figure 60. PG&E EV Fleet School Bus Charging Load Curve September 28, 2021



During site visits two PG&E customers shared their use of load management during 2021. Compared to all school districts, once load management was implemented, less than 15% of charging took place between 4 p.m. and 9 p.m. (as shown in Figure 61).

Figure 61. Example of PG&E EV Fleet Customers Using Load Management



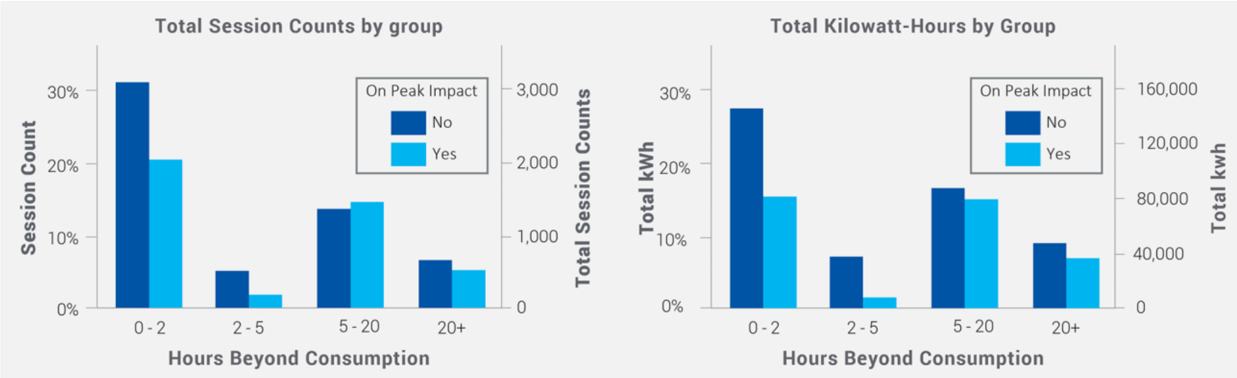
The Cadmus team used charging session summaries from EVSPs to assess potential flexibility in when charging sessions consumed energy. In our initial analysis of sessions, the team scanned for realistic durations of connection or charging and potential faults ending sessions prematurely. Flexibility is currently defined as how much time in excess of the consumption an EV was connected to a charging port.

Figure 62 highlights that over 40% (4,200) of all school bus charging sessions consumed at least some energy between 4 p.m. and 9 p.m.: 20% (2,100) of the charging sessions that impacted that time period had two hours or more of charging flexibility. This means that most energy during this unideal time period can likely be shifted to a time period at less cost and lower emissions. Load management strategies could allow for shifting consumption to other lower cost and lower emissions time periods.

The histograms below represents 100%[77] of school bus charging sessions while the colors indicate whether a portion of their consumption took place between 4 p.m. and 9 p.m. The left variation is based on charging sessions while the right chart is by energy (kilowatt-hours).

[77] The Cadmus team removed charging sessions with known or suspected errors from this analysis.

Figure 62. PG&E EV Fleet Flexibility of School Bus Charging Sessions



Petroleum Displacement

The Cadmus team modeled petroleum displacement from the vehicle electrification enabled by PG&E's EV Fleet program. We used diesel gallons equivalent (DGE) for reporting purposes. Transit buses primarily use CNG fuel, which means that we needed to convert their natural gas consumption into DGE units based on the fuel's energy content.

Table 78 summarizes petroleum displacement for the EV Fleet program for EY2021, including estimated annualized impacts for EY2021 and the 10-year forecast. Nearly 40,000 hours of off-road electrical equipment use and 800,000 miles of on-road vehicle travel resulted in the displacement of over 300,000 DGE on an annualized basis. For market segments with fewer than 15 customers, all except for school buses, per evaluation criteria, the EY2021 results are grouped together.

Table 78. PG&E EV Fleet Petroleum Displacement Summary

Petroleum Displacement	Evaluation Year 2021			Annualized	10-Year Projected Impact
	Total Usage (kWh)	Usage	Petroleum Displacement (DGE)	Petroleum Displacement (DGE)	Petroleum Displacement (DGE)
School Buses	912,483	707,746 miles	77,519	113,886	1,138,856
Transit Buses, Medium-Duty Vehicles, Heavy-Duty Vehicles, and Forklifts	1,100,243	39,241 hours and 92,312 miles	146,949	192,375	1,923,747
Total	**2,012,726**	--	**224,467**	**306,260**	**3,062,603**

For the PG&E EV Fleet program, the largest market segment contributing to petroleum displacement was the electrification of heavy-duty vehicles. These heavy-duty vehicles were primarily yard tractors engaged in intermodal transfers for multiple shifts per day. This market is more mature than that for on-road heavy-duty vehicles for regional or long-haul transport. The second highest petroleum displacement segment was school buses.

Based on our analysis of EY2021 operational sites, the program is on target to displace more than 3 million DGE over a 10-year period. The actual displacement will be higher as more EVs are added at existing sites. Additionally, site operations may be reasonably expected to increase to pre-pandemic levels of service. In addition to greater use at existing sites, the program will build out additional sites resulting in higher total program impacts in the months and years ahead.

Greenhouse Gas and Criteria Pollutant Impact

The Cadmus team calculated reduced emissions from displaced fossil fuel use from ICE vehicles that were not in service because of the EV Fleet program. The team first developed ICE counterfactuals for common vehicle types, 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 EV chargers emit GHGs and criteria pollutants.

Table 79 summarizes GHG impacts for the EV Fleet program for EY2021, including estimated annualized impacts for EY2021 and the 10-year forecast.

Table 79. PG&E EV Fleet GHG Reductions Summary

GHG Reduction	Evaluation Year 2021		Annualized	10-Year Projected Impact	% GHG Reduction
	Total Usage (kWh)	GHG Reduction (MT)	GHG Reduction (MT)	GHG Reduction (MT)	
School Buses	912,483	608	905	9,050	75%
Transit Buses, Medium-Duty Vehicles, Heavy-Duty Vehicles, and Forklifts	1,100,243	1,327	1,750	17,505	85%
Total	**2,012,726**	**1,872**	**2,655**	**26,555**	**81%**

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. Local emissions reductions estimates are relatively small in EY2021, with the exception of heavy-duty vehicles, which saw a substantial amount of usage, followed by forklifts, which have poor emissions profiles. We annualized and projected these impacts in Table 81 and Table 82.

Table 80. PG&E EV Fleet Local Emissions Reductions Summary – EY2021

Market Segment	Evaluation Year 2021 Local Emissions Reductions				
	HC (kg)	PM_{10} (kg)	$PM_{2.5}$ (kg)	ROG (kg)	CO (kg)
School Buses	N/A	1.5	1.5	6.9	199.3
Transit Buses, Medium-Duty Vehicles, Heavy-Duty Vehicles, and Forklifts	158.2	23.7	21.1	171.2	9,318.7
Total	**158.2**	**25.2**	**22.6**	**178.1**	**9,518.0**

Table 81 shows local emissions reductions on an annualized basis (reflecting the emissions reductions we would have expected if the sites had been operational for the entire year).

Table 81. PG&E EV Fleet Local Emissions Reductions Summary – Annualized

Market Segment	Annualized Local Emissions Reductions				
	HC (kg)	PM_{10} (kg)	$PM_{2.5}$ (kg)	ROG (kg)	CO (kg)
School Buses	N/A	2.3	2.2	10.1	401.3
Transit Buses, Medium-Duty Vehicles, Heavy-Duty Vehicles, and Forklifts	209.0	30.6	27.3	225.9	12,504.6
Total	**209.0**	**32.9**	**29.5**	**236.0**	**12,945.9**

Table 82 shows local emissions reductions over 10 years. These are the annualized reductions from Table 81 extended over a decade.

Table 82. PG&E EV Fleet Local Emissions Reductions Summary – 10 Year

Market Segment	10-Year Projected Local Emissions Reductions				
	HC (kg)	PM_{10} (kg)	$PM_{2.5}$ (kg)	ROG (kg)	CO (kg)
School Buses	N/A	22.6	21.7	101.4	4,013.1
Transit Buses, Medium-Duty Vehicles, Heavy-Duty Vehicles, and Forklifts	2,090.1	306.4	272.9	2,258.2	125,445.6
Total	**2,090.1**	**329.0**	**294.6**	**2,359.6**	**129,458.7**

Table 83 shows counterfactual vehicle 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 Cadmus team estimated a total GHG reduction of 81% and a reduction in NO_X of 77% from the use of EVs compared to counterfactual vehicles. Transit buses had increased emissions of NO_x primarily due to the emission factor used for electric grid imports used to power the electric buses, and because of the very low NO_x emissions of CNG buses. In balance, the sites reduce local (tailpipe) emissions.

Table 83. PG&E EV Fleet Annualized GHG Reductions

Market Segment	Annualized GHG (MT)			
	Counterfactual	Utility	Reduction	% GHG Reduction
School Buses	1,205	300	905	75%
Transit Buses, Medium-Duty Vehicles, Heavy-Duty Vehicles, and Forklifts	2,075	324	1,750	84%
Total	**3,280**	**624**	**2,655**	**81%**

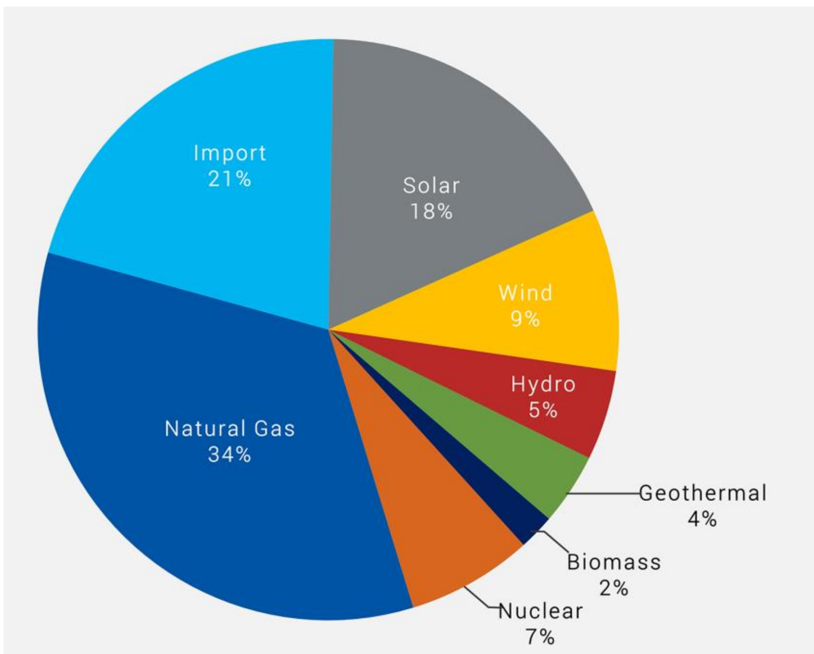
Table 84. PG&E EV Fleet Annualized NO_x Reductions

Market Segment	Annualized NO_x (kg)			
	Counterfactual	Utility	Reduction	% GHG Reduction
School Buses	1,046	234	812	78%
Transit Buses, Medium-Duty Vehicles, Heavy-Duty Vehicles, and Forklifts	1,068	255	813	76%
Total	**2,114**	**489**	**1,625**	**77%**

Figure 63 shows the annual program net electricity generation mix matching the hours when the EVs were charging. The CAISO grid mix varies from moment to moment depending on factors such as the level of total demand for power on the grid and availability of fossil generation and variable renewable resources such as solar. At this early stage of the program, it appears that the vehicles were not charging predominantly during the peak hours of solar output. Over 20% of the grid mix is comprised of electricity imports, which are assumed to match the resource mix of the Western grid.[78]

Based on the real-time grid conditions when the charging occurred, the overall energy mix was about 45% zero-emissions or renewable sources of electricity (including solar, wind, hydro, geothermal, biomass, and nuclear) and 34% 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 by having EVs charge at off-peak times when the grid is supplied with more renewable resources such as solar. Finally, emissions will decrease even more as more charging sites and EVs are added in future years.

Figure 63. Annualized PG&E EV Fleet Net Electricity Mix



Health Impacts

The *Greenhouse Gas and Criteria Pollutant Impact* section includes estimates of the program's reduction of $PM_{2.5}$: the team evaluated the potential health benefits associated with that reduction. As part of this analysis, we also examined the benefits for DACs, which may be disproportionately burdened by sources of pollution that could include air pollution from ICE vehicles. Because only a small number of sites were

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78 The power associated with imports comes from a mixture of hydro, nuclear, and natural gas power plants located outside the CAISO balancing authority.

activated and operational during EY2021, the health benefits of reducing $PM_{2.5}$ were correspondingly small.[79] Overall, based on annualized activity, the EV Fleet program's health impacts were near-zero but detectable: the program saved DACs about $3,803.24 and saved non-DACs about $152.79 in lifetime health care costs (Table 85). Although the value of the reduction in mortality risk had the largest effect—at a $3,953 reduction in mortality costs for DACs and non-DACs combined—it remains small (less than one excess death avoided) because of the small number of sites and the number and type of vehicles they supported.

Table 85. PG&E EV Fleet Health Impacts

Health Impact	DAC		Non-DAC	
	Incidence	Valuation	Incidence	Valuation
Mortality (Valuation Discount Rate 7%)	0.0004960	$3,800.21	0.0000199	$152.66
Work Loss Days	0.0140502	$2.74	0.0006340	$0.12
Emergency Room Visits (Cardiovascular)	0.0000845	$0.11	0.0000026	<$0.01
Hospital Admissions (Respiratory)	0.0000123	$0.11	0.0000003	<$0.01
Emergency Room Visits (Respiratory)	0.0000729	$0.07	0.0000021	<$0.01
Total	**N/A**	**$3,803.24**	**N/A**	**$152.79**

Net Impacts

Qualitative Assessment of Spillover

The Cadmus team asked fleet managers if their participation in the program had any impact on their procurement of EVs and charging equipment that was not a direct result of program incentives. Among participating fleets, three fleet managers said that the program had an influence:

- "The program fast-tracked the construction of a charging site for up six vehicles when the original charging site only had the capacity for two vehicles."
- "I do not think we would have been as encouraged to alter our buses or white fleet vehicles without this program."
- "The EV fleet program generously covered the expense of power supply. Without that I am not sure the district would have been able to afford the switch [to electric buses]."

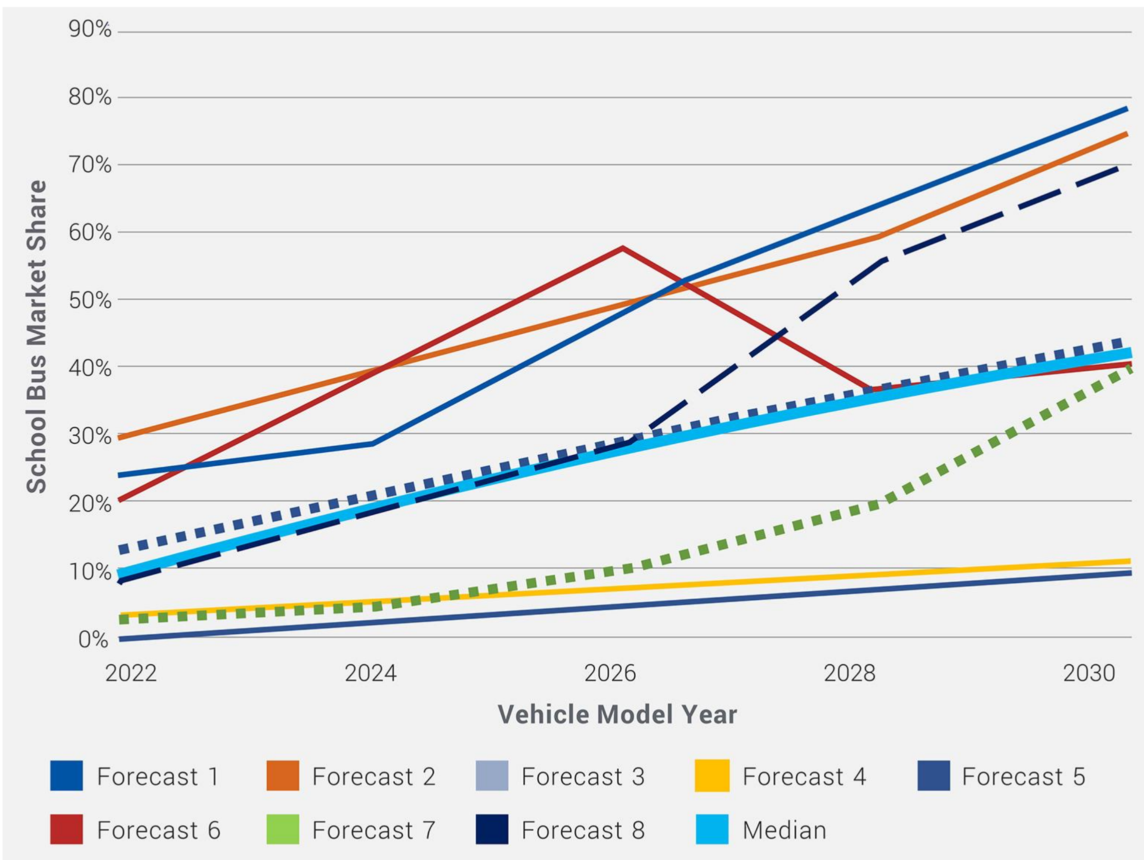
Among fleets that withdrew from the program, one fleet manager rated their experience in the program as *somewhat important* in their decision to electrify their school bus fleet. This customer ended up electrifying four school buses, as planned, but withdrew from the program due to concerns from the city's electrical department over jurisdiction for the work and how it would be completed.

[79] The EPA's BenMAP, which the team used to run the health impacts analysis, is only capable of estimating health impacts at reductions in concentrations down to the sixth decimal place. A significant number of project site reductions were at or past the seventh digit, resulting in undetectable impacts. While some project sites had $PM_{2.5}$ air concentration reductions at the sixth decimal place, the team opted to run BenMAP with a cut-off at the fifth decimal place in an attempt not to overstate potential impacts at such a low level of precision.

Market Effects: School Bus Electrification Market Share Baseline

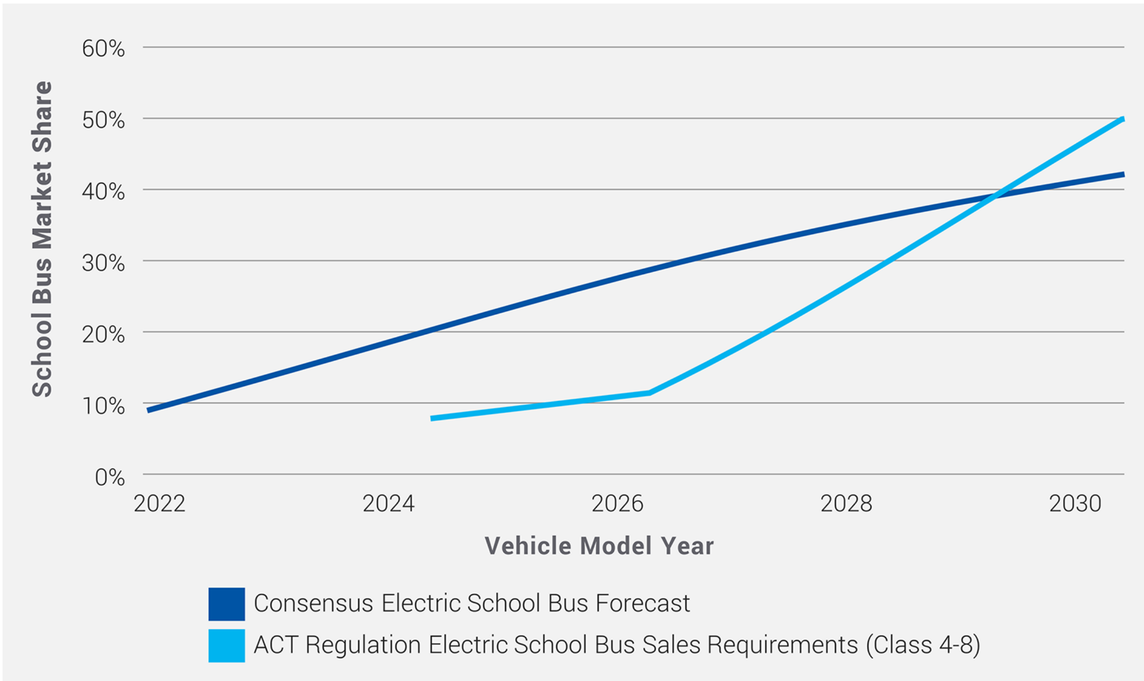
Measuring market effects is intended to inform Research Objective 1: "whether transportation electrification (TE) investments accelerated widespread TE." As noted in the Methodology section, the calculation of market effects requires knowing the actual adoption of EVs, program net impacts, and naturally occurring market adoption of EVs. While actual adoption and program net impacts will be measured as the Utility programs progress, the ideal time to measure the naturally occurring market adoption is before significant program activity has commenced. This is because the naturally occurring market adoption is a counterfactual scenario where the Utility interventions do not exist. To determine this baseline, the Cadmus team developed a consensus forecast for the baseline market share of electric school buses in California through vehicle model year 2030 following two rounds of input from the Delphi process. Figure 64 shows the individual curves from the first round of input (Round 1), along with the median curve. Note that the horizontal axis is for vehicle model year and only applies to *new vehicles*, not to the entire statewide vehicle stock.

Figure 64. Round 1 Baseline Electric School Bus Adoption Forecasts



Despite the range in Round 1 forecasts, there was general agreement that the EV market share will increase over time. In Round 2, five of eight panelists agreed with the median or consensus forecast, while three panelists submitted new forecasts and rationales. As over half of the panelists were in agreement, the median forecast was the final consensus result. Figure 65 shows the final consensus estimate compared to the zero-emission truck sales schedule from the Advanced Clean Trucks (ACT) regulation for Class 4 through Class 8 vehicles. It shows that experts do not think the ACT regulation will drive adoption of electric school buses, possibly because the regulation allows flexibility in how manufacturers decide to meet the California sales requirements across all covered MDHD vehicles.

Figure 65. Electric School Bus Baseline Market Share Forecast



Of the three experts who did not agree with the median, two believed that the market share will grow faster due to a tipping point in the late 2020s once EVs establish a clear TCO advantage over ICE vehicles. This will likely manifest as a supply- and demand-side shift wherein manufacturers and fleet managers will view ICE vehicles as financially irrational. The third expert thought the electric school bus market share will grow at a much slower rate than the median forecast due to the relative price and TCO of electric school buses, the delay in bus purchases resulting from the COVID-19 pandemic, manufacturing limitations, and the lack of sufficient funding.

The Cadmus team recognized that while deriving the consensus forecast achieved the main goal of the Delphi panel, 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.

Nearly all the panelists agreed that the availability of funding poses the greatest driver or barrier to wider school bus electrification. Experts stated that the financial standing of school districts as well as the costs for production, batteries, and overall vehicles comprise the major barriers that suppress increased adoption. These panelists referred to incentives, rebates, and other programs at the local, state, and federal levels such as the Bipartisan Infrastructure Law, HVIP, and the U.S. EPA's Clean School Bus Program as vital mechanisms that will alleviate the financial burden and accelerate the electric school bus market.

While panelists named funding availability, or the costs currently associated with owning and operating electric school buses, as the main deterrent, they also mentioned many other barriers to increased uptake of electric buses. For instance, panelists whose forecasts were below the median curve cited infrastructure challenges such as EVSE placement and availability, incompatible charging schedules, vehicle range, and charging rates within their supporting rationales. One panelist noted that, irrespective of cost, funding, or other advantageous changes, certain school bus routes and fleets will be difficult to electrify due to customers being resistant to change.

The final concern raised by panelists was related to vehicle or model availability being a constraint on adoption. Experts disagreed over this issue: some believed that the availability of vehicles was not a bottleneck, some were certain that supply will be insufficient to meet demand, and some thought that while the initial ramp up in supply will not be able to meet demand, vehicle availability will not suppress adoption in later years of the study period.

Experts were split between whether the ACT regulation would influence the electric school bus market. Half the panelists viewed the regulation as a “floor” or “background noise” rather than a driving force. These observations result from schools historically following bus replacement schedules regardless of any regulations, the lack of available vehicles or vehicle models, and the regulation’s classification of school buses within a broad category wherein sales of varying vehicle types can count toward the regulation’s sales requirements. The remaining half of panelists said the ACT regulation increased their market forecast within the Delphi panel. As previously mentioned, some panelists predict that the regulation will induce a supply-side shift, causing manufacturers to view ICE vehicle production as no longer profitable or feasible in the long term. Other experts expect the ACT regulation to indirectly support electric school bus uptake, as it will help reduce battery and other input costs for all EVs. Several experts also pointed to the emissions standards within California’s Clean Air Act (reinstated through a waiver by the U.S. EPA) as spurring a significant transition toward electric school buses in 2027.

Finally, experts provided insight into the impact that California’s electric Utilities could produce on the consensus forecast. Over half the experts (five of eight panelists) predict that the Utilities will shift the baseline forecast upward considerably through mechanisms such as funding, EVSE and infrastructure support, education and outreach programs, and targeted charging rates.

5.1.3. Lessons Learned

The Cadmus team identified a number of lessons learned from EY2021. These lessons are presented below with key supporting findings. 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.

Additional customer support can help to reduce site activation timelines.

Of the 28 activated sites spanning five market segments in PG&E’s EV Fleet program, the median start-to-finish timeline for site activation ranged from 364 days (12 months) to 615 days (over 20 months), with the largest market segment (school buses) taking a median of 507 days to activate (almost 17 months). In its program materials, PG&E estimates that the process takes 13 to 19 months (three to five months for the preliminary design and 10 to 14 months for the final design and execution). This indicates that site activation was generally within the range that PG&E estimated. Of the six program phases, the construction complete phase took the longest to complete, at a median of 169 days.

During interviews, Utility staff indicated that one reason for the length of this phase was that all but one of the contracts issued through 2021 were with participants who have been responsible for the design, permitting, and installation process for their site's BTM infrastructure. Utility staff indicated that because some of these customers (such as school districts) had little experience with RFPs and other procedural steps in this process, and because PG&E required sites to conduct some BTM work before PG&E completed its TTM work (to ensure that sites followed through on BTM infrastructure installation), this phase took longer than participants expected.

For sites where the Utility may have impacted activation timelines, additional customer support could be helpful to reduce the duration of the design and permitting and construction complete phases when customers are responsible for the BTM infrastructure installation process, while acknowledging that additional program support would likely impact the program's budget. During interviews, program staff noted that they sought to better support customers through the BTM process by providing them with a dedicated site manager after working with an onboarding specialist.

The EV Fleet program addressed participants' top barriers to electrification, and participants were satisfied with the program overall.

Based on the fleet manager survey, prior to participating in the program, participants said that the cost of EVs, the cost of installing EV charging infrastructure, and insufficient charging equipment along routes were the biggest barriers to electrification. Six out of 13 program participants who completed surveys reported that barriers still existed after participating in the program, with the most prevalent remaining barrier for program participants being that their routes were too long for the EVs available. These results indicate that major barriers to electrification such as costs and the availability of chargers along routes were reduced after participating in the EV Fleet program.

Overall, participants were satisfied with the program: 10 of 13 fleet managers rated themselves as *very satisfied* with the program overall, while three rated themselves as *somewhat satisfied*.

Fleet operators reported that both EV charging equipment and EVs themselves were reliable.

Survey respondents in PG&E's EV Fleet program found that, overall, both EVs and EV charging equipment were reliable (11 of 13 respondents rated the EVs as reliable, while 10 of 13 respondents rated EV charging equipment as reliable). However, two respondents rated the charging equipment as *not at all reliable*, while two others rated it as *very reliable*, which indicates inconsistent experiences with the equipment. Three respondents reported some challenges with EV charging equipment due to regular failures, and one of these participants believed their chargers were not sized properly for school buses and that the failures were due to the limited amperage provided. When asked about what they would have done differently if they were to go through fleet electrification again, four respondents noted issues with charging, saying they would have found a better charging solution, made sure the power source and chargers were more powerful than what was required, had a larger power supply brought in, and considered solar panels with storage batteries to supplement high demand during peak times to reduce costs and grid impacts.

Most fleet operators did not manage charging, resulting in increased operating costs. Flexibility in charge times provides opportunities for improved grid integration and further electrification.

While program data indicates that most of the EVs and EVSPs participating in the program have the capability to limit charging during certain hours, only two of the 25 sites visited had a load management plan to reduce electric fuel costs and grid impacts. In addition, during site visits, few of the fleet managers reported being aware of their electric fuel costs, even after several months of operation, often due to bills being processed by front office staff. Most fleet managers in the evaluation sample were not managing charging and, as a result, were paying more for charging than necessary. This was despite PG&E's efforts to educate and encourage customers to charge when electricity demand and costs are lower.

For school buses, the largest market segment, the grid impacts analysis revealed that approximately 40% of school bus charging sessions impacted electricity consumption during peak hours, when rates were highest. The grid impacts analysis also showed that school bus charging could be shifted away from peak hours (see Figure 62). For these fleets, the load curves and the time spent parked (but not actively charging) at chargers indicted that after the afternoon routes were completed, charging could be shifted to off-peak times. Therefore, increased awareness of electric fuel costs and how to mitigate them through charge management could help fleet managers reduce their electric fuel costs, manage grid impacts, and accommodate additional EVs.

There was general agreement among market experts that the EV market share for the school bus segment will increase over time.

Nearly all the experts on the Delphi panel for school bus electrification agreed that the availability of funding poses the greatest driver or barrier to wider school bus electrification. They cited the various government funding programs as vital mechanisms that will alleviate the financial burden and accelerate the electric school bus market. They noted that the financial standing of school districts as well as the costs for production, batteries, and overall vehicles comprise the major barriers that suppress increased adoption.

Half the market experts did not believe the ACT regulation would be the main driving force in electrification of the school bus market, citing factors such as bus replacement patterns, lack of available vehicles, or flexibility within the regulation that allows for sales of different types of vehicles to count toward compliance. The remaining half of panelists said the ACT regulation increased their baseline market forecast. Some panelists predict that the regulation will induce a supply-side shift, causing manufacturers to view ICE vehicle production as no longer profitable or feasible in the long term. Other experts expect the ACT regulation to indirectly support electric school bus uptake, as it will help reduce battery and other input costs for all EVs.

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 Pilot implementation process, ME&O activities, EY2021 sites, budget status, and a major milestone timeline. Following the overview, we present the EY2021 findings and lessons learned.

Pilot Description

Schools Pilot: Through its Schools Pilot, PG&E offers 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. While PG&E will build and maintain the EV service connection and supply infrastructure for all sites, the equipment can either be owned by PG&E or by the site host. Where PG&E owns the equipment, the site works with a pre-approved EVSP to help manage equipment operation. 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 time-of-use (TOU) rate. PG&E will also provide educational materials to promote awareness of the newly installed EVSE and benefits of EVs.

Schools Pilot Targets

- 4 or 6 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: PG&E's Parks Pilot offers direct installation of L2 chargers and DCFC in state parks and beaches within PG&E's service territory. Staff designed the Pilot to enable state parks and beaches to charge the EVs in their own fleet in addition to staff and patron light-duty vehicles with the installation of new chargers. 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 where upgrading the existing electric infrastructure would be cost prohibitive given the distance from electric infrastructure but that have sufficient capacity to support charging. For all sites, PG&E is the owner of the chargers, but will contract out a third-party EVSP to maintain the equipment. The third party is responsible for managing the charger electricity costs as well. In addition to chargers, PG&E will post educational signs around the chargers for park and beach patrons to raise awareness of being able to charge at more state park and beach locations across the state.

Parks Pilot Targets

- 40 L2 and 3 DCFC charging ports
- 15 State Parks and Beaches
- 25% in DAC locations

Parks Pilot Design Goal

Encourage state parks and beaches to charge their own EV fleets and offer charging to staff and patrons with light-duty vehicles.

Implementation

In order to prepare the Schools and Parks Pilots for roll-out, PG&E staff coordinated with key internal and external stakeholders to create Pilot materials and establish processes for securing and implementing each site. Before staff began recruitment, they created dashboards and Salesforce portals to track Pilot activity (such as application statuses and costs), set expectation thresholds for individual site costs, and organize work flows between different departments and various stakeholders within PG&E to keep sites moving toward completion To implement the Schools and Parks Pilots, PG&E relies on the expertise of internal staff across several departments: the Schools Pilot and Parks Pilot managers, the onboarding specialists, and the Engineering, Legal, Marketing, and Information Technology teams. Where possible, PG&E used implementation strategies from existing programs (such as expected utilization similar to those approved in PG&E's EV Charge Network program). For the Schools and Parks Pilots, eligibility is primarily driven by whether the site is cost prohibitive. To determine if a site would cost too much to be allowed in the program, PG&E staff outlined key eligibility requirements:

- Topographic features of the potential site (such as having no significant incline)
- Existing transformer box infrastructure (capacity and step-down)
- Length of trenching needed
- Degree of construction needed to meet ADA requirements

After an interested customer becomes aware of either Pilot—through PG&E marketing efforts, solicitations from EVSPs, word-of-mouth, or directly from a PG&E account manager—they can choose to submit an application as the first step in the implementation process. Figure 66 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 California Department of Parks and Recreation expects to approve a master participation agreement 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.

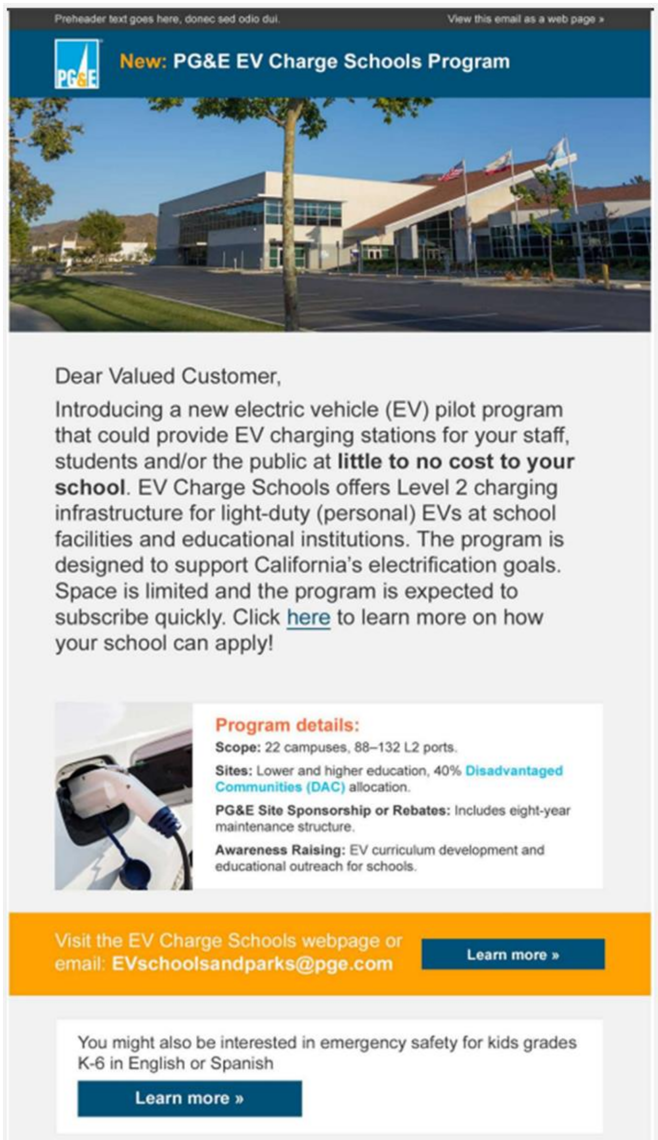
Figure 66. Schools and Parks Pilot Implementation Process

ME&O Summary

Schools and Parks Pilots: PG&E staff designed marketing materials before either Pilot launched. Additionally, PG&E leveraged existing materials that were relevant to its Pilots, including infographic collateral promoting the two different kinds of chargers offered through the Schools and Parks Pilots: the EVBox Iqon and the ChargePoint Level 2 Commercial CT4000 charging station. PG&E also promoted the Pilot on their website (see the *Utility Web Page Insights* section for more detail about the website findings).

Schools Pilot: As shown in Figure 67, the primary marketing effort to recruit site hosts for the Schools Pilot was an email to schools in PG&E's service territory promoting the Pilot. This email succinctly highlighted several aspects of the Pilot, including the little to no cost aspect of the Pilot for schools, the L2 charging infrastructure, the included maintenance structure, and links to more resources. Finally, PG&E staff worked with a third party to design an educational curriculum for the Schools Pilot during EY2021. The curriculum covers topics related to transportation electrification and is meant to build awareness of both the benefits of EV adoption and of PG&E's programs. Once finalized, this curriculum will be available to all schools in PG&E's service territory, not just those participating in the Schools Pilot.

Figure 67. PG&E Schools Pilot Marketing Email



Parks Pilot: PG&E staff did not develop any specific marketing efforts for the Parks Pilot during EY2021, as they focused their efforts on working directly with the California State Parks.

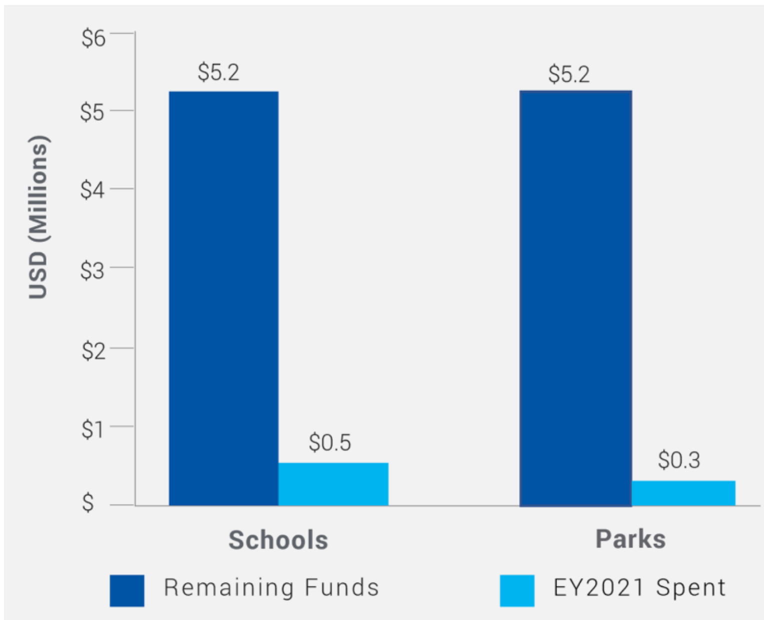
Site Summary

PG&E did not have any Schools Pilot or Parks Pilot activated or constructed sites in EY2021.

Budget Summary

As shown in Figure 68, through the end of 2021 PG&E spent $537k out of the $5.76 million approved for the Schools Pilot and $300k out of the $5.54 million approved for the Parks Pilot.

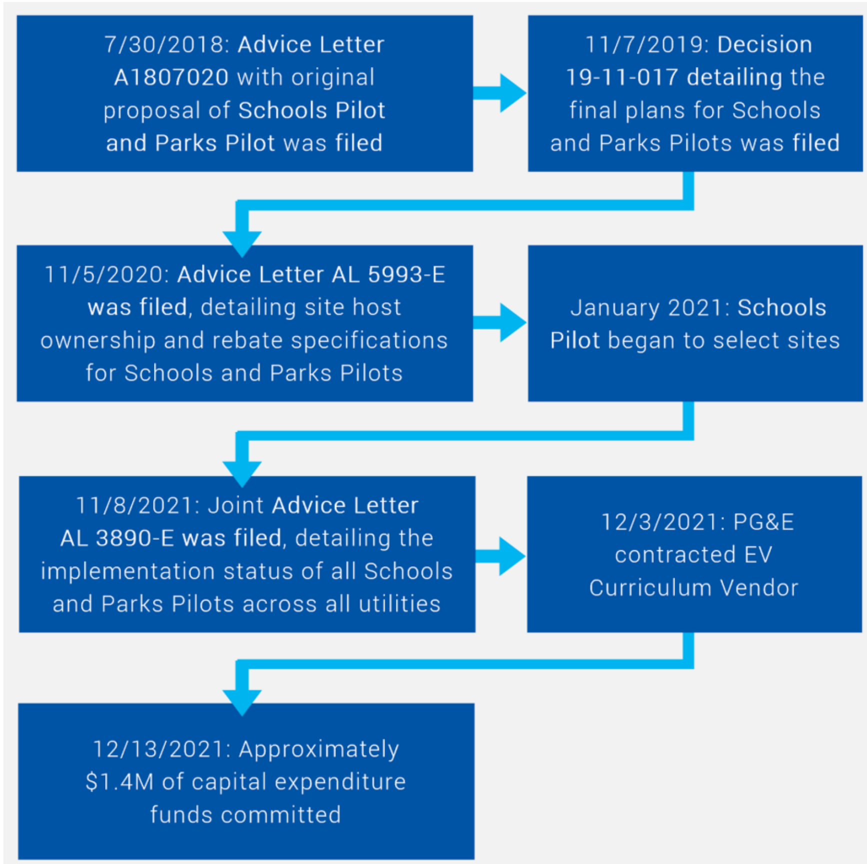
Figure 68. Budget Remaining versus Spend through 2021



Timeline

Since the inception of the Schools and Parks Pilots in 2018, there have been several milestones, as shown in Figure 69.

Figure 69. Timeline of Key Schools Pilot and Parks Pilot Milestones



Note: Though the Schools Pilot began to select sites in Q1 2021, the Pilot will not officially start until the first site breaks ground for construction.

5.2.2. Findings

As discussed in the *Overview* section, neither the PG&E Schools Pilot nor the Parks Pilot had any activated sites in EY2021. As a result, the Cadmus team did not complete any visual site visits for this reporting period and will complete the first round of impacts (including incremental EV adoptions, petroleum displacement, GHG and criteria pollutant reductions, health impacts, and grid impacts) as part of the EY2022 analysis and reporting. This report provides limited insights based on analyses completed for 2021 including a TCO contextual analysis, Utility website review, and staff interviews. These findings are provided below.

Total Cost of Ownership

The Cadmus team analyzed key industry cost trends for public charging due to the limitations of the EY2021 cost data and to set the stage for EY2022 TCO analysis. This section provides context to the financial costs associated with installing EV infrastructure.

Infrastructure costs include BTM and TTM costs, as well as the cost for the charger and related materials. As shown in Table 86, these cost categories vary in the degree of variance, with BTM and TTM costs typically being the most significant cost drivers and having the largest degree of variance on a per-site basis.

Table 86. Infrastructure Costs

Category	Degree of Cost Variance	Context and Rationale
Behind-the-Meter Costs	High	BTM includes site excavation for service line extensions to connect charging stations to the relevant meter. Costs may vary depending on lengths for trenching and cabling. BTM costs are also impacted by the cost of labor and any relevant supply chain and labor shortages. [a]
To-the-Meter Costs	High	TTM costs may vary depending on the current capacity available for site hosts and, particularly, if a new transformer is required to supply power for EV charging. Costs may also vary depending on lengths for trenching and cabling. TTM costs are also impacted by the cost of labor and any relevant supply chain and labor shortages. [a]
Charger Costs	Moderate	Per-unit charger costs may decline with greater deployment of chargers per site. However, there are potential impacts from supply chain constraints and costs that may vary by charger power level. With current supply chain constraints, charger manufacturing costs may be affected, possibly increasing overall costs. [b]
Material Costs	Moderate	Material costs may include the cost of panels, meters, and the cabling required to connect the charger to the Utility distribution system. Similar to the cost of the charger, material costs are subject to supply chain constraints and may increase overall costs. [c]

[a] PG&E. February 2022. "Program Advisory Council Meeting Q4 2021." Presentation.
[b] California Energy Commission. Accessed March 2022. "CALeVIP DC Fast Chargers, Average Rebate, Unit Cost, and Total Project Cost per Charger." and California Energy Commission. Accessed March 2022. "CALeVIP Level 2, Average Rebate, Unit Cost, and Total Project Cost Per Connector Installed."
[c] PG&E. February 2022. "Program Advisory Council Meeting Q4 2021." Presentation.

Significant TTM costs include transformer upgrades and costs related to upgrading and maintaining the distribution system.[80] Significant BTM costs can include trenching, site excavation for service line extensions, and cabling requirements to connect charging stations to the relevant meter. In the context of the Utility-sponsored public charging programs, Utility staff across programs noted higher-than-expected infrastructure costs, occurring both BTM and TTM. Specifically, Utility staff noted significant variable costs such as the need for transformer upgrades and longer-than-anticipated lengths for trenching as well as ensuring compliance with the ADA.[81]

Material costs for charging stations are rising at least in part to the ongoing COVID-19 pandemic and global disruptions on supply chains.[82] This increase was noted during a PAC meeting in which stakeholders mentioned that significant increases in material costs (such as copper wire and panels) are impacting contractors' ability to hold pricing

> Ongoing supply chain constraints and labor shortages will increase infrastructure costs.

80 PG&E. February 2022. "Program Advisory Council Meeting Q4 2021." Presentation.

81 PG&E. February 2022. "Program Advisory Council Meeting Q4 2021." Presentation.

82 White House (Helper, Susan, and Evan Soltas). June 2021. "Why the Pandemic has Disrupted Supply Chains."

past three to six months.[83] Related to material costs, the cost of the charger itself is subject to price volatility with global supply chain constraints disrupting manufacturing processes. In addition, in California, the shortage in labor supply and high labor rates in the construction industry can add additional costs for EV charging deployment.[84] In addition, it can be difficult to quantify the supply chain impacts to material and labor costs, as revealing these costs may be detrimental to vendors' competitive advantage, allowing for competitors to adjust their prices accordingly.[85]

In addition to infrastructure costs, the installation of EV chargers also includes a number of soft costs with a range of impact on the site development. Soft costs can also be difficult to quantify, as some cost categories may apply across a Utility program as opposed to a single site location. As shown in Table 87, potential site delays and opportunity costs have the largest degree of variability for soft costs related to EV charging deployment.

Table 87. Summary of Soft Costs

Category	Degree of Cost Variance	Rationale
Site Delays	High	Delays in building out EV charging are difficult to predict and the financial impact of such delays can be difficult to quantify. A delay may increase site costs as it may require extending the timeline for BTM and/or TTM construction and result in an increased labor cost. [a]
Opportunity Costs	High	Utilities implementing transportation electrification programs invest time to engage site hosts in the program process, conduct site visits, and so on. Utilities will need to coordinate with property owners and key decision-makers, and this coordination effort is specific to each site There is a time cost associated with the uncertainty of the permitting process and delays, as well as multiple revisions and meeting schedules which can result in extending the timeline for approval across sites. For instance, Utility staff noted that certain site schedules have to adhere to school board or city council meeting timelines to receive the relevant approvals to move sites forward. [b] This time could be spent on other sites. Opportunity costs are critical to consider and difficult to quantify, particularly as costs may vary by site based on the level of complexity. [c]
Permitting	Moderate	Permitting costs can vary as unexpected permits from cities and/or counties have been required.
Site Design	Moderate	Sites may ask for multiple iterations to refine the site design, to change the location of charging stations, and/or to change the number of ports. These adjustments may require additional site visits.
Operations and Maintenance	Low	Operations and maintenance costs occur on a routine basis and are relatively fixed to the type of charger installed.
Taxes	Low	Taxes are a relatively fixed cost.
Communication/ Networking	Low	Networking costs are built into the cost of installing the charging infrastructure and are billed on a fixed reoccurring basis.

83 SCE. March 18, 2022."SCE Transportation Electrification Program Advisory Council." Presentation.

84 Public Policy Institute of California (Johnson, Hans). March 2022. "Who's Leaving California-and Who's Moving In?"

85 Rocky Mountain Institute (Nelder, Chris, and Emily Rogers). 2019. "Reducing EV Charging Infrastructure Costs."

Category	Degree of Cost Variance	Rationale
Marketing and Customer Outreach Costs	Low	Marketing and outreach costs are considered in Utility cost methodologies. However, marketing costs are commonly applied across programs and may be difficult to link with a single site location. [d]

[a] PG&E. July 2021. "Program Advisory Council Meeting Q2 2021." Presentation.
[b] SCE. March 18, 2022. "SCE Transportation Electrification Program Advisory Council." Presentation.
[c] Rocky Mountain Institute (Nelder, Chris, and Emily Rogers). 2019. "Reducing EV Charging Infrastructure Costs."
[d] PG&E, SCE, and SDG&E. Report Filed on March 31, 2022. "Joint IOU Electric Vehicle Load Research and Charging Infrastructure Cost Report 10th."

Our research indicates that soft costs can contribute significantly to the overall cost of public charging stations, particularly for public DCFC sites, which have high levels of energy demand and can be more complex installations.[86] Soft costs are difficult to consider on a per-site basis. Utilities often quantify soft costs such as program management and ME&O on a program level; yet more fixed soft costs are quantifiable on a site level (such as site design costs, taxes, permitting, operations, maintenance, and networking and communication costs).

However, complex sites will require a greater investment of time and resources, thus increasing the site-related soft costs. This level of complexity will depend on variable factors including the decision-makers involved, the power level of the installed charging, and any site delays. Related to this investment of time and resources, there is a high degree of variability in opportunity costs for Utilities engaged in transportation electrification programs. These technologies are relatively nascent, and Utilities expend effort to engage site hosts, conduct site visits, and make adjustments to improve these programs. This time could be spent on other Utility activities.

> EV charger site costs vary as the result of uncertainties is both infrastructure and soft costs. Additionally, an increase in soft costs can compound infrastructure costs.

Soft costs are interrelated to infrastructure costs. In the context of Utility-sponsored public charging programs, Utility staff have specifically noted that BTM labor costs can be complicated by site host BTM construction delays. Reasons for these delays can include RFP challenges, internal decision-making related to paying for BTM work, and lack of familiarity with BTM construction. These BTM delays are a common driver of overall site completion delays.[87] As sites are delayed, other costs may accumulate without the financial impacts being readily quantified. Current supply chain constraints may increase the costs of infrastructure while also increasing soft costs due to resulting delays.

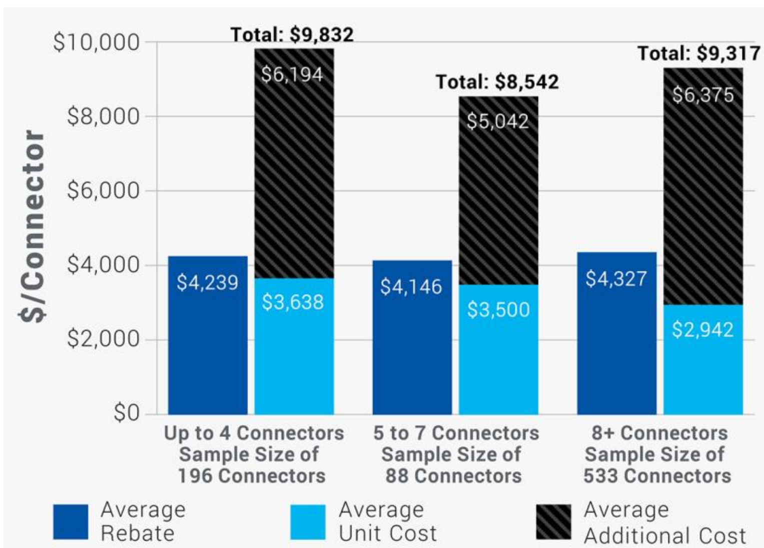
86 Rocky Mountain Institute (Nelder, Chris, and Emily Rogers). 2019. "Reducing EV Charging Infrastructure Costs."

87 PG&E. July 2021. "Program Advisory Council Meeting Q2 2021." Presentation.

In addition to considering the EV infrastructure and soft costs discussed above, the team also examined a cost case study based on the California Electric Vehicle Infrastructure Project (CALeVIP). CALeVIP offers incentives to acquire and install EV charging infrastructure at publicly accessible sites throughout California. The 2021 CALeVIP data on L2 costs (Figure 70) and DCFC costs (Figure 71) showcases the decline in per-unit costs (shown in blue) and the variance in total per charger costs (shown in gray).[88] Based on CALeVIP data shown in Figure 70, L2 per-unit costs decrease in sites with a greater number of chargers per site. Similar to L2 data, DCFC per-unit costs decrease in sites with a greater number of chargers per site (Figure 71). However, for both DCFC and L2 charging, the soft costs and remaining infrastructure costs—beyond the charger itself—(shown as the *average additional costs* in the gray bars) do not reflect a direct relationship between the number of chargers per site and the total cost per charger per site.

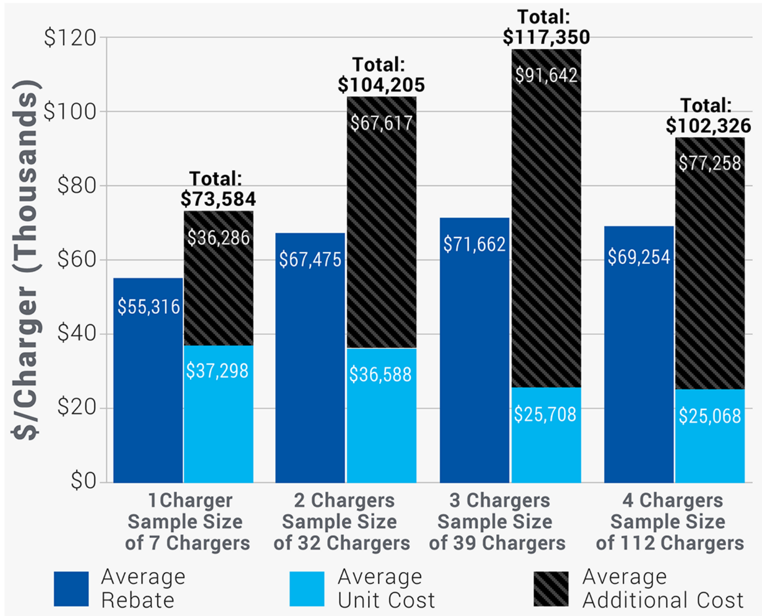
Per-unit charger costs will likely decline with greater numbers of chargers per site. Unlike per-unit costs, total costs per charger may not decline with a greater number of chargers per site.

Figure 70. CALeVIP Level 2 Charger Costs



88 California Energy Commission. Accessed March 2022. "CALeVIP DC Fast Chargers, Average Rebate, Unit Cost, and Total Project Cost per Charger." and California Energy Commission. Accessed March 2022. "CALeVIP Level 2, Average Rebate, Unit Cost, and Total Project Cost Per Connector Installed."

Figure 71. CALeVIP DCFC Costs



Utility Web Page Insights

The team conducted a high-level review of PG&E's web page, "Electric vehicle programs and resources," to identify what was available. The page covers several PG&E offerings and includes a menu that visitors can toggle to see more information about the Schools and Parks Pilots (an example of part of this menu is shown in Figure 72). Overall, we found that the web page is well-organized, the visuals are relevant and help the reader understand the Pilots, and the information is concise and digestible. Key topics covered include a Pilot summary, ownership options, rebate information based on equipment type, participation criteria, DAC targets, estimated utilization rates, partnership engagement, and vendor information (Schools Pilot only). There are also several links to external sites with important information such as a section dedicated to *Tools, Incentives Rebates* and another to *EV Electric Rule 29 Program*.

Figure 72. Example of Information Available for EV Schools on PG&E Website

Rebate information:

- For eligible site host owners PG&E will provide a one-time rebate in the amount up to the cost of the EVSE, the warranty, ongoing maintenance and operating costs, and networking fees for a period up to eight years, per the table below.
- The total rebate amount is equal to or exceeds the cost for most of the equipment qualified in PG&E's RFQ.
- The rebate amount approximates per cost category the one-time equipment cost (cost of the charging station, commissioning, installation fees), warranty, maintenance, and networking fees for a period of eight years.
- The rebate will pay an "up to" dollar amount per cost category and will not exceed the total equipment costs and fees.
- View a rebate notification letter (PDF, 237 KB) for customers and Electric Vehicle Service Providers.

Equipment Type	Equipment Cost	Warranty	Maintenance/ Network Service (8 years)	Rebate
L2 (Single)	$4,000	$1,500	$3,500/$2,500	$11,500
L2 (Dual)	$6,000	$1,500	$4,000/$4,000	$15,500

Utility Staff Insights

In EY2021, the Cadmus team interviewed PG&E program staff about it Schools and Parks Pilots twice (once in September 2021 and again in March 2022) in addition to monthly check-ins about the Pilots' status and quarterly joint Utility calls.[89] Through these conversations, PG&E staff identified key insights from what they experienced in 2021.

Schools Pilot and Parks Pilot

Before rolling out the Pilots, PG&E Pilot staff identified the processes and systems intended to make implementation as smooth as possible:

- **Internal Coordination:** PG&E Pilot staff set up procedures to coordinate with other internal departments within PG&E. By leveraging the expertise of internal staff across several departments (the Onboarding Specialists and staff from the Engineering, Legal, Marketing, and Information Technology groups), PG&E Pilot staff felt that they were able to efficiently prepare for rolling out the Pilots.
- **Application and Portal Development:** Staff built and customized Pilot application and activity portals to fit the needs of the Pilots. Staff developed the portal in an iterative process over the course of implementation in response to early feedback and testing. For example, when the application portal was first built, any specific site that was wait-listed got categorized with the others without clear notes on why each was wait-listed. However, it became clear to the Pilot staff that they would need to add portal flags for why a site was wait-listed. PG&E Pilot staff examined the wait-listed applications for reasons why, came up with categories based on

[89] The Cadmus team began conducting Schools Pilot and Parks Pilot joint Utility quarterly calls in Q4 2021.

commonalities, and implemented those changes directly into the portal to improve Pilot activity tracking.

- **Contracts and Easements:** With the help of PG&E's Legal Department, PG&E Pilot staff drafted boilerplate contract, easement, and other documents that would be necessary for each site.
- **Support Documentation**: PG&E Pilot staff designed expected site flows from the perspective of the customer and for the steps they would need to take internally and with their contractors.

Staff reported a common challenge was that the expected cost for each site was higher than anticipated. In particular, staff noted that opportunity costs had been trending significantly higher. Staff also reflected that construction labor and material costs had increased as inflation has been rising and that COVID-19 disrupted supply chains and the labor force. For example, though it was expected that some trenching would have to be done at each site, more trenching is needed than was originally expected and budgeted when the Pilots were designed. In addition, although permitting costs were expected, construction costs to meet ADA requirements were unexpectedly high. The significant rise in cost estimates has been a driving reason for why PG&E staff have had to wait-list 82% (n=56)[90] of their Schools Pilot customer applications in 2021.

Schools Pilot

When first implementing the Schools Pilot, PG&E Pilot staff said that while there was some initial work to raise awareness among school districts about the Pilot, once they established relationships with customers, they received a steady pipeline of interested schools. However, as noted above, due to uncertainty in the face of higher costs per site, many interested schools were wait-listed. In addition, staff reported that site hosts commonly encountered two key barriers during the application process and into the construction phase:

- **Safety considerations.** Staff reported that many schools were concerned about student safety if chargers were always accessible to the public. Therefore, PG&E staff allowed the schools to keep the chargers limited to private use by faculty, staff, and/or parents (depending on the school's preference).
- **COVID-19.** At the same time the Schools Pilot was rolling out, schools across California were still dealing with the impacts and uncertainty caused by COVID-19. PG&E staff noted that the priority of ensuring school staff and student health and safety limited the schools' capacities to work with PG&E on getting the EV charging infrastructure installed.

Another unanticipated barrier for schools was the layers of approval needed before a school could complete enrollment in the Pilot. Though PG&E staff typically first connected with a school staff member who works at the potential site, staff noted that this contact was not always the final decision-maker at that stage. PG&E typically passes on the contract, easement, and other program documents to their contact early in the process to socialize with decision-makers. However, staff do not typically have the capability to verify if that was done thoroughly, primarily because the decision-making process

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90 PG&E. February 16, 2022. "PG&E Program Advisory Council Meeting: Q4 2021." PowerPoint presentation.

varies between schools. This is compounded by the fact that multiple layers of approval are needed in almost every case: many schools require board approval for sites of this scale (which may include a period for public comment). If PG&E's primary point-of-contact does not correctly escalate the documents early enough in the process, PG&E staff may move forward under the assumption that the school intends to enroll in the Pilot. The result of this communication barrier is that PG&E invests resources into sites that ultimately do not complete their participation journey, particularly if the customer moves forward with site walks and full designs, with PG&E issuing a formal participation agreement before finding out that the decision-makers actually do not approve of having the site participate.[91] Therefore, PG&E staff now seek to identify more than one site host champion.

Parks Pilot

Though the Parks Pilot had limited activity through 2021,PG&E staff's work on the Pilot still resulted in preliminary insights. Mainly, PG&E staff identified that the limitation of only being able to serve state parks has been the primary driver for delays in Pilot activity. Though PG&E staff know what parks they intend to engage based on the state parks and beaches in its territory, staff have been unable to move forward with engaging site hosts due to process delays at the state level.

To address this constraint, PG&E staff, in conjunction with Pilot staff from SCE and SDG&E,[92] have engaged the California Department of Parks and Recreation to finalize participation agreement language that could be used for all state parks that will be served by the Pilot. However, likely due to multiple staff changes at the California Department of Parks and Recreation, PG&E and their Utility colleagues have had trouble keeping the participation agreement approval moving through the Department approval process. When Department staff transitions occurred, PG&E staff and their Utility colleagues often have to re-orient the new staff member on the purpose of the Pilot and all steps completed to date. Therefore, PG&E staff now seek to identify more than one champion. Additionally, PG&E staff anticipate that there may be some site design challenges as a result of the prescriptive language used during the initial design of the Pilot. For example, in Decision 19-11-017, PG&E staff established two standard site designs and projected how many and what type of chargers would be part of each design. However, staff reported that there may be challenges with meeting those criteria if the actual site locations are not conducive to either design.

5.2.3. Lessons Learned

The team identified a number of lessons learned from EY2021. These lessons, presented below with key supporting findings and recommendations, may be applied to future Pilot years and to other similar efforts.

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91 This result may also occur if a primary point-of-contact is intentionally dishonest with PG&E about receiving the appropriate approval.

92 Though Liberty is also implementing an Parks Pilot, PG&E, SCE, and SDG&E are leading the coordination with the California Department of Parks and Recreation.

Schools Pilot and Parks Pilot

Unexpected market impacts and site design requirements resulted in higher-than-expected site costs and limited participation.

PG&E began the Schools and Parks Pilots during the COVID-19 pandemic. COVID-19 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 19-11-017 (which mandated the Schools and Parks Pilots at their determined funding levels) did not reflect the actual costs for implementation. Though PG&E staff conducted research ahead of Pilot design, these expenses were then compounded by inadvertent inaccuracies in Pilot design estimations. For example, while designing actual sites, PG&E found that the costs associated with a typical trench length assumption had been underestimated. Similarly, more construction is needed than what was estimated to meet ADA permit requirements. For example, the significant rise in cost estimates has been a driving reason for PG&E needing to wait-list 82% (n=56)[93] of their Schools Pilot applicants in 2021.

Staffing constraints contributed to conflicting priorities from site hosts, which resulted in site delays or withdraws.

Participating in either the Schools or Parks Pilot requires the site host to make a commitment that often spans several months. Site hosts must not only be willing to install EVSE on their property, but—at a minimum—they must also work with PG&E to coordinate site walks, approve the site design, and review and approve contracts, easements, and other critical documents. PG&E reported that many site hosts of both the Schools Pilot and the Parks Pilot had staffing constraints that either delayed or completely prevented participation.

In EY2021, PG&E's Parks Pilot was most influenced by staff turnover at the California Department of Parks and Recreation. When Department staff transitions occur, Utility staff must often re-orient the new staff member to the purpose of the Parks Pilot and all the steps completed to date. Moving forward, PG&E staff will seek to identify multiple champions to support the approval process.

The Schools Pilot was also influenced by staff constraints. In addition to turnover, Schools Pilot site hosts were constrained by the available bandwidth of current staff. In 2021, this was exasperated by COVID-19. Since the Pilot began, schools have been burdened with making ever-changing decisions regarding virtual versus on-site learning, mask mandates, and similar choices. PG&E staff noted that the priority of ensuring school staff and student health and safety limited the schools' capacities to work with PG&E on getting the EV charging infrastructure installed.

The strong internal processes PG&E developed prior to launching the Pilot were key to smooth internal implementation and coordination.

Before rolling out the Pilots, PG&E staff set up procedures to coordinate with other internal departments. By leveraging the expertise of internal staff across several departments, PG&E was able to efficiently prepare for the roll out. For example, staff developed the necessary Pilot documentation

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93 PG&E. February 16, 2022. "PG&E Program Advisory Council Meeting: Q4 2021." PowerPoint presentation.

(such as common contract and easement language) and built out application and activity portals from scratch. Having established these processes and pre-familiarized internal departments with the Schools and Parks Pilots, PG&E staff can now easily leverage the expertise of these departments if Pilot issues arise. For example, PG&E was able to adapt their application tracking portal mid-implementation in order to better document the reasons for application wait-listing and identify common problem areas across sites.

Schools Pilot Only

Initial contacts at interested Schools Pilot sites were not necessarily the ultimate decision-makers, which resulted in site delays or withdraws.

K–12 schools often need multiple layers of approval before signing a contract for sites like those designed under the Schools Pilot. Often, approval must come from the school board (which, in some cases, means the site may be open to scrutiny and public comment) or from specific personnel who may not work at the site. These multiple layers add complication and time to enrollment and implementation processes. PG&E staff tried to account for multiple layers of approval at the beginning of the Schools Pilot enrollment process by providing their primary site contact with example contract and easement language to share with decision-makers. However, the lack of clarity around the multiple layers of approval occasionally inhibited PG&E staff from being able to help site hosts through the decision-makers' Pilot participation concerns. For example, PG&E staff only knew what the primary site contact disclosed about what happened after the documents were passed off to decision-makers. If PG&E staff received approval from their site contact they were able to move forward with the design. However, PG&E staff reported instances where they learned in later steps of the process that their site contact was not authorized to provide permission, meaning the site came to a halt. While in some cases it was only a temporary delay, in other cases the site would fully pull out of the Pilot even after PG&E had made significant investments into enrollment and site design. Moving forward, PG&E staff will seek to identify multiple site host champions to support the approval process.

Parks Pilot Only

Highly prescriptive Pilots may be more susceptible to significant delays in achieving desired targets.

The prescriptive language in the Parks Pilot mandating that PG&E must work with state parks and beaches limited the extent to which PG&E could engage with sites in its territory. While PG&E could scout potential sites, the decision to participate—and the language included in any participation agreement—must be approved by state-level offices. Given the delays that PG&E experienced with the California Department of Parks and Recreation, the Parks Pilot has been on hold, awaiting participation agreement approval. In additional, PG&E staff anticipate some site design challenges as a result of the prescriptive language used during the initial Pilot design. For example, in Decision 19-11-017, PG&E staff established two standard site designs and projected how many and what type of chargers would be part of each design. However, staff reported that there may be challenges with meeting those criteria if the actual site locations are not conducive to either design.

5.3. EV Fast Charge Program

5.3.1. Overview

This overview provides a detailed description of the PG&E EV Fast Charge program and summaries of the program implementation process, ME&O activities, EY2021 sites, budget status, and a major milestone timeline. Following the overview, we present the EY2021 findings 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 transportation electrification 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, ultimately accelerating 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 lacking ready access to home charging, those who need charging stations in transportation corridors for longer trips, or for those who participate in ridesharing.

EV Fast Charge Targets

- 52 sites
- 234 DCFC chargers
- 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 the DC fast chargers. 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 also 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

Between Decision 18-05-040 and the first solicitation for applications in August 2019, PG&E staff worked to set up internal processes to track applications, draft common contract language, and conduct similar administrative tasks to ensure smooth implementation of the program over time. In addition, staff developed numerous materials to help orient the site host to the program, including an application template, hardware and software guides, information and consent forms for site hosts, kickoff and orientation materials for contractors and EVSPs, and materials for the solicitations. PG&E staff also identified key eligibility considerations for each site:

1. Available space for chargers and additional power equipment
2. Length of trenching needed
3. Degree of construction needed to meet ADA requirements
4. Proximity to PG&E power source or transformer
5. Anticipated utilization

PG&E uses of 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, such as by adding questions or making sure site host decision-makers were included in the call (not just a potential contact at the actual site).

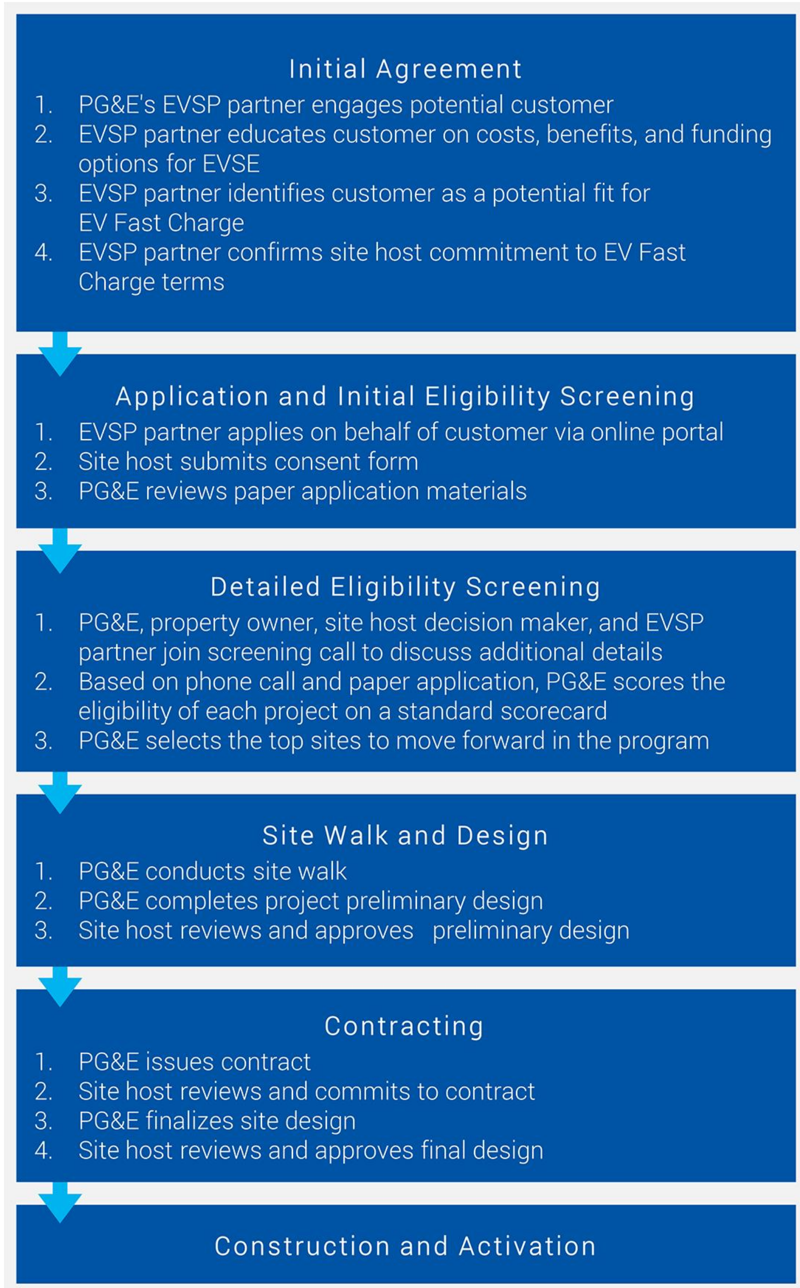
Example Screening Questions

- "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?"

Staff completed the first EVSP RFQ in July 2019 (plus three more between then and June 2021, for a total of four RFQs). Vendor RFQs resulted in a total of 17 EVSPs who qualified for the program. Of those, 10 vendors submitted applications to the program. After the first solicitation in August 2019, staff began accepting applications from EVSPs on behalf of interested site hosts who were likely to be eligible for the program. Sites that were identified as high cost but not entirely cost prohibitive were wait-listed. Starting in March 2020, with the onset of COVID-19, there were program delays including a work stoppage that lasted until May 2020. After the first solicitation for sites in August 2019, there were three additional solicitations through July 2021, for a total of four before program staff decided to fill the remaining spots with sites that had previously been wait-listed.

After an EVSP engages with a potential customer, the implementation process of the program begins, as detailed in Figure 73.

Figure 73. EV Fast Charge Program Implementation Process



ME&O Summary

Although PG&E did not enact a formal ME&O campaign, staff developed several different types of ME&O materials aimed at both potential site hosts and EVSP partners. For example, Figure 74 presents the EV Fast Charge approved vendor list. 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: information sheets about the program, approved products, and an application prep sheet.

Figure 74. EV Fast Charge Approved Vendor List Example Page

eV fast charge

Vendor List | 1

Vendor	Hardware Used	Vendor Contact Information
ampUp	BTC Efacec Tritium	**Contact Name:** Matt Bloom **Email:** matt@ampup.io **Phone:** 833.692.6787 **Website:** www.ampup.io
chargepoint	ChargePoint	**Contact Name:** Mike Casterline **Email:** mike.casterline@chargepoint.com **Phone:** 408.596.0252 **Website:** www.chargepoint.com
enel x	Tritium	**Contact Name:** Karen Hsu **Email:** karen.hsu@enel.com **Phone:** 949.975.9018 **Website:** www.enelx.com
evconnect	ABB BTC Efacec Tritium	**Contact Name:** Ram Ambatipudi **Email:** rambatipudi@evconnect.com **Phone:** 818.606.9732 **Website:** www.evconnect.com
EVGATEWAY	BTC	**Contact Name:** Laura Pichardo **Email:** laura@evgateway.com **Phone:** 949.945.6300 **Website:** www.evgateway.com
EVgo	ABB BTC	**Contact Name:** Lars Peters **Email:** lars.peters@evgo.com **Phone:** 707.364.9879 **Website:** www.evgo.com
FREEWIRE	Freewire Boost Charger	**Contact Name:** Renee Samson **Email:** rsamson@freewiretech.com **Phone:** 415.297.4360 **Website:** www.freewiretech.com
greenlots	ABB Efacec Tritium	**Contact Name:** John Mason **Email:** jmason@greenlots.com **Phone:** 323.590.8575 **Website:** www.greenlots.com
juicebar	Efacec Tritium	**Contact Name:** David Tanner **Email:** david@juicebarev.com **Phone:** 202.664.3283 **Website:** www.juicebarev.com

PG&E

www.pge.com/evfastcharge

Site Summary

For EY2021, the program data included the number of sites, location of sites, DAC status of sites, and days by application phase; the team will continue to work with the Utilities to expand our collection of program data for future evaluation years.

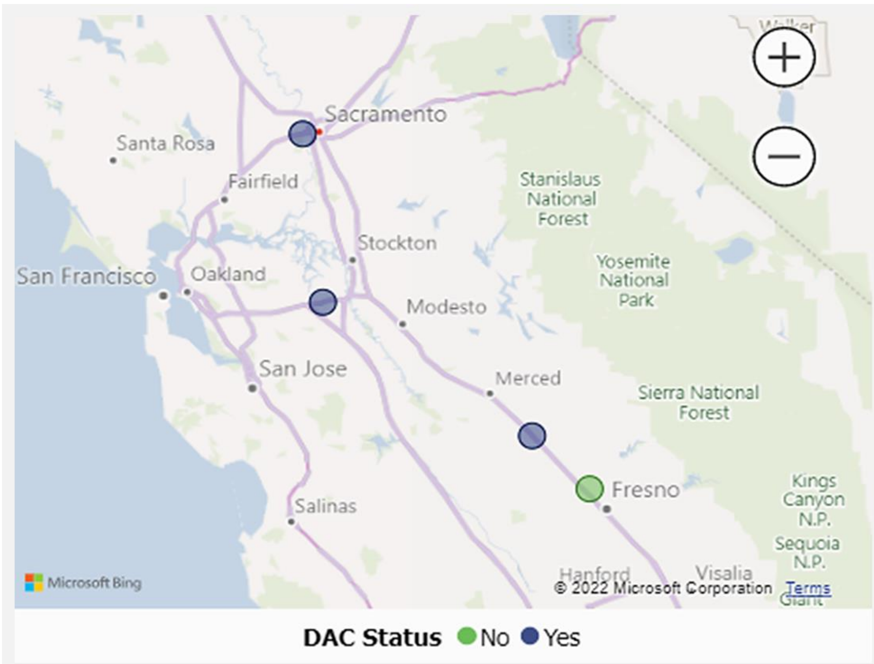
Table 88 provides the count of construction complete sites in PG&E EV Fast Charge program by completion status.

Table 88. EY2021 PG&E EV Fast Charge Program Complete Site Count By Status

Site Status	EY2021
Utility Construction Complete	4
Activated	4
Operational	4
Closed Out	4

Figure 75 shows the locations of four activated and operational EV Fast Charge stations in PG&E territory broken out by DAC status. Each site has four ports and three sites are located in DAC territories.

Figure 75. PG&E EV Fast Charge Locations



These four sites finished the full phase cycle in a median of 532 days starting with the application reviewal through activation. The longest phase was for design and permitting, at 154 days, while the shortest phase was the activation phase, at only eight days. Table 89 shows the median number of days by phase. The full phase median cycle of days is larger than the sum of the median number of days by cycle due to the inclusion of days when no phases were taking place.

Table 89. Median Number of Days by Phase

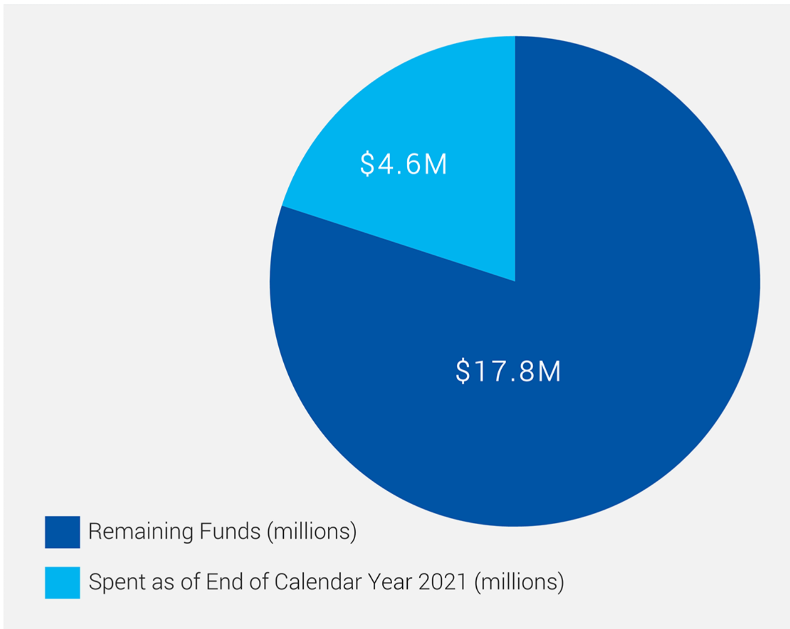
Phase Status	Median Number of Days
Application Reviewal	59
Site Assessment	42
Contract Issuance	105
Design and Permitting	154
Construction Complete	149
Activation	8

With four sites activated in 2021, PG&E staff anticipate that the program will be fully subscribed in 2022.

Budget Summary

As shown in Figure 76, through the end of 2021 PG&E had spent $4.6M out of $22.4M on EV Fast Charge.

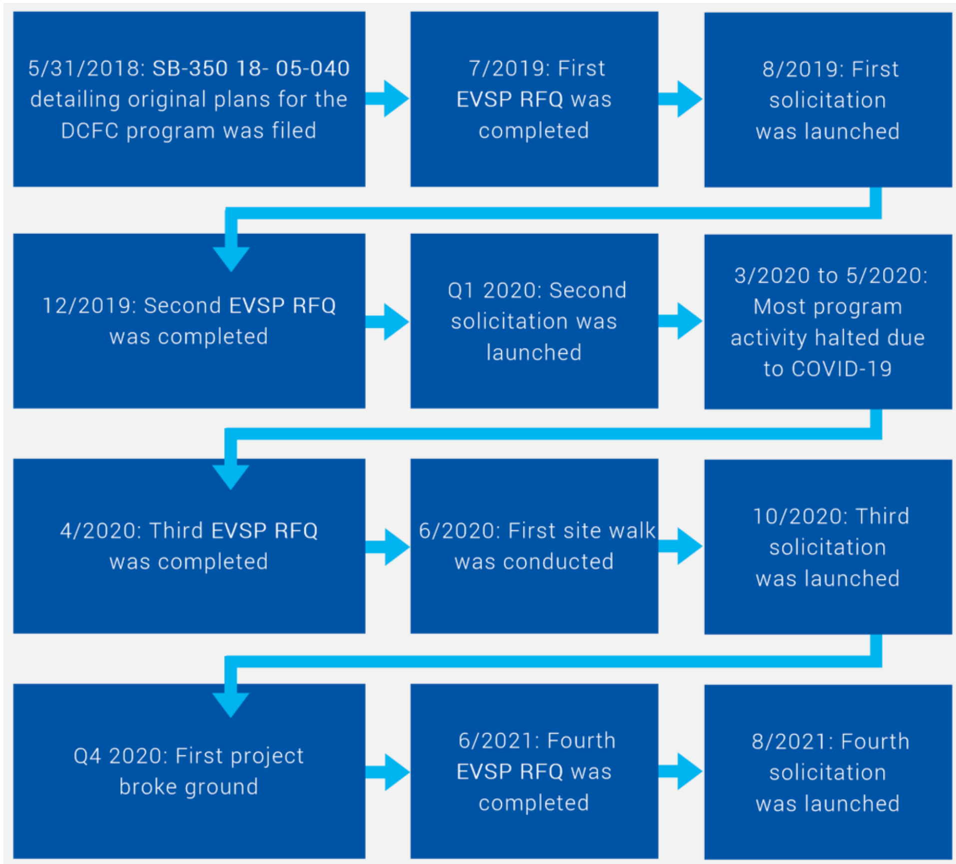
Figure 76. Budget Remaining versus Spend through 2021



Timeline

Since the inception of the EV Fast Charge program in 2018, there have been several milestones, as shown in Figure 77.

Figure 77. Timeline of Key EV Fast Charge Program Milestones



5.3.2. Findings

As discussed in the *Overview* section, the PG&E EV Fast Charge program secured four activated and operational sites for EY2021. Although impact data are limited to these four sites, the Cadmus team assessed the preliminary impacts associated with the PG&E EV Fast Charge program including incremental EV adoptions, petroleum displacement, GHG and criteria pollutant reductions, program costs, health impacts, and grid impacts, and we conducted a TCO contextual analysis, four visual site visits, a Utility website review, and staff interviews. These findings are provided below. Table 90 provides an overview of the estimated annual impacts for the EV Fast Charge EY2021 operational sites.

Table 90. EV Fast Charge Program EY2021 Impacts Summary

Impact Parameter	Annual Estimate [a]	Impact to DACs, %
Population of Activated Sites (#)	4	75%
Sites Included in Analysis (#) [b]	4	75%
Charging Ports Installed (#)	16	75%
Electric Vehicles Supported (#) [c]	N/A	N/A
Electric Energy Consumption (MWh)	82.91	74%
Petroleum Displacement (GGE)	7,319	73%
GHG Emission Reduction (MT GHG) [d]	49.9	74%
PM_{10} Reduction (kg)	0.27	74%
$PM_{2.5}$ Reduction (kg)	0.24	74%
ROG Reduction (kg)	4.7	74%
CO Reduction (kg)	149	74%

[a] Energy consumption, petroleum displacement, emission reductions, and health benefits are based on annualized data.
[b] The number of sites included in analysis differs from the population of activated sites because some sites were only activated for a short period during 2021 (such as one or two months).
[c] The team derived the EVs' supported value from applicants' vehicle acquisition plans. This value represents the maximum number of vehicles expected to be supported by the charging infrastructure.
[d] GHGs include CO_2, CH_4, and N_2O multiplied by their respective GWP as defined by IPCC AR5 (see the Methodology section for more details).

Incremental EVs Adoption

The team estimated the effect of the public charging stations on EV adoption for neighboring populations[94] 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 methodology section for the Stage 1 analysis.

Stage 2 Analysis: Ownership Attributable to PG&E EV Fast Charge Program Investments

Using the impact estimates from the Stage 1 analysis, the Cadmus team estimated the impact of investments in public charging on EV ownership. In 2021, four charging stations in PG&E's EV Fast

94 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 availability of EV charging equipment at convenient locations (for midday charging away from home) is expected 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 availability of nearby charging infrastructure is expected to lower the cost of EV ownership by providing alternatives to home charging. It is expected 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 lift EV ownership through both channels and that there may be positive interactive effects between the channels that lift the overall impact of public charging networks. The Cadmus team focused on analyzing the second channel. We will analyze the impacts for the first channel separately when data become available.

Charge program became activated and operational. We estimated the impact of these stations on annual EV registrations.

Based on the composite measure of public charging access, we calculated the change in access from the program stations for each census block group (CBG) where access was affected by PG&E's investment. As shown in Table 91, the average change in composite measure of access per affected CBG was 4.88, and the average increase in number of chargers was four. Normalized EV annual registration per 1,000 households was 34.57 in the affected CBGs from 2015 through 2020.

Table 91. Summary Statistics for CBGs Affected by the EV Fast Charge Program Stations

	CBG Mean (Standard Deviation) [a]			
	Change in Composite Measure of Access	Change in Number of Chargers	Normalized Annual EV Registrations	Number of Households
Fast Charge Program	4.88	4.00	34.57	322.30
	(0.69)	(0.00)	(39.69)	(208.40)
CBGs (N)	3	3	3	3

[a] The change in composite measure of access, change in number of chargers, and change in number of households are averages for the affected CBGs, measured from 2015 through 2020. Sample standard deviations are in parentheses.

We 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 to estimate the impact of Utility charging investment on EV ownership. 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 92 presents the estimates of annual EV registrations attributable to PG&E'S EV Fast Charge program investments.[95] Based on the OLS long differences model, PG&E's investments in the EV Fast Charge program stations increased annual EV registrations by 0.36 vehicles. Based on the IV-2SLS long differences model, PG&E's investments increased annual EV registrations by 0.79 vehicles. These estimates assumed that the four activated EV Fast Charge sites operate for a whole year.

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95 The long differences model estimates indicate the impact of public charging on EV registration over five years. The Cadmus team divided these estimates by five to annualize them.

Table 92. Annual EV Registrations Attributable to Fast Charge Program

	Annual Increase of EV Registrations Caused by the Utility Program [a]	
	OLS	IV-2SLS
Fast Charge Program	0.36	0.79
	(0.10)	(0.46)

[a] The table shows that the annual EV registrations attributable to the Utility investments in public charging infrastructure affected CBGs overall. We based these estimates on the OLS and IV-2SLS long differences models. We 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 10 largest cities. The long differences estimates are five-year estimates, which we divided by five to annualize. For each affected CBG, we 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, multiplied by the number of CBG households (in thousands). Robust standard errors clustered at the block group level are in parentheses.

The estimated EY2021 impacts of the EV Fast Charge program on EV registrations are small. Across all three affected CBGs, the average annual number of EV registrations is about 105, so the impact of the EV Fast Charge program lifts EV registrations by less than 1%.

The small, estimated impact of the EV Fast Charge program is attributable to two factors. First, the PG&E EV Fast Charging stations are located in or close to nonresidential areas with few households. Of the 31 affected census blocks, 26 had no households according to the U.S. Census. Second, the PG&E EV Fast Charging investments led to relatively small increases in EV charging access. As Table 92 showed, the average increase in the composite measure of access was only 4.88 and the average increase in access to charging sites was four.

Site Visit Findings

The team visited all four EY2021 active and operational sites, which were located at gas stations and convenience stores near major highways. While on the site, we assessed signage, payment mechanisms, pricing, number and placement of charging ports at each location, kilowatt capacity per charger, and how the site fit into the local charging context.

The team did not observe any wayfinding signage on nearby streets or highways at any of the sites. However, one sites had temporary signage facing the street advertising that charging was now available.

All four of the EV Fast Charge sites can be located with multi-brand and network-specific mobile applications. These applications offer the real-time status of each charging port and can be used to pay for and initiate a charging session. We observed that one of the sites used a bolt-on credit card reader on the charging stations, accepting magnetic strip, EMV chip, and FID-enabled credit cards. The charging stations at the other three sites only included RFID card readers, in addition to payment by application.

Pricing was flat rate at all four sites ($0.50 or $.057 per kilowatt-hour) with an idle parking fee applied after charging was complete. While this pricing aligns with many public DCFC, TOU rates are becoming more common. Replacing the current flat rates for TOU rates may provide lower cost energy to drivers and other benefits such as increasing renewable energy use with lower priced electricity when solar production is high. Including continued fees after a session has been completed or an allotted duration has expired may improve turn-over between individual charging sessions and overall site utilization as drivers adapt to moving their cars as soon as possible.

As show in Table 93, each site has four charging stations, with at least one station being ADA-accessible. One comparison is that some sites had the chargers installed directly adjacent to the building, which may lead to competition of those parking spaces between EV charging and general use of the convenience store, reducing charger and site utilization and EV driver preference of selecting a site. Other sites had the chargers placed further away where competition is less likely. One site used 50 kW charging stations (200 kW installed charging capacity) and the remaining sites used 62.5 kW stations with pairing kits to provide up to 125 kW (250 kW total charging capacity) shared between two stations for EVs capable of charging above 62.5 kW. In the short term the pairing capability could worsen the load factor by increasing power draw during peak hours and increasing the cost to the host as shorter, higher-power sessions contribute to demand. However, in the long term, the opportunity to charge vehicles more quickly could improve site utilization and revenue, as well as create an improved customer experience. These sites were built to allow future expansion of up to 150 kW per port. The transformers do appear to have some additional capacity currently and have headroom for up to 150 kW per port, at least for intermittent periods of operation.

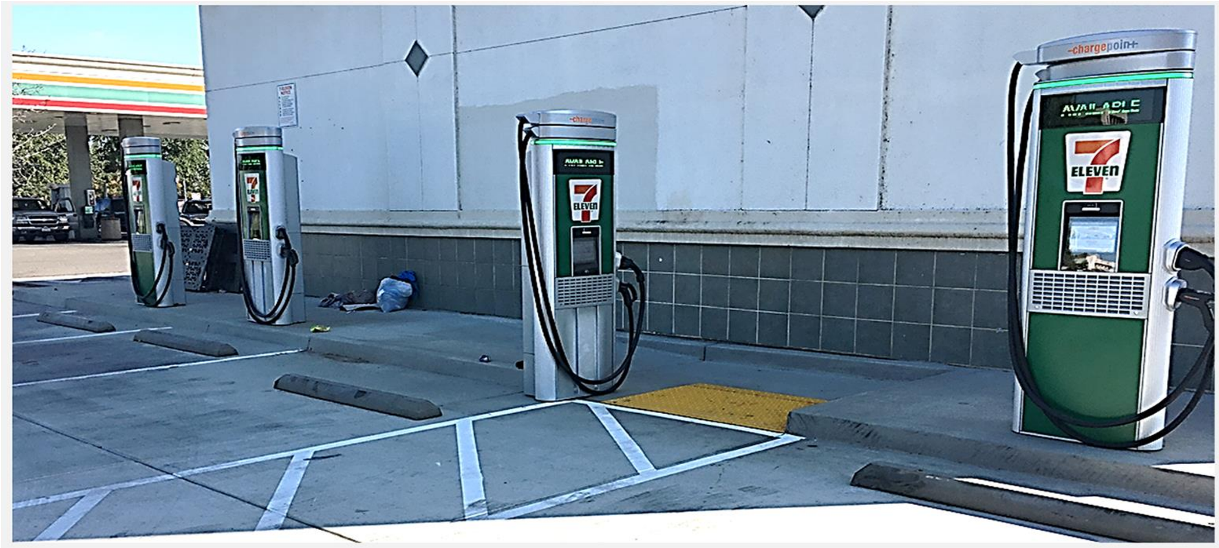
Table 93. PG&E EV Fast Charge Program Site Summary

Site	Number of DCFCs on Site	Connectors per Charger	ADA-Accessible	Adjacent to or Near the Destination Building	Charger Power (kW)	Total Installed Charging Power Capacity (kW)	Transformer Size (kVA)
1	4	1 CHAdeMO, 1 CCS	1	1-Yes, 3-No	50	200	150
2	4	1 CHAdeMO, 1 CCS	1	Yes	62.5 [a]	250	300
3	4	1 CHAdeMO, 1 CCS	1	No	62.5	250	300
4	4	1 CHAdeMO, 1 CCS	1	No	62.5	250	300

[a] Each pair of chargers can share load, enabling one of the chargers to double the amount of power dispensed.

Figure 78 shows an example of charging stations located directly adjacent to the convenience store building. This building-adjacent type of installation is surrounded by hardscape, making future expansion of the number of ports more difficult. This also may yield competition for parking between EV charging and people visiting the convenience store.

Figure 78. PG&E EV Fast Charge Program Public Charging Site in Fresno, California; Building Adjacent



Charging stations at the other sites were located farther away from the building along the edge of the parking lot, as shown in Figure 79. Placing stations away from the building may reduce the potential for space competition with non-EV drivers. In addition, locating charging stations away from the building may reduce the distance to the Utility feed and offer more space for placing a new transformer; however, the distance from the building may increase construction costs due to a longer trenching distance if the ADA-accessible charging station is located near the building for easier access (this was observed at one site). While these sites appear to have been designed for least cost, ADA requirements add significant costs in certain circumstances. These building-proximate locations appear to have less surrounding hardscape, which may make future expansion of the number of charging ports more financially feasible.

Figure 79. PG&E EV Fast Charge Program Public Charging Site in Tracy, California; Building Proximate

The ChargePoint stations (CPE250 models were installed at three of the four sites) have a shorter charger cord (estimated at 10 feet), which limits access based on where the charging port is located on a given vehicle, potentially restricting the direction in which the driver must park. Six additional feet of cord length would provide easier reach to the vehicle charging ports regardless of parking orientation (backed in or straight in).[96] Additional cord length could potentially allow the charging stations to serve additional adjacent parking spaces for driver convenience and resiliency by maintaining the ability to charge from all spaces in the event that one of the charging stations becomes inoperable.

Three of the four sites had no other nearby charging available at the same freeway exit, highlighting the importance of the site not only for enabling regional EV travel but also for supporting local EV charging.

Grid Impacts

The team estimated grid impacts for the EV Fast Charge program based on the power consumed by the four operational charging sites installed through the program in EY2021, combined with charging session data from the EVSPs. Table 94 presents a summary of the estimated EV Fast Charge program grid impacts by EY2021, an annual estimate, and a 10-year forecast.

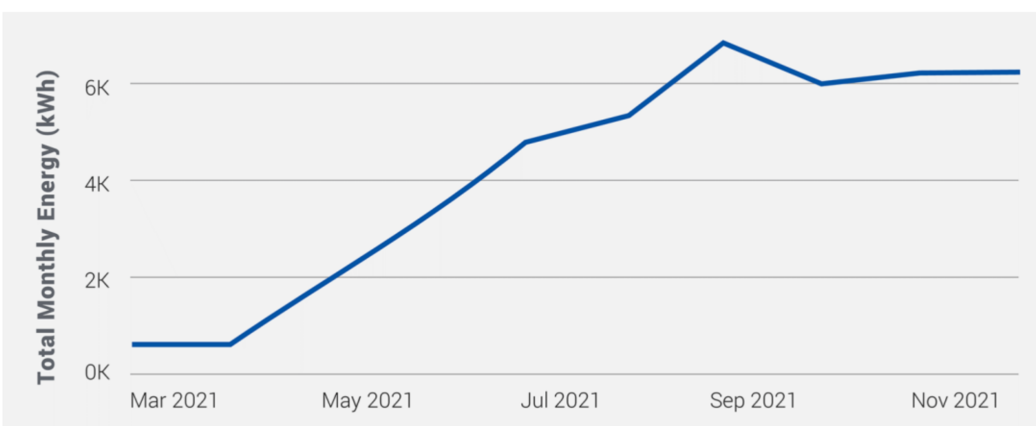
Table 94. PG&E EV Fast Charge Program Grid Impacts

Impact Parameter	Evaluation Year 2021	Annual Estimate	10-Year Projection
Operational Sites	4	4	4
Electric Energy Consumption, MWh	42.81	53.54	535.41
On-Peak MWh (4 p.m. to 9 p.m.) (and % of total)	14.8 (35%)	N/A	N/A
Maximum Demand, kW (with date and time)	160.64 (12/6/21, 6:45 p.m.)	N/A	N/A
Maximum On-peak Demand, kW (with date and time)	160.6 (12/6/21, 6:45 p.m.)	N/A	N/A

The remainder of this section provides detailed findings on the actual monthly consumption for EY2021, as well as maximum demand and load curves.

As shown in Figure 80, actual monthly consumption for EY2021 continually increased from April through September 2021 before leveling out. As the site usage continues to mature, monthly energy consumption is likely to increase further during EY2022.

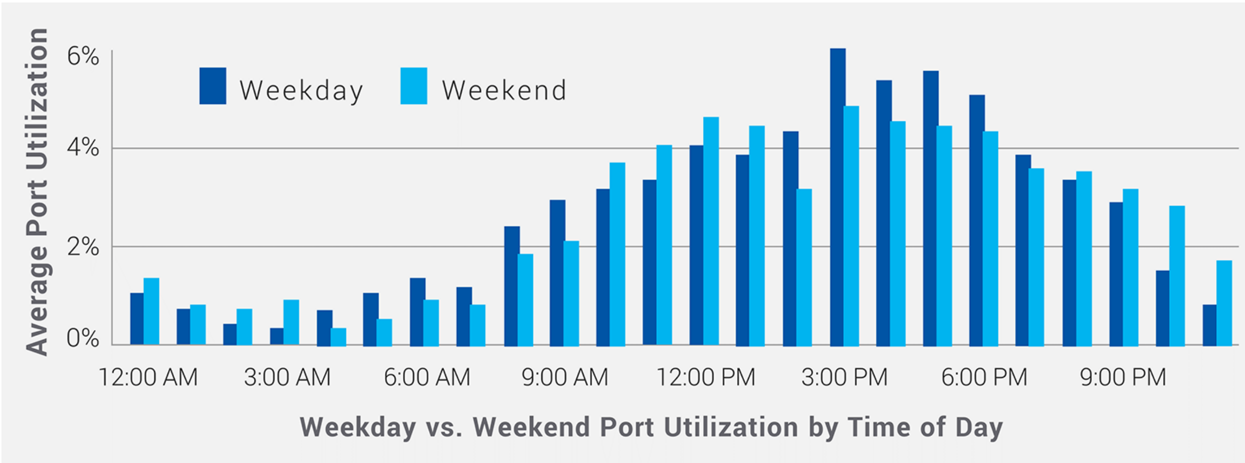
Figure 80. PG&E EV Fast Charge Program EY2021 Monthly Energy Consumption



[96] Charging stations typically have 16-foot or 18-foot cords.

Figure 81 presents daily port utilization trends, showing that charging began to increase mid-day and peaked in the early evening, with very little utilization between 11 p.m. and 8 a.m.

Figure 81. PG&E EV Fast Charge Program Port Utilization by Day Type and Time



Four sites with approximately 1 MW of capacity were installed through the EV Fast Charge program in 2021. Of these sites, three had paired chargers to allow for double the charging power, thus providing up to 125 kW, as the photo of the charger screen indicates in Figure 82. This unique feature supports higher utilization but also likely more frequent maximum demand. This feature requires a smaller overall Utility service while enabling faster charging by sharing electrical capacity, which will become more valuable in the future as the site use matures and more EVs capable of charging above 62.5 kW become available.

Figure 82. PG&E EV Fast Charge Program Charger Displaying Higher Power Capability than Nameplate

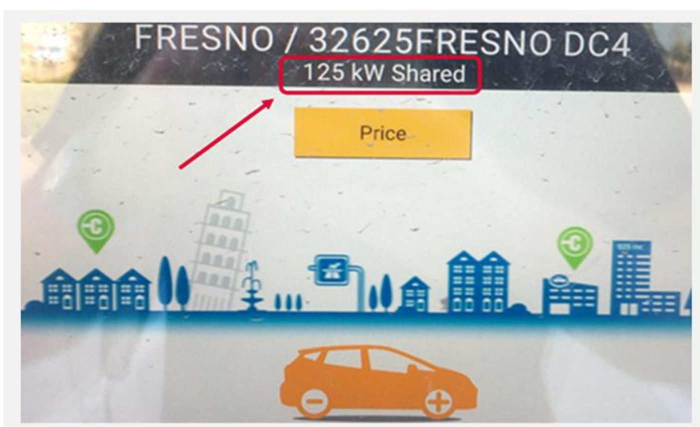


Figure 83 highlights more DCFC usage on weekends and reveals overall sporadic utilization day by day, infrequently achieving the highest possible demand.

Figure 83. PG&E EV Fast Charge Program Daily Trends Highlighting Weekends Consumption (kWh)

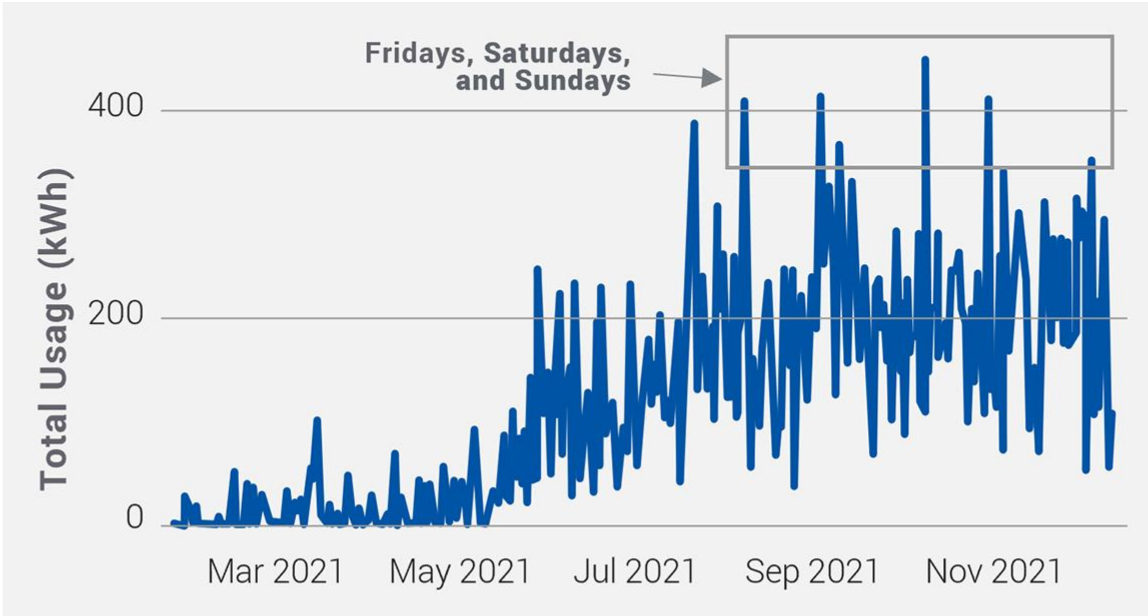
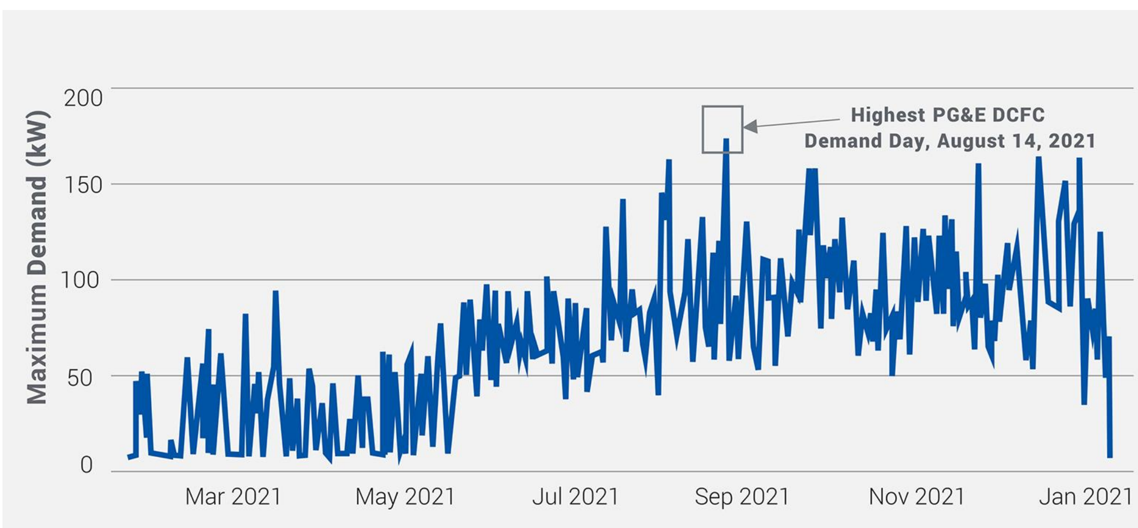


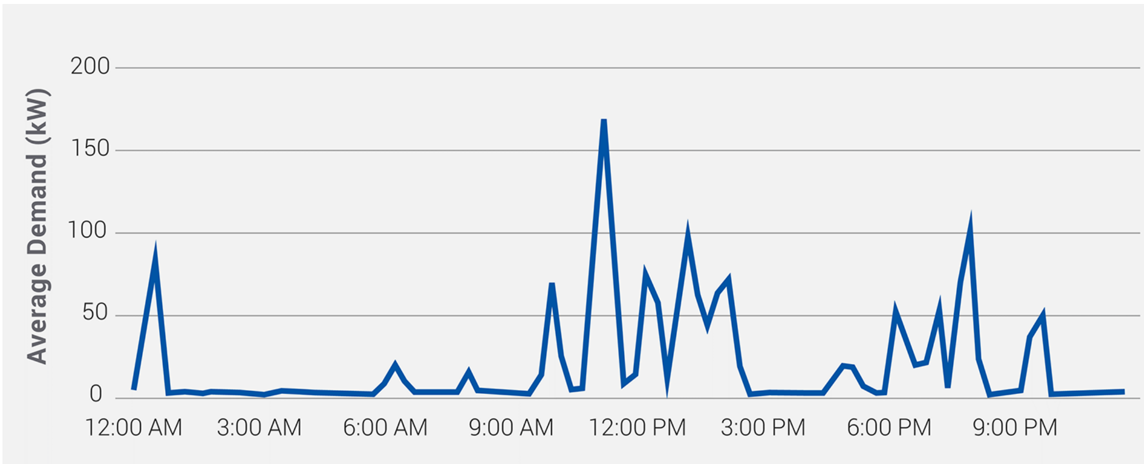
Figure 84 presents a closer look at daily trends, showing sporadic maximum demand on a daily basis. Maximum demand approached 175 kW, while the total installed capacity across the four sites was approximately 1,000 kW. This disparity may be due to the naissance of these sites. These sites are all relatively new and can be expected to take several more months to achieve significant gains in usage as local drivers begin to rely on them.

Figure 84. PG&E EV Fast Charge Program Charging Behavior Demand



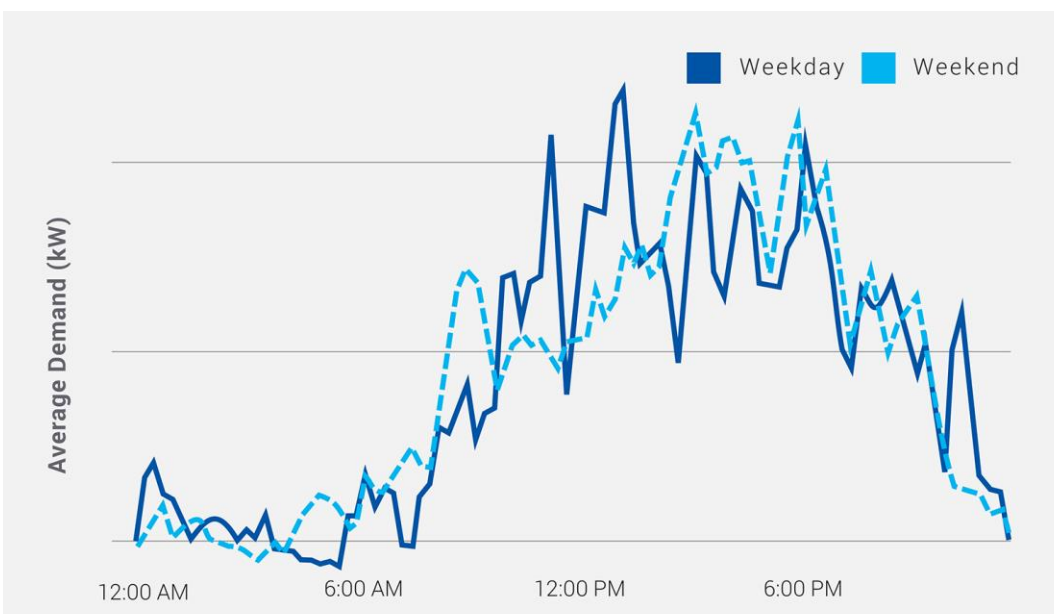
Saturday August 14, 2021, represents the highest demand for EY2021, while October 22, 2021, had the highest daily electricity consumption. As shown in Figure 85, sporadic charging sessions took place in the early afternoon and evening during the highest demand day (same is true for highest daily electricity consumption day). Overall, this pattern indicates that charging stations were used during common business hours, with one-third of the use occurring during the highest electricity price periods, between 4 p.m. and 9 p.m., which increased the cost to the site hosts while the costs to EV drivers remained the same due to a flat rate per kilowatt-hour throughout the day.

Figure 85. PG&E EV Fast Charge Program Peak Annual Demand Day on August 14, 2021



As shown in Figure 86, there was very little activity in the middle of the night; however, there were examples of charging late in evenings. Weekday and weekend charging appears more frequent between 11 a.m. and 9 p.m. than during other times, with a significant portion taking place during the highest electricity price periods (4 p.m. and 9 p.m.).

Figure 86. PG&E EV Fast Charge Program Average Port Demand by Day Type and Time



Petroleum Displacement

The team estimated program-induced petroleum displacement related to the four operational sites for EY2021 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 we estimated the reduction in equivalent gallons of petroleum as a result of the PG&E EV Fast Charge program. Table 95 presents the petroleum displacement resulting from the four operational EV Fast Charge program sites in EY2021, along with annualized and 10-year totals, as well as by impact location (inside and outside of DACs).

Table 95. PG&E EV Fast Charge Program Petroleum Displacement Summary

Impact Location	Evaluation Year 2021		Annualized	10-Year Projected Impact
	Total Usage (kWh)	Petroleum Displacement (GGE)		
In DAC	35,733	3,154	5,398	53,984
Outside of DAC	7,079	625	1,920	19,202
Total	**42,812**	**3,779**	**7,319**	**73,186**

Note: GGE stands for gasoline gallons equivalent (the energy content of one liquid gallon of gasoline).

As shown above, the four operational sites resulted in an annualized impact of just over 7,000 gallons, with more than 70% of this reduction from stations located in DACs. This closely tracks the three of four sites located in DACs. Based on current operational sites, the program would result in displacement of more than 73, 000 gallons over a 10-year period.

Greenhouse Gas and Criteria Pollutant Impact

The 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, then calculated the emissions associated with the operation of these vehicles for the same number of miles traveled as the EVs would have traveled based on the electricity consumed. Although EVs have no tailpipe emissions, the fossil-fuel power plants in the area that supply electricity to the EV charging stations still release some GHGs and criteria pollutants.

Table 96 presents the GHG reductions resulting from the four operational EV Fast Charge program sites in EY2021, along with annualized and 10-year totals, by impact location (inside and outside of DACs). Overall, the program resulted in a 74% reduction of GHGs.

Table 96. PG&E EV Fast Charge Program GHG Reductions Summary

Location	Evaluation Year 2021		Annualized	10-Year Projected Impact	% GHG Reduction
	Total Usage (kWh)	GHG Reduction (MT)	GHG Reduction (MT)	GHG Reduction (MT)	
In DAC	35,733	21	37	369	74%
Outside of DAC	7,079	4	13	130	74%
Total	**42,812**	**25**	**50**	**499**	**74%**

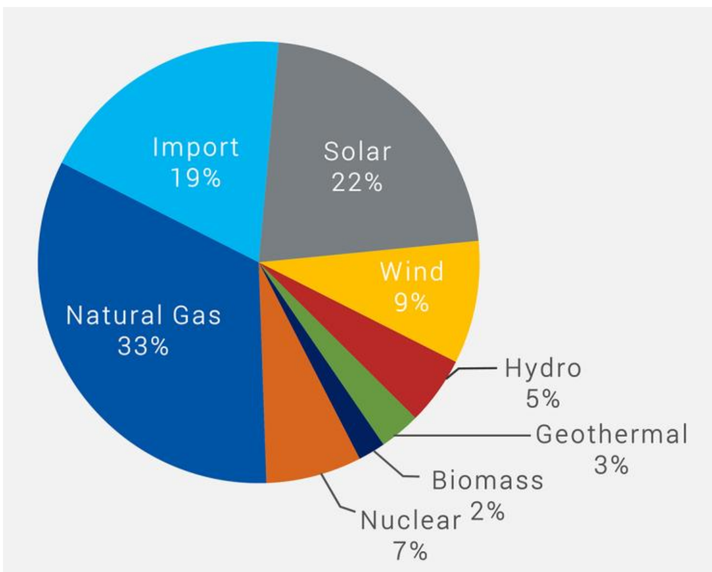
Overall, of the local emissions, the program had the highest impact in reducing CO, resulting in an estimated annualized reduction of 149 kg on an annualized basis (DACs account for about 74% of this reduction; see Table 97).

Table 97. PG&E EV Fast Charge Program Local Emissions Reductions

Emissions	Net Reduction		
	Evaluation Year 2021 Actuals	Annualized	10-Year Projected Impact
PM_{10} (kg)	0.13	0.27	2.66
$PM_{2.5}$ (kg)	0.12	0.24	2.44
ROG (kg)	2.36	4.67	46.73
CO (kg)	75.30	148.97	1,489.66

The current mix of electricity generation sources from the CAISO grid used to support the PG&E EV Fast Charge program sites is shown in Figure 87.[97] Based on the real-time grid conditions when the EV charging occurred, the overall energy mix contained about 48% zero emissions or renewable sources of electricity (including solar, wind, hydro, geothermal, biomass, and nuclear) and 33% 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 87. PG&E EV Fast Charge Net Electricity Mix – Annualized



97 The power associated with imports comes from a mixture of hydro, nuclear, coal, and natural gas power plants located outside the CAISO grid.

Health Impacts

The team calculated health benefits related to reductions in $PM_{2.5}$ (as shown in the *Greenhouse Gas and Criteria Pollutant Impact* section) that resulted from EY2021 program activity:

- Mortality: incidence and valuation ($)
- Work loss days: reduction in days lost incidence and valuation ($)
- Emergency room visits: cardiovascular and respiratory incidence and valuation ($)
- Hospital admissions: respiratory benefits incidence and valuation ($)

As part of this analysis, we also examined the health benefits specifically within DACs, which may be disproportionately burdened by sources of pollution (including air pollution from ICE vehicles). However, the amount of $PM_{2.5}$ reduction that resulted from the EY2021 EV Fast Charge program annualized activity was not substantial enough to detect a change within DACs or otherwise for this reporting period. The U.S. EPA's BenMAP, which the team used to run the health impacts analysis, is only capable of estimating health impacts at reductions in concentrations down to the sixth decimal place. A significant number of project site reductions were at or past the seventh digit, resulting in undetectable impacts. While some project sites had $PM_{2.5}$ air concentration reductions at the sixth decimal place, the team opted to run BenMAP with a cut-off at the fifth decimal place in an attempt not to overstate potential impacts at such a low level of precision.

Total Cost of Ownership

The Cadmus team analyzed key industry cost trends for public charging due to the limitations of the EY2021 cost data and to set the stage for EY2022 TCO analysis. This section provides context to the financial costs associated with installing EV infrastructure.

Infrastructure costs include BTM and TTM costs, as well as the cost for the charger and related materials. As shown in Table 98, these cost categories vary in the degree of variance, with BTM and TTM costs typically being the most significant cost driver and having the largest degree of variance on a per-site basis.

Table 98. Infrastructure Costs

Category	Degree of Cost Variance	Context and Rationale
Behind-the-Meter Costs	High	BTM includes site excavation for service line extensions to connect charging stations to the relevant meter. Costs may vary depending on lengths for trenching and cabling. BTM costs are also impacted by the cost of labor and any relevant supply chain and labor shortages. [a]
To-the-Meter Costs	High	TTM costs may vary depending on current capacity available for site hosts and, particularly, if a new transformer is required to supply power for EV charging. Costs may also vary depending on lengths for trenching and cabling. TTM costs are also impacted by the cost of labor and any relevant supply chain and labor shortages. [a]
Charger Costs	Moderate	Per-unit charger costs may decline with greater deployment of chargers per site. However, there are potential impacts from supply chain constraints and costs that may vary by charger power level. With current supply chain constraints, charger manufacturing costs may be affected, possibly increasing overall costs. [b]
Material Costs	Moderate	Material costs may include the cost of panels, meters, and the cabling required to connect the charger to the Utility distribution system. Similar to the cost of the charger, material costs are subject to supply chain constraints and may increase overall costs. [c]

[a] PG&E. February 2022. "Program Advisory Council Meeting Q4 2021." Presentation.
[b] California Energy Commission. Accessed March 2022. "CALeVIP DC Fast Chargers, Average Rebate, Unit Cost, and Total Project Cost per Charger." and California Energy Commission. Accessed March 2022. "CALeVIP Level 2, Average Rebate, Unit Cost, and Total Project Cost Per Connector Installed."
[c] PG&E. February 2022. "Program Advisory Council Meeting Q4 2021." Presentation.

Significant TTM costs include transformer upgrades and costs related to upgrading and maintaining the distribution system.[98] Significant BTM costs can include trenching, site excavation for service line extensions, and cabling requirements to connect charging stations to the relevant meter. In the context of the Utility-sponsored public charging programs, Utility staff across programs noted higher-than-expected infrastructure costs, occurring both BTM and TTM. Specifically, Utility staff noted significant variable costs such as the need for transformer upgrades and longer-than-anticipated lengths for trenching, as well as ensuring compliance with the ADA.[99]

Ongoing supply chain constraints and labor shortages will increase infrastructure costs.

Material costs for charging stations are rising at least in part to the ongoing COVID-19 pandemic and global disruptions on supply chains.[100] This increase was noted during a PAC meeting in which stakeholders mentioned that significant increases in material costs (such as copper wire and panels) are impacting contractors' ability to hold pricing past three to six months.[101] Related to material costs, the cost of the charger itself is subject to price volatility with global supply chain constraints disrupting manufacturing

98 PG&E. February 2022. "Program Advisory Council Meeting Q4 2021." Presentation.

99 PG&E. February 2022. "Program Advisory Council Meeting Q4 2021." Presentation.

100 White House (Helper, Susan, and Evan Soltas). June 2021. "Why the Pandemic has Disrupted Supply Chains."

101 SCE. March 18, 2022."SCE Transportation Electrification Program Advisory Council." Presentation.

processes. In addition, in California, the shortage in labor supply and high labor rates in the construction industry can add additional costs for EV charging deployment.[102] It can also be difficult to quantify the supply chain impacts to material and labor costs, as revealing these costs may be detrimental to vendors' competitive advantage, allowing for competitors to adjust their prices accordingly.[103]

In addition to infrastructure costs, the installation of EV chargers also includes a number of soft costs with a range of impact on the site development. Soft costs can also be difficult to quantify, as some cost categories may apply across a Utility program as opposed to a single site location. As shown in Table 99, potential site delays and opportunity costs have the largest degree of variability for soft costs related to EV charging deployment.

Table 99. Summary of Soft Costs

Category	Degree of Cost Variance	Rationale
Site Delays	High	Delays in building out EV charging are difficult to predict and the financial impact of such delays can be difficult to quantify. A delay may increase site costs as it may require extending the timeline for BTM and/or TTM construction and result in an increased labor cost. [a]
Opportunity Costs	High	Utilities implementing transportation electrification programs invest time to engage site hosts in the program process, conduct site visits, and so on. Utilities will need to coordinate with property owners and key decision-makers, and this coordination effort is specific to each site. There is a time cost associated with the uncertainty of the permitting process and delays, as well as multiple revisions and meeting schedules which can result in extending the timeline for approval across sites For instance, Utility staff noted that certain site schedules have to adhere to school board or city council meeting timelines to receive the relevant approvals to move sites forward. [b] This time could be spent on other sites. Opportunity costs are critical to consider and difficult to quantify, particularly as costs may vary by site based on the level of complexity. [c]
Permitting	Moderate	Permitting costs can vary as unexpected permits from cities and/or counties have been required.
Site Design	Moderate	Sites may ask for multiple iterations to refine the site design, change the location of charging stations, and/or to change the number of ports. These adjustments may require additional site visits.
Taxes	Low	Taxes are a relatively fixed cost.
Operations and Maintenance	Low	Operations and maintenance costs occur on a routine basis and are relatively fixed to the type of charger installed.
Communication/ Networking	Low	Networking costs are built into the cost of installing the charging infrastructure and are billed on a fixed reoccurring basis.

[102] Public Policy Institute of California (Johnson, Hans). March 2022. "Who's Leaving California-and Who's Moving In?"

[103] Rocky Mountain Institute (Nelder, Chris, and Emily Rogers). 2019. "Reducing EV Charging Infrastructure Costs."

Category	Degree of Cost Variance	Rationale
Marketing and Customer Outreach Costs	Low	Marketing and outreach costs are considered in Utility cost methodologies. However, marketing costs are commonly applied across programs and may be difficult to link with a single site location. [d]

[a] PG&E. July 2021. "Program Advisory Council Meeting Q2 2021." Presentation.
[b] SCE. March 18, 2022. "SCE Transportation Electrification Program Advisory Council." Presentation.
[c] Rocky Mountain Institute (Nelder, Chris, and Emily Rogers). 2019. "Reducing EV Charging Infrastructure Costs."
[d] PG&E, SCE, and SDG&E. Report Filed on March 31, 2022. "Joint IOU Electric Vehicle Load Research and Charging Infrastructure Cost Report 10th."

Our research indicates that soft costs can contribute significantly to the overall cost of public charging stations, particularly for public DCFC sites, which have high levels of energy demand and can be more complex installations.[104] Soft costs are difficult to consider on a per-site basis. Utilities often quantify soft costs such as program management and ME&O on a program level, yet more fixed soft costs are quantifiable on a site level (such as site design costs, taxes, permitting, operations, maintenance, and networking and communication costs).

However, complex sites will require a greater investment of time and resources, thus increasing the site-related soft costs. This level of complexity will depend on variable factors including the decision-makers involved, the power level of the installed charging, and any site delays. Related to this investment of time and resources, there is a high degree of variability in opportunity costs for Utilities engaged in transportation electrification programs. These technologies are relatively nascent and Utilities expend effort to engage site hosts, conduct site visits, and make adjustments to improve these programs. This time could be spent on other Utility activities.

> EV charger site costs vary as the result of uncertainties is both infrastructure and soft costs. Additionally, an increase in soft costs can compound infrastructure costs.

Soft costs are interrelated to infrastructure costs. In the context of Utility-sponsored public charging programs, Utility staff have specifically noted that BTM labor costs can be complicated by site host BTM construction delays. Reasons for these delays can include RFP challenges, internal decision-making related to paying for BTM work, and lack of familiarity with BTM construction. These BTM delays are a common driver of overall site completion delays.[105] As sites are delayed, other costs may accumulate without the financial impacts being readily quantified. Current supply chain constraints may increase the costs of infrastructure while also increasing soft costs due to resulting delays.

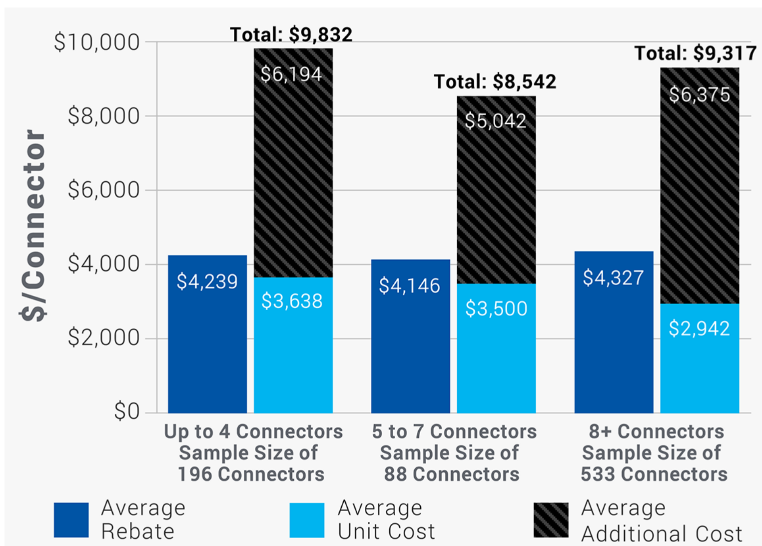
104 Rocky Mountain Institute (Nelder, Chris, and Emily Rogers). 2019. "Reducing EV Charging Infrastructure Costs."

105 PG&E. July 2021. "Program Advisory Council Meeting Q2 2021." Presentation.

In addition to considering the EV infrastructure and soft costs discussed above, the team also examined a cost case study based on the California Electric Vehicle Infrastructure Project (CALeVIP). CALeVIP offers incentives to acquire and install EV charging infrastructure at publicly accessible sites throughout California. The 2021 CALeVIP data on L2 costs (Figure 88) and DCFC costs (Figure 89) showcases the decline in per-unit costs (shown in blue) and the variance in total per charger costs (shown in gray).[106] Based on CALeVIP data shown in Figure 88, L2 per-unit costs decrease in sites with a greater number of chargers per site. Similar to L2 data, DCFC per-unit costs decrease in sites with a greater number of chargers per site (Figure 89). However, for both DCFC and L2 charging, the soft costs and remaining infrastructure costs—beyond the charger itself—(shown as the *average additional costs* in the gray bars) do not reflect a direct relationship between the number of chargers per site and the total cost per charger per site.

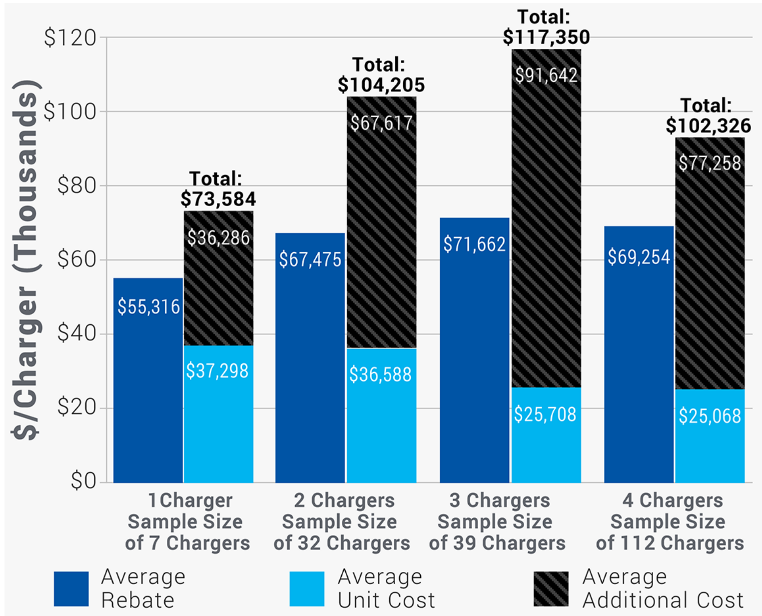
> Per-unit charger costs will likely decline with greater numbers of chargers per site. Unlike per-unit costs, total costs per charger may not decline with a greater number of chargers per site.

Figure 88. CALeVIP Level 2 Charger Costs



106 California Energy Commission. Accessed March 2022. "CALeVIP DC Fast Chargers, Average Rebate, Unit Cost, and Total Project Cost per Charger." and California Energy Commission. Accessed March 2022. "CALeVIP Level 2, Average Rebate, Unit Cost, and Total Project Cost Per Connector Installed."

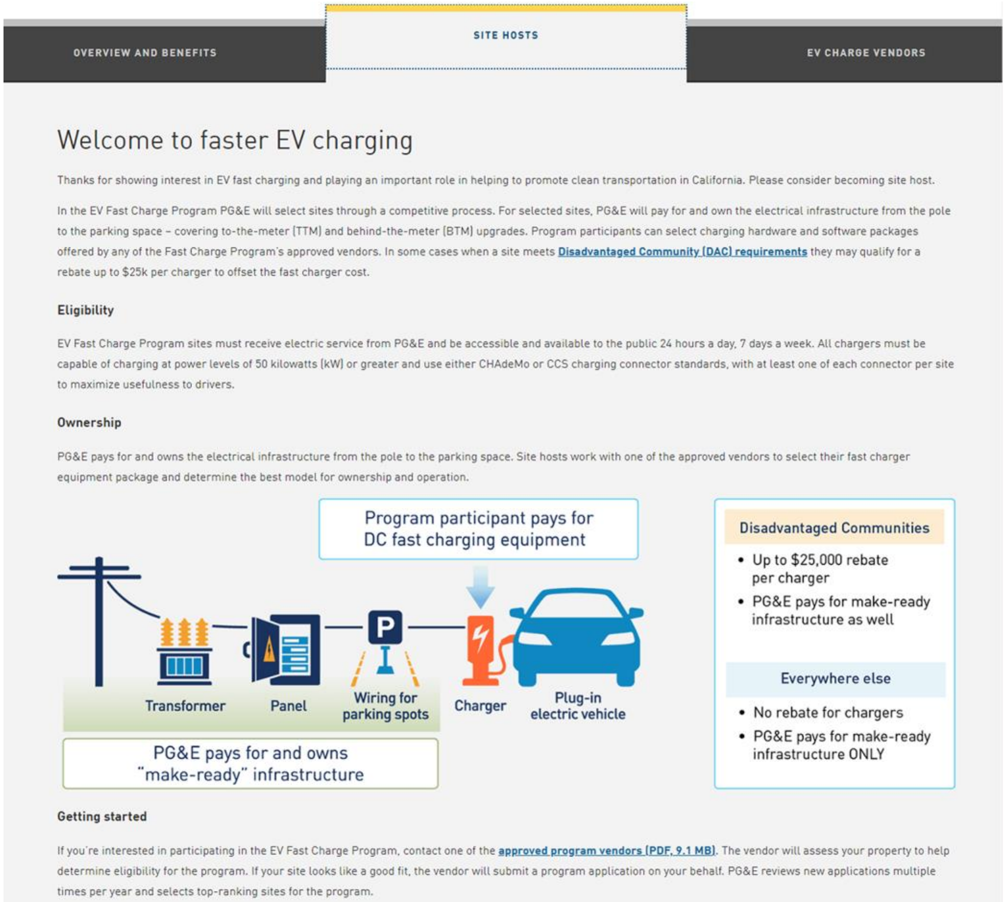
Figure 89. CALeVIP DCFC Costs



Utility Web Page Insights

The team conducted a high-level review of PG&E's EV Fast Charge program web page. Overall, we found that the web page was well-organized, the visuals are relevant and help the reader understand the EV Fast Charge program, and the information is concise and digestible. There are also several links to external sites including important information, such as to the CalEnviroScreen website, so potential participants could check if they are eligible for a bonus incentive for being located in a DAC. Figure 90 shows part of the web page, highlighting some of the information available to site hosts in a combination of text and graphics.

Figure 90. Example Screenshot from PG&E EV Fast Charge Web Page



Utility Staff Insights

Over the course of EY2021, the Cadmus team interviewed PG&E staff for its EV Fast Charge program twice (once in September 2021 and again in March 2022), in addition to monthly check-ins about the program status. Through these conversations, PG&E staff identified key insights from their experience in 2021.

Staff reflected that the decision to have all site hosts apply though an approved EVSP is intended to ensure that the program applications contain the most useful site information and enhance PG&E's ability to determine site potential before the preliminary design or a site walk. Staff noted that the application may feel excessive or intimidating for many site hosts, resulting in customer frustration or incomplete data. To support the EVSP vendors, PG&E provided training to help them become knowledgeable about the application while maintaining customer satisfaction. Staff said they will continue to monitor the effectiveness of this application submission strategy as the program progresses. The main challenge PG&E program staff reported with implementing EV Fast Charge in 2021 was accounting for increased site costs. In particular, opportunity costs have been trending significantly higher. In addition, staff noted that construction labor and material costs have increased as inflation has been rising and said that COVID-19 disrupted supply chains and the labor force. Program staff also noted that the construction cost increases were compounded as assumptions that had been made in 2018—such as expected trench length and proximity to PG&E power source or transformer—were underestimated. In addition, while permitting costs were as expected, construction costs to meet ADA requirements were unexpectedly high. Finally, PG&E staff reflected that at the start of program implementation, costs per site were also increasing due to negotiating with property owners and stakeholders over design and contract details. Once these inefficiencies were identified, the PG&E team adapted the application process to capture common issues early and address them wherever possible. For example, PG&E staff began to complete an upstream review of the site with a PG&E engineer prior to the phone screen with the potential site host to get a better understanding of the potential site costs.

As the program continued, staff reported adjusting to these increased costs as much as possible. For example, when the program was first designed, the goal was to spend less than $70k per port. However, as the program activity began, staff realized this was unrealistic and they had to increase their expected cost per port. Additionally, with each solicitation, staff considered the cost of a new solicitation and processing new applications versus choosing a more expensive site that had previously been wait-listed. To prioritize funding for site development, after the fourth solicitation, staff decided there would be no further solicitations for the EV Fast Charge program and chose to work with remaining sites from the wait-list to fully subscribe the program. However, staff reported being concerned that there is a higher demand for DCFC EVSE than the program can currently provide. This includes areas with DACs: program staff noted that the allocated budget for increased DAC rebates ($25k) was exhausted before the program was fully subscribed due to the disproportionately high number of DAC sites that applied.

Withdrawals early in the process do not cost the program too much, but staff said the program faced a challenge with promising sites withdrawing partway through the evaluation process. Most commonly, staff said this is because the ultimate decision-makers of a site, or the site host's legal department, could not ultimately agree with terms of the contract or could not make the significant upfront investment in DCFC chargers (which could cost over $100,000 up front). Since participants are not required to sign a formal participation agreement until the final design has been completed and agreed upon, PG&E accepts a certain amount of risk when investing in a site evaluation. After encountering this issue more often than anticipated, staff adapted their application screening process accordingly. Furthermore, staff also coordinated with partnering EVSPs to try and target site hosts that would be less likely to withdraw and asked preliminary questions before applying to the EV Fast Charge program on their behalf. However, despite these adaptations to the recruitment process, PG&E staff still found that the program was investing more resources than anticipated on site hosts who were ultimately unable to commit to the program.

5.3.3. Lessons Learned

The team identified a number of lessons learned from EY2021. These lessons, presented below with key supporting findings and recommendations, may be applied to future Pilot years and to other similar efforts.

Adaptability in the program enrollment process enabled PG&E to successfully meet customer needs and secure participation in the EV Fast Charge program.

In addition to setting up procedures to coordinate with other internal departments, EV Fast Charge staff took the time to learn from the sites that went through the application process early in the program. For example, PG&E quickly learned that the boilerplate contract language would likely need to be adjusted for each site's different needs or requirements. Therefore, PG&E adjusted their assumption for how long a contract review would take, they encouraged the primary site contact to share programmatic documents with decision-makers early, and they added questions about contract signing to their phone screening process (such as who would be responsible and how long it would take). In general, PG&E honed the phone screen over time, adding questions to newer participants' calls that had been useful in previous calls, including requesting the presence of decision-makers in the preliminary call screens (not just site host points of contact). By updating their implementation process in real time, PG&E's EV Fast Charge process became more efficient and customer friendly with each application processed.

Unexpected market impacts and site design requirements resulted in higher-than-expected site costs and limited participation.

PG&E began the EV Fast Charge program just as the COVID-19 pandemic started. COVID-19 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. Though PG&E staff conducted research ahead of Pilot design, these expenses were then compounded by inadvertent inaccuracies in program design estimations. For example, while designing actual sites, PG&E found that the typical trench length assumption had been underestimated and that some site hosts requested EVSE locations that would require excessive trenching. Similarly, more construction is needed than what was estimated to meet ADA permit requirements.

The lack of a formal commitment in advance of site walks resulted in PG&E starting to invest in uncommitted customers.

EV Fast Charge participants are not required to sign a formal participation agreement or contribute any funds to the site until the final site design has been completed and agreed upon. Therefore, PG&E accepts a certain amount of risk when investing in planning a site. Although withdrawals early in the process are not significantly disruptive, PG&E staff experienced challenges when promising sites withdrew partway through the planning process; this was particularly straining on the program budget, as PG&E had invested considerably in the sites (such as conducting site walks). Despite adapting the intake process, this challenge resulted in the EV Fast Charge program investing more resources in withdrawn applicants than anticipated.

6. SDG&E Transportation Electrification Programs

This section provides process and impact evaluation findings and lessons learned for SDG&E's PYDFF program, Schools and Parks Pilots, and V2G Pilot.

6.1. *Power Your Drive for Fleets*

6.1.1. Overview

Per Decision 18-05-040, SDG&E's PYDFF program provides infrastructure for fleet electrification while working with fleets from the initial planning phases to design, construction, and ongoing site maintenance. The program launched in November 2020 and is designed to serve a minimum of 300 sites supporting the electrification of 3,000 MDHD on- and off-road vehicles. SDG&E is working with 38 sites that can support 1,221 MDHD EVs, including those sites in the application phase (as of October 2021).[107] PYDFF has a budget of $155 million. Customers participating in the program can choose Utility ownership or customer ownership of BTM infrastructure. If SDG&E owns the infrastructure, then 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 TTM infrastructure and the customer will pay for, construct, own, and maintain all BTM infrastructure and receive a rebate 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 Fortune 1000 companies.

PYDFF Goal:

Achieve minimum of 300 sites with 3,000 MDHD EVs supported.

To participate in the PYDFF program, customers must meet specific criteria. The 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, transportation refrigeration units, airport ground support equipment, 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 EVSE, and use qualified/state-licensed labor for all work, among other requirements. The SB 350 Decision determines the ranges of spending for SDG&E. SDG&E has a requirement that 30% of participating sites are located in DACs. SDG&E is allowed to revisit the DAC requirement after the program has been in effect for two years if they are not trending toward meeting their target.

PYDFF Update:

SDG&E is working with 38 sites that can support up to 1,221 MDHD EVs (as of October 2021).

107 SDG&E. October 14, 2021. "Clean Transportation Programs Advisory Council."

Implementation and Timeline

Customers participating in PYDFF submit an interest form and work alongside an SDG&E representative to determine eligibility and finalize the application process over the course of one to two months. In the next six to nine months, SDG&E conducts a preliminary design and engineering phase to finalize the infrastructure package and obtain relevant permits. In an estimated three to four months, SDG&E will construct make-ready infrastructure. After a month, SDG&E will activate the site and conduct a final closeout and any required maintenance for SDG&E-owned infrastructure. Participating in the program is estimated to take 11 to 16 months.

Site Summary

Participating sites in the SDG&E PYDFF program were reviewed and analyzed by program status. Table 100 provides the count of construction complete sites in PYDFF program by completion status.

Table 100. EY2021 SDG&E PYDFF Program Complete Site Count By Status

Site Status	EY2021
Utility Construction Complete	2
Activated	1
Operational	1
Closed Out	1

ME&O Summary

The Cadmus team reviewed available program-related materials, such as program websites, marketing materials, Decisions, Advice Letters, and Program Advisory Committee (PAC) presentations. The program material review is important to establish a foundational understanding of the program design intent, to track changes in design over time, and to understand implementation progress. In the program materials review process for PYDFF, the team assessed the level of accessibility for program web pages, presentation and navigation, overall layout and design, efficacy of the materials to establish trust and credibility, content clarity, how materials engaged eligible customers, and how the materials set program expectations and aided in decision-making.

Budget Summary

The CPUC Decision that approved SDG&E's PYDFF program allocated $155 million to the program and allowed the Utility to recuperate program costs through rates that were in effect prior to the CPUC's program evaluation, provided the program satisfies *per se reasonableness* requirements. SDG&E also reports on these *per se reasonable* measures in the Utility's annual SB 350 report to the CPUC.

As of the end of Q1 2022, SDG&E had spent approximately $9.6 million, which equates to roughly 6% of its total allotted program budget. There were 38 MDHD sites as of the end of October 2021 that can support up to 1,221 MDHD EVs.

Program Updates

SDG&E created an EV-friendly charging rate (EV-HP) designed to make the transition to EVs easier and more cost-effective for fleets. The new rate eliminates demand charges, and instead uses a subscription-based fee model based on the amount of power fleets need to charge their vehicles, which provides consistent, straightforward monthly bills. The EV-HP rate went into effect in January 2022 and therefore was not a factor for consideration in EY2021.

6.1.2. Findings

Table 101 summarizes key impact parameters for EY2021.

Table 101. PYDFF EY2021 Impacts Summary

Impact Parameter	Annual Estimate [a]	Percentage in DAC
Population of Activated Sites (#)	1	0%
Sites Included in Analysis (#) [b]	1	0%
Ports Installed (#)	2	0%
Electric Vehicles Supported (#) [c]	2	0%
Electric Energy Consumption (MWh)	N/A	N/A
Petroleum Displacement (Diesel Gallons Equivalent)	N/A	N/A
GHG Emission Reduction (MT GHG) [d]	N/A	N/A
NO_x Reduction (kg)	N/A	N/A
PM_{10} Reduction (kg)	N/A	N/A
$PM_{2.5}$ Reduction (kg)	N/A	N/A
ROG Reduction (kg)	N/A	N/A
CO Reduction (kg)	N/A	N/A

[a] Energy consumption, petroleum displacement, emission reductions, and health benefits are based on annualized data.
[b] The number of sites included in analysis differs from the population of activated sites because some sites were only activated for a short period during 2021 (such as one or two months).
[c] The team derived the EVs supported value from applicants' vehicle acquisition plans. This value represents the maximum number of vehicles expected to be supported by the charging infrastructure.
[d] GHGs include CO_2, CH_4, and N_2O multiplied by their respective GWP as defined by IPCC AR5 (see the Methodology section for more details).

Program Performance Metrics

As of December 31, 2021, SDG&E's PYDFF program fully activated one MDHD site that supports two MDHD vehicles in the medium-duty vehicle market segment.[108] As shown in Table 102, this MDHD site is not located within a DAC.

Table 102. SDG&E PYDFF Applicant and Activated Site Summary

Market Sector	Number of Activated Sites in DAC	Number of Activated Sites Outside of DAC	Total Number of EVs Supported
Medium-Duty Vehicles	0	1	2

[108] SDG&E provided data pertaining to two MDHD customer applications, with one having been activated.

The CPUC established six phases in program timelines per the SB 350 reporting template. While the PYDFF program has activated only a single site, SDG&E has a second MDHD applicant in the activation phase of the program. Given the limited number of active sites, the following discussion applies to both the activated site and the applicant within the activation stage.

Table 103 and Figure 91 summarize the amount of time that SDG&E's two MDHD sites spent per phase of the program. The variance in the median calendar days per phase attests to how the duration varies by each program phase. The distributions per program phase provide deeper insight into program phase completion, illustrating that the site assessment, design and permitting, and construction complete phases typically take the most calendar days to complete. Note that the sum of calendar days in Table 103 does not equate to the total program duration as program phases overlap and applicants can concurrently work toward completing multiple phases.

Table 103. SDG&E PYDFF Median Calendar Days per Phase

Program Phase	Calendar Days (Median)
Application Reviewal	16
Site Assessment	165
Contract Issuance	29
Design and Permitting	159
Construction Complete	125
Activation	49

Note: This table only includes data from sites in the activation stage by the end of 2021.

Customer applications experienced the shortest amount of time per phase during the application reviewal and contract issuance phases of the program. Customer applications tend to spend the most calendar days in the site assessment, design and permitting, and construction complete program phases.

Figure 91. Summary of Calendar Days per Phase for Customer Applications in the PYDFF Program

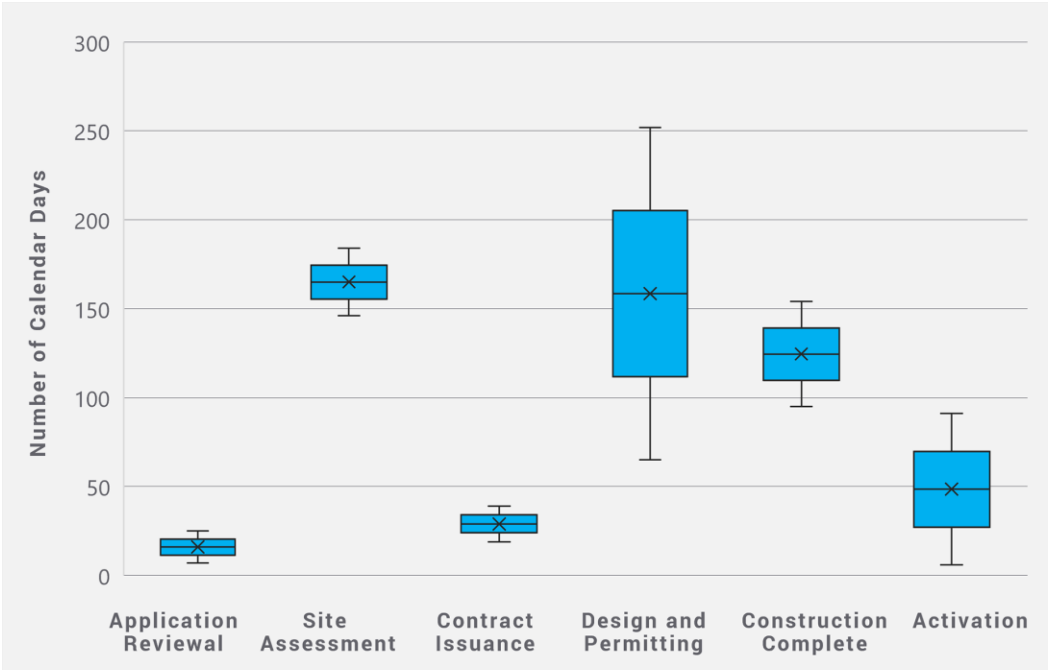


Table 104 displays the median quantity of calendar days that applicants took from application reviewal to activation. The two applicants in the medium-duty vehicle market sector completed activation in just over one and a quarter years (468 calendar days).

Table 104. PYDFF Median Duration for Site Activation, by Market Segment

Market Sector	Median Start-to-Finish Activation (Calendar Days)
Medium-Duty Vehicles	468

Note: This table only includes data from sites in the activation stage by the end of 2021

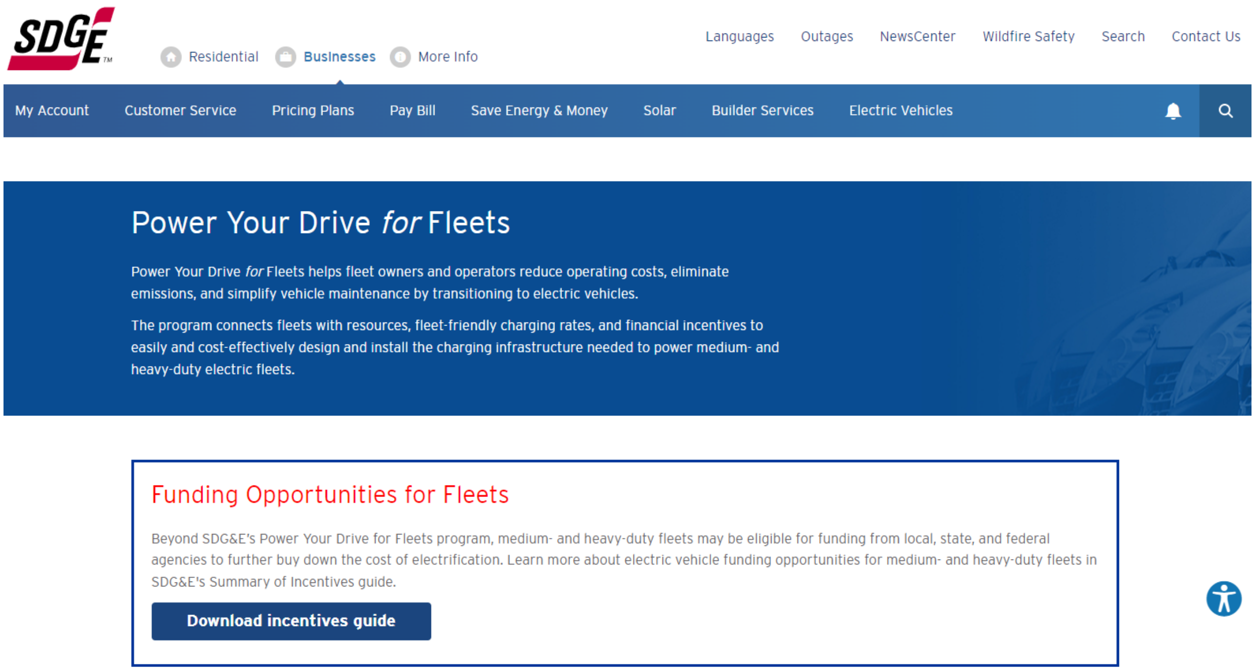
Program Materials Review

The program materials review was important to establish foundational insights into program design intent, changes, and implementation progress. The EY2021 evaluation review of marketing, education, and outreach materials focused heavily on program web pages. Program web pages are a central repository for program information. Because of this, and the fact that their non-static nature enables them to reflect current phases of the implementation process, they were an accessible and insightful element of the materials review for EY2021. While web pages are a central element of SDG&E's fleet marketing strategy, the Cadmus team recognizes that they are part of SDG&E's larger, multi-pronged approach to promote PYDFF that includes targeted digital advertising, email marketing, call center outreach, collaborative webinars, in-person events, outreach to equipment manufacturers and dealerships, and in-person customer meetings.

SDG&E MDHD Program Web Page Assessment Findings

In April 2022, the Cadmus team reviewed SDG&E's program web page ("Medium/Heavy-Duty (MD/HD) EV Charging Infrastructure Program"), its subpages ("Electrification for Small Business Fleets," Electrification for Regional Fleets," "Service Fleets Landing page," "Shuttle Bus Fleet page," "Fleet Friendly Charging Rates," and "Disadvantaged Communities Fleets"), and the online interest submission form. Figure 92 shows a screenshot of the main program page.

Figure 92. Screenshot of SDG&E's PYDFF Web Page



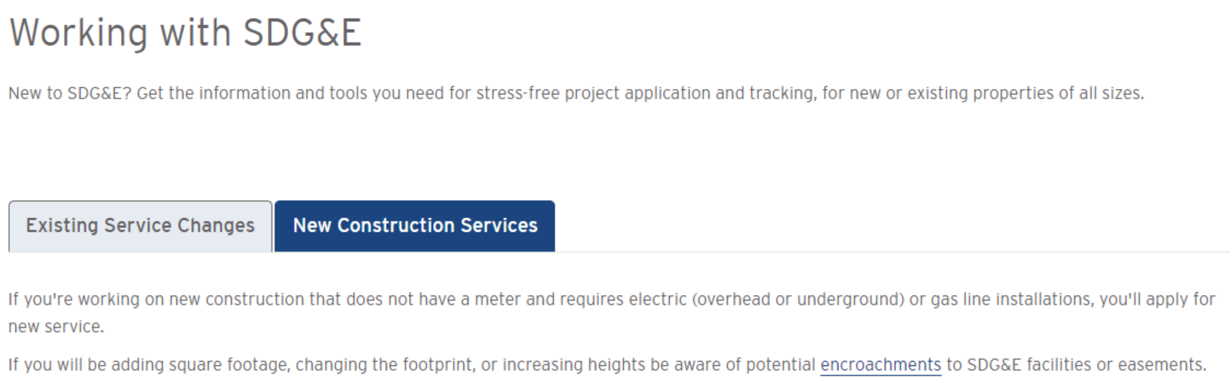
The team used an assessment template that grouped assessment criteria into seven areas. The first four areas addressed navigation, design, credibility, and content clarity. The last three areas guided the review of how the pages supported the primary page objectives. Based on the current implementation stage and web page content, we determined that the page objectives were to drive qualified program leads, set program expectations, and aid in decision-making about fleet electrification. Overall, the Cadmus team found that the web pages provided helpful, accurate, and informative content and that subtle organizational and information architecture modifications could enhance the user experience.

Navigation and Information Architecture

The main page has a clear and succinct description of the program at the top of the page. Below this, the page includes several call-to-action (CTA) buttons, followed by a set of button links to subpages, then sections on how the program works, an electrification timeline, rate options, rebates and additional funding, infrastructure installation options, eligibility, and additional resources. SDG&E's PYDFF program web pages provide the information users are likely to look for, such as program details, available incentives, and how to participate.

Using a navigation menu or submenu, such as tabs, as shown in Figure 93, could improve the program page navigation. Using this style of navigation keeps navigation options in the same place from page to page, making it easy for users to find, while not competing with the primary SDG&E web page menu, which remains at the top of the page. Using navigation options provides quick links to key information, making it easier for users to find what their looking for when a page includes a lot of content.

Figure 93. Example of Tab Navigation From Another SDG&E Web Page



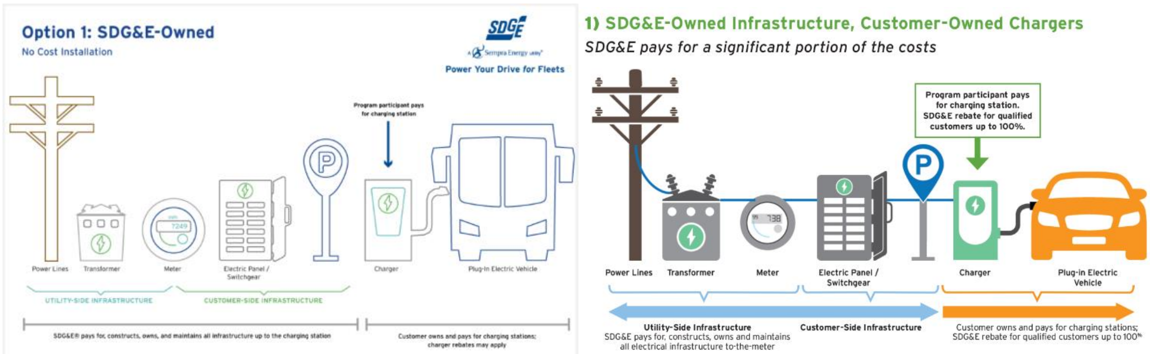
The content sections below the navigation buttons provide a wealth of useful information such as a sample project timeline and rebate details. With rebate and incentive programs, customers typically first look to see what the program offers them (in terms of services and incentives), then look to see whether they are eligible. Including answers to these questions first supports a positive user experience. Additional program details, such as project timelines and installation options, can follow this. Information not directly related to the program, such as rate options and additional funding opportunities, can be included after all the program information.

The pages include a site search, but the site search does not return any results for “EV fleets” or “EV charging.” The Cadmus team understands that SDG&E has an ongoing corporate initiative to create a more user-friendly website, which includes addressing overall site navigation issues. The team acknowledges that this is part of the broader Utility site structure and not for one program to address, but observes that it would improve user experience if the site search could return results for these and other related keywords.

Layout and Design

The program pages have a functional layout and design, but improved graphics could increase ease of viewing. The pages have a consistent structure from page to page and provide a clear introduction to the focus of each page at the top. Text treatment and styles are mostly consistent, although the electrification timeline steps have an inconsistent font color. The site is responsive to screen size, maintaining functionality when viewed on a mobile device. Some graphics on the site—notably the electrification timeline, infrastructure installation options, total cost of ownership, and DAC map graphics—are not optimized for web usage: they include font sizes that are too small for easy legibility, especially when viewed on a small screen, such as a mobile device, and illustrations do not use high contrast colors or bold images, which increase ease of viewing on a screen. As an example, Figure 94 shows the Infrastructure Installation Options graphics on the PYDFF page compared to a similar graphic from another page on sdge.com that uses solid-color illustrations. Although the text is too small for easy legibility in both graphics, the solid illustrations in the second graphic make the image easier to view.

Figure 94. Examples of Two Similar Graphics from sdge.com



Left: Infrastructure Installation Options graphic from "Medium/Heavy-Duty (MD/HD) EV Charging Infrastructure Program" page. Right: Infrastructure Installation Options graphic from "Power Your Drive for Apartments and Condos" page.

Trust and Credibility

The program pages come across as a trustworthy and credible source of information. They are hosted within the core SDG&E website, www.sdge.com, use the same template and branding as the rest of the Utility site, and the information is clearly written and presented.

Content Clarity

SDG&E's PYDFF program web pages provide a useful summary of program information. Text is generally brief and to the point and uses tables and lists in place of paragraphs where appropriate. Titles and subtitles introduce page sections to make it easier for users to scan page content.

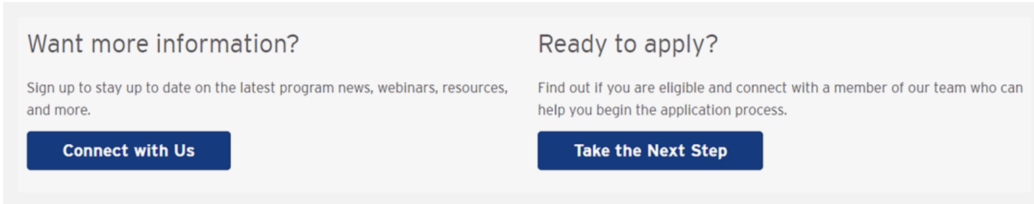
The Cadmus team identified some ways content clarity could be improved. Page copy switches between the active and passive voice. Consistently using the active voice can help simplify copy and make it more compelling. Some of the copy is repeated in multiple sections. Distilling this could improve readability.

Drive Qualified Leads

The pages prompt users to submit an interest form in multiple places and give the CTA prime real estate at the top of the page. There are two side-by-side CTA buttons: "Connect with Us" and "Take the Next Step." Web pages typically include a single CTA since multiple CTAs with the same emphasis will compete with each other. SDG&E, however, recognized that when the only CTA option was "Take the Next Step" it received a high volume of non-qualified customers and industry experts who were interested in what the program was doing, but not ready or qualified to enroll. SDG&E added the second CTA button, "Connect with Us," and optimized the language of both buttons to help sort qualified leads from unqualified leads and avoid overwhelming sales staff.

Figure 95 shows a screenshot of the PYDFF page featuring the two CTA buttons.

Figure 95. Screenshot of CTA buttons on the PYDFF page



The interest form itself is brief and easy to complete, increasing the likelihood that eligible users will complete and submit the form once they reach that page. The form field does not currently conduct simple field validation, such as confirming the correct number of digits for a phone number, which could support information accuracy. The Cadmus team, however, recognizes that individual Utility programs may be confined to working within a broader website architecture and may not have the ability to customize functionality.

Set Program Expectations

The program pages provide high-level information about what the program offers as well as valuable information about a typical site timeline, different infrastructure ownership options supported by the program, rebate amounts, and program eligibility criteria, all of which help set program expectations for prospective participants. Additional information about program service offerings beyond rebate amounts and the nonfinancial benefits of fleet electrification could further aid customers' program understanding, as well as help motivate participation.

Aid Decision-Making

The web pages offer a number of tools and resources to help fleet owners and operators understand what converting their fleet to electric might mean to them. These resources include FAQs, factsheets and guidebooks, information about available EVs and rate options, a charging station vendor list, and links to additional funding resources. A calculator to estimate individual cost savings from fleet electrification could provide an additional persuasive decision-making tool: this could be either an SDG&E tool or a link to a third-party tool.

While the very first sentence beneath the title includes the tagline, "… helps fleet owners and operators reduce operating costs, eliminate emissions, and simplify vehicle maintenance…," the pages could further highlight non-financial benefits of fleet electrification in the page content to support the case for why fleet owners and operators should convert their fleet to EVs.

For EY2021, the Cadmus team utilized a focused approach in its review of program materials by concentrating on the PYDD web site for this first year context of the broad range of marketing, education, and outreach efforts conducted for PYDFF.

Utility Staff Insights

Through speaking with SDG&E program staff, the Cadmus team sought to better understand the program's design and operations, barriers to transportation electrification, and ways that SDG&E planned to overcome those barriers.

SDG&E staff indicated that the program could help overcome barriers to electrification presented by high upfront costs, risks associated with electrification, and the complexities of navigating the electrification process. They indicated that via the program, they could help alleviate these barriers and spur early adopters.

SDG&E has found that the program does not work as well for small businesses. Smaller businesses often do not know where to begin and need grant funding. Because of economies of scale, small businesses also have proportionally high fixed costs. Additionally, the program is challenging for customers who are tenants rather than site owners. Committing to 10 years at a site is challenging for tenants.

Among all program-related costs, SDG&E found that switch gear and transformer costs were significant. They also spent a significant amount on construction costs, recruiting and onboarding customers, and guiding customers through the program. Design costs were high but were also stable and predictable. Materials were a big cost driver due to price variability resulting from COVID-19-induced supply chain issues. SDG&E believed that these supply chain issues could make it difficult for them to meet the program goals.

SDG&E set up a stage gate process to cut back on excess costs, ensuring that it spends resources on customers who are committed to electrification. They also implemented a process for reviewing the technical aspects of a site to assess cost-effectiveness. While SDG&E found that large sites typically have better cost-effectiveness due to economies of scale, staff also found that it is very important to have customers who are eager to proceed with electrification and passionate about the work. Customers who are eager are more likely to accept the Utility's recommendations, which can help prevent costs associated with redesign.

Site Visit Findings

The Cadmus team visited the only activated site in EY2021, which also had an operational EV fleet. During the site visit, the team collected qualitative and quantitative information that provided us with an understanding of fleet composition and operations. This included information on the make, model, and number of EVs; 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, as well as whether there was interest in on-site solar and/or storage associated with the site.

As shown in Table 105, the site included two L2 charging ports with two medium-duty EVs. The Utility completed all work TTM and BTM. According to the fleet operator, this made their experience simple and convenient.

Table 105. SDG&E PYDFF Summary by Site

Site	Number of DCFC Ports	Number of L2 Ports	Market Segment	Charger Power (kW)	Total Charging Capacity (kW)
1	0	2	Medium-Duty Vehicles	10.5	21

The fleet operator noted a significant impact to vehicle operation due to the pandemic. The EVs are used to transport students to and from after-school activities. Limited school attendance during the first half of 2021 and social distancing reducing vehicle capacity, and the fleet operator reported that they did not achieve pre-pandemic operations level by the end of 2021.

Installation of the charging equipment, shown in Figure 96, was completed approximately two months before EVs were delivered. This timing allowed the EVSP to set up the load management functionality by the start of operation. The operator explained their use of a lock-out function to avoid charging between 4 p.m. and 9 p.m. (confirmed by the analysis).

Figure 96. Electrical Switch Gear in Relation to EVSE

The operator represents one of only three SB 350 MDHD programs to employ load management and has maintained exceptionally low consumption between 4 p.m. and 9 p.m. The operator noted that the load management approach has presented a challenge as the EVs have had instances of not starting or not completing the full charge by the morning. RFID key fobs are used to initiate a charging session, but the operator noted that these key fobs were not always reliable.

The operator did not gain access to the EVSP online portal until several months after the charging stations were commissioned but were able to at the time of the site visit. This enabled the Cadmus team to review load management and charging records. The operator discussed internal practices of documenting vehicle logs to allow for tracking the EV range and electrical energy consumption rate. This information would be helpful as the operator reported recently running out of range while on a student trip. Due to this incidence, the operator is considering limiting the EVs to trips within a 50-mile radius unless there are able to use public DCFC to extend the daily range. The operator was unaware of their EV charging monthly costs and how they compare to conventional ICE vehicles.

According to the operator, public funding was critical for the EV purchase and SDG&E connected them with an organization that funded the entire EV cost through a grant. This site is leased by the operator, which required the landlord’s involvement in contracting. The lease scenario presents a risk to long-term benefits of the installation in the event the lease is not renewed. SDG&E electrical access required the charging to be installed in a part of the facility dedicated to other tenants.

The charging installation has capacity for electrical expansion; however, the location itself is constrained (see Figure 97). A new stepdown transformer to 208 volts was installed approximately 100 feet away from an existing transformer up the hill.

Figure 97. Charging Installation Layout

Total Cost of Ownership

The Cadmus team is not including a TCO analysis in the evaluation report for EY2021. SDG&E provided all of the necessary data to support the TCO analysis including cost data, and the team did conduct a TCO analysis, but due to the limited number of sites (as a single site was closed out), it was impossible to protect customer confidentiality if this analysis were published. The Cadmus team presented the TCO to SDG&E for their internal reference.

Grid Impacts

The Cadmus team is not including an analysis of grid impacts in the evaluation report for EY2021 to protect customer confidentiality and since the evaluation threshold of at least 15 sites was not reached. SDG&E provided all necessary inputs, including AMI data, to support the grid impacts analysis. However, due to the limited number of sites (as a single site was operational), the Cadmus team presented the grid impacts analysis to SDG&E for its internal reference only. Similar to other Utilities' sections in this report, the results of grid impacts analysis will be included in EY2022 report.

Petroleum Displacement

The Cadmus team is not including an analysis of petroleum displacement in the evaluation report for EY2021 for reasons stated in the *Grid Impacts* section above. The Cadmus team conducted the petroleum displacement analysis but due to the limited number of sites (a single site was operational), we presented the results of the analysis to SDG&E for internal reference only. Similar to other Utilities' sections in this report, the results of petroleum displacement analysis will be included in EY2022 report.

Greenhouse Gas and Criteria Pollutant Impact

The Cadmus team is not including an analysis of GHG and criteria pollutant emissions in the evaluation report for EY2021 for reasons stated in the *Grid Impacts* section above. The Cadmus team conducted the analysis but due to the limited number of sites (a single site was operational), we presented the results of the analysis to SDG&E for internal reference only. Similar to other Utilities' sections in this report, the results of GHG and criteria pollutant emissions analysis will be included in EY2022 report.

Health Impacts

The Cadmus team is not including an analysis of health impacts in the evaluation report for EY2021 for reasons stated in the *Grid Impacts* section above. The Cadmus team did conduct the analysis but due to the limited number of sites (a single site was operational) the results were not substantial enough to detect a change within DACs or otherwise. Similar to other Utilities' sections in this report, the results of health impacts analysis will be included in EY2022 report.

Net Impacts

Market Effects

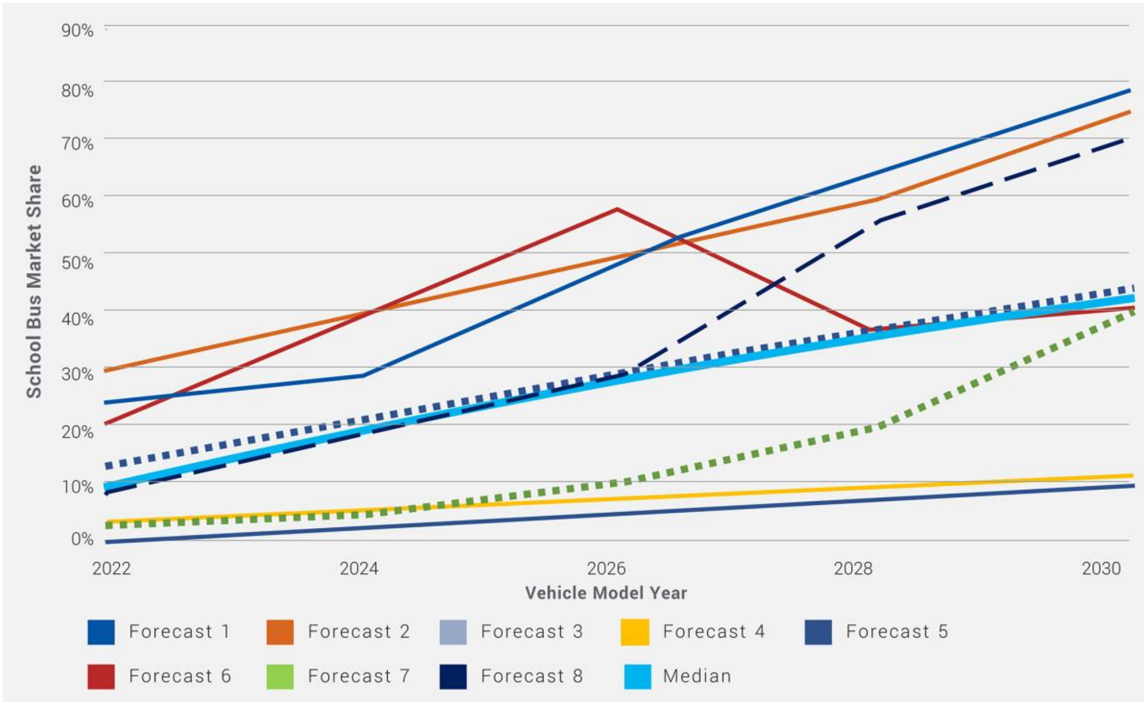
Measuring market effects is intended to inform Research Objective 1: "whether transportation electrification (TE) investments accelerated widespread TE." The calculation of market effects requires knowing actual adoption of EVs, program net impacts, and naturally occurring market adoption of EVs. The team will measure actual adoption and program net impacts as the Utility programs progress—the ideal time to measure the naturally occurring market adoption is before significant program activity has commenced. This is because the naturally occurring market adoption is a counterfactual scenario where the Utility interventions do not exist. In this evaluation, the Cadmus team used expert opinion to determine this baseline.

SDG&E did not have any activated school bus sites in EY2021, so the Cadmus team investigated the counterfactual adoption of electric school buses statewide since this market segment was the most highly represented in the other Utilities' programs. We will study additional market segments in EY2022.

School Bus Electrification Market Share Baseline

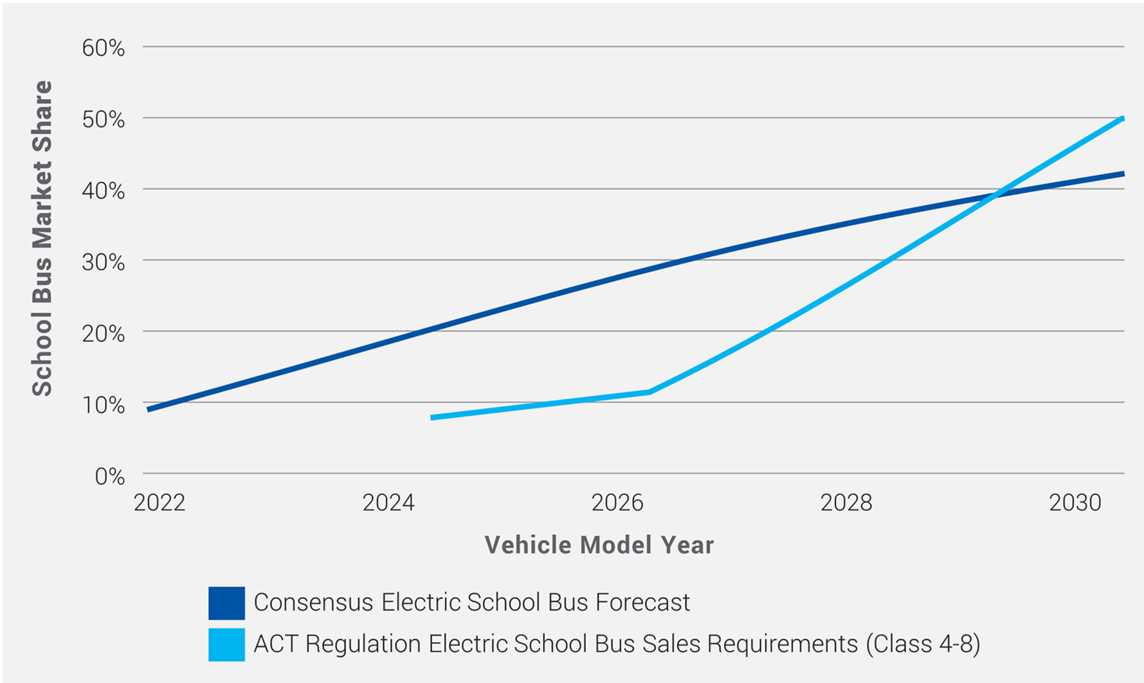
The Cadmus team developed a consensus forecast for the baseline market share of electric school buses in California through vehicle model year 2030 following two rounds of input from the Delphi process. Figure 98 shows the individual curves from the first round of input (Round 1), along with the median curve. Note that the horizontal axis is for vehicle model year and only applies to *new vehicles*, not to the entire statewide vehicle stock.

Figure 98. Round 1 Baseline Electric School Bus Adoption Forecasts



Despite the range in Round 1 forecasts, there was general agreement that the EV market share will increase over time. In Round 2, five of eight panelists agreed with the median or consensus forecast, while three panelists submitted new forecasts and rationales. As over half of the panelists were in agreement, the median forecast was the final consensus result. Figure 99 shows the final consensus estimate compared to the zero-emission truck sales schedule from the Advanced Clean Trucks (ACT) regulation for Class 4 through Class 8 vehicles. It shows that experts do not think the ACT regulation will drive adoption of electric school buses, possibly because the regulation allows for flexibility in how manufacturers decide to meet the California sales requirements across all covered MDHD vehicles.

Figure 99. Electric School Bus Baseline Market Share Forecast



Of the three experts who did not agree with the median, two believed that the market share will grow faster due to a tipping point in the late 2020s once EVs establish a clear TCO advantage over ICE vehicles. This will likely manifest as a supply- and demand-side shift wherein manufacturers and fleet managers will view ICE vehicles as financially irrational. The third expert thought the electric school bus market share will grow at a much slower rate than the median forecast due to the relative price and TCO of electric school buses, the delay in bus purchases resulting from the COVID-19 pandemic, manufacturing limitations, and the lack of sufficient funding.

The Cadmus team recognized that while deriving the consensus forecast achieved the main goal of the Delphi panel, 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.

Nearly all the panelists agreed that the availability of funding poses the greatest driver or barrier to wider school bus electrification. Experts stated that the financial standing of school districts as well as the costs for production, batteries, and overall vehicles comprise the major barriers that suppress increased adoption. These panelists referred to incentives, rebates, and other programs at the local, state, and federal levels such as the Bipartisan Infrastructure Law, Hybrid and Zero-Emission Truck and Bus Voucher Incentive Program (HVIP), and the U.S. EPA's Clean School Bus Program as vital mechanisms that will alleviate the financial burden and accelerate the electric school bus market.

The panelists also mentioned many other barriers to increased uptake of electric buses. For instance, panelists whose forecasts were below the median curve cited infrastructure challenges such as EVSE placement and availability, incompatible charging schedules, vehicle range, and charging rates within their supporting rationales. One panelist noted that, irrespective of cost, funding, or other advantageous changes, certain school bus routes and fleets will be difficult to electrify due to customers being resistant to change.

The final concern raised by panelists was related to vehicle or model availability being a constraint on adoption. Experts disagreed over this issue: some believed that the availability of vehicles was not a bottleneck, and some were certain that supply will be insufficient to meet demand, while others thought that while the initial ramp-up in supply will not be able to meet demand, vehicle availability will not suppress adoption in later years of the study period.

Experts were split between whether the ACT regulation would influence the electric school bus market. Half the panelists viewed the regulation as a “floor” or “background noise” rather than a driving force. These observations result from schools historically following bus replacement schedules regardless of any regulations, the lack of available vehicles or vehicle models, and the regulation’s classification of school buses within a broad category wherein sales of varying vehicle types can count toward the regulation’s sales requirements. The remaining half of panelists stated that the ACT regulation increased their market forecast within the Delphi panel. As previously mentioned, some panelists predict that the regulation will induce a supply-side shift, causing manufacturers to view ICE vehicle production as no longer profitable or feasible in the long term. Other experts expect the ACT regulation to indirectly support electric school bus uptake, as it will help reduce battery and other input costs for all EVs. Several experts also pointed to the emissions standards within California’s Clean Air Act (reinstated through a waiver by the U.S. EPA) as spurring a significant transition toward electric school buses in 2027.

Finally, experts provided insight into the impact that California’s electric Utilities could produce on the consensus forecast. Over half the experts (five of eight panelists) predict that the Utilities will shift the baseline forecast upward considerably through mechanisms such as funding, EVSE and infrastructure support, education and outreach programs, and targeted charging rates.

6.1.3. Lessons Learned

Due to the early stage of the PYDFF program and the activation of a single site thus far, these EY2021 lessons learned are limited to market activity and not specific to any program finding.

There was general agreement among market experts that the EV market share for the school bus segment will increase over time.

Nearly all the experts from the Delphi panel on school bus electrification agreed that the availability of funding poses the greatest driver or barrier to wider school bus electrification. They cited the various government funding programs as vital mechanisms that will alleviate the financial burden and accelerate the electric school bus market. They noted that the financial standing of school districts as well as the costs for production, batteries, and overall vehicles comprise the major barriers that suppress increased adoption.

Half the market experts did not believe the ACT regulation would be the main driving force in electrification of the school bus market, citing factors such as bus replacement patterns, lack of available vehicles, or flexibility within the regulation that allows for sales of different types of vehicles to count toward compliance. The remaining half of panelists said that the ACT regulation increased their baseline market forecast. Some panelists predict that the regulation will induce a supply-side shift, causing manufacturers to view ICE vehicle production as no longer profitable or feasible in the long term. Other experts expect the ACT regulation to indirectly support electric school bus uptake, as it will help reduce battery and other input costs for all EVs.

6.2. Schools and Parks Pilots

6.2.1. Overview

This overview provides a detailed description of the SDG&E Schools and Parks Pilots and summaries of the Pilot implementation process, ME&O activities, EY2021 sites, budget status, and a major milestone timeline. Following the overview, we present the EY2021 findings and lessons learned.

Pilot Description

Schools Pilot: Through its Schools Pilot, SDG&E offers 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.[109] SDG&E designed a turnkey ownership model, where SDG&E offers to install, own, operate, and maintain the charging stations. The charging stations are required to use TOU rate pricing. Site hosts can opt to own the chargers, in which case the site hosts are eligible for a rebate equivalent to the cost that SDG&E would pay to install EVSE under the SDG&E turnkey model. For both types of participants, SDG&E offers EV curriculum to provide EV education for students.

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 offers direct installation of 74 light-duty public chargers in 12 state parks and beaches within SDG&E's 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

Prior to reaching out to potential site hosts, SDG&E staff set up internal processes to track applications, draft common contract language, and conduct other administrative tasks to ensure smooth implementation of both Pilots over time. Staff relied on the expertise of several departments to facilitate the efficient establishment and implementation of these processes: Permitting and

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109 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 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.

Contracting, Standards Group, Civil Group, Transmission, Construction Services, District and School Account Executives, Legal, Regional Public Affairs, and the Customer Solutions Team. Additionally, SDG&E staff developed educational materials for both Pilots to raise awareness about the chargers and benefits of EVs.

When considering potential sites, SDG&E staff monitored the distribution of Schools and Parks Pilots sites across its service territory to ensure that sites will be spread out and not clustered in any one particular area. SDG&E considered several additional key eligibility criteria for each site:

- Topographic features of a potential site (such as having no significant incline)
- Length of trenching needed
- Degree of construction needed to meet ADA requirements
- Potential utilization of site based on proximity to other public points of interest (such as freeway access and public buildings like libraries, office buildings, restaurants, retail centers, or places of worship)
- DAC or non-DAC

Figure 100 shows the implementation process for the Schools and Parks Pilots. Note that the customer agreement step is slightly different for state parks compared to the process for municipal parks and the Schools Pilot, since it is anticipated that the California Department of Parks and Recreation will approve a master participation 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 100. Schools Pilot and Parks Pilot Implementation Process

ME&O Summary

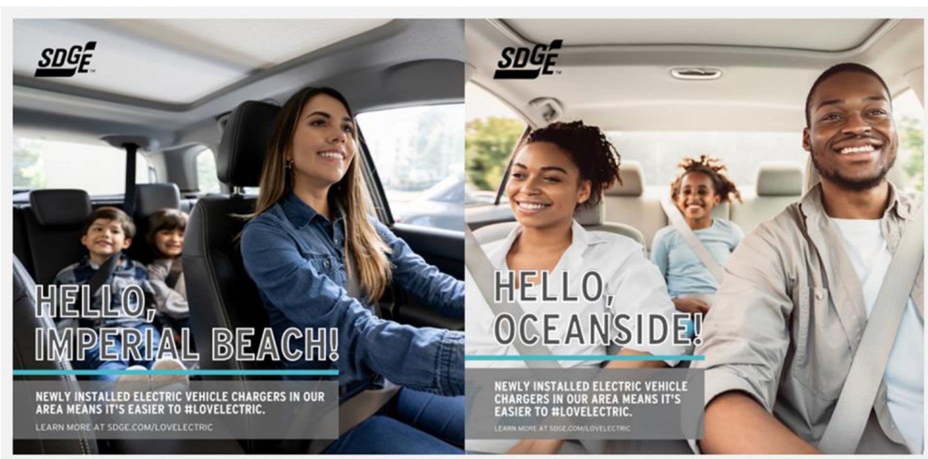
Schools Pilot and Parks Pilot: SDG&E staff worked with their community relations and regional public affairs departments to identify and engage potential site hosts. Within these departments, staff hosted joint community and media events, such as ribbon cuttings and community outreach videos that highlight the benefits of adding EV infrastructure to their community.

Schools Pilot: The main ME&O activity for the Schools Pilot was a regional video competition (the 20th Annual iVIE Student Film Festival & Awards Ceremony) for middle- and high-school students centered around the benefits of electric charging. To implement the competition, SDG&E partnered with the non-profit Media Arts Center San Diego. The two winning teams were both awarded $750. The videos can be found online:

- STEAM Academy presents "The Future is Electric," a short film where students explain how driving electric can help reduce smog and GHG emissions and deconstruct the claim that EVs are more expensive than conventional cars.
- High Tech High International presents "We Didn't Hear Them Coming," a short film that alludes to how quiet and fun to drive EVs are and that briefly explains the differences in how EV batteries work versus ICE batteries.

Parks Pilot: There were three main ME&O activities for the Parks Pilot. SDG&E organized a ribbon cutting press event with the County Supervisor Vice Chair, Beach Mayor, and SDG&E's Vice President of Energy Procurement and Sustainability Estela De Llanos after a municipal site was activated. SDG&E also prepared social media sharing kits for municipalities after site activation. These sharing kits provided pre-written text and pre-designed images the municipalities could use to promote the activated sites. An example of two of these images designed for completed sites is shown in Figure 101.

Figure 101. Example Image from SDG&E Social Media Kit for Municipal Parks Pilot Sites



Finally, SDG&E created of two videos:

- The short "LOVELECTRIC Charge While You Recharge" general Parks Pilot promotional and awareness video, which is available in both English and Spanish
- The short "Oceanside EV Chargers" video, which promotes a specific municipality site. This video was made with members of the community to help them tell their specific story and to promote chargers at the specific site.

Site Summary

For EY2021, the Pilot data included the number of sites by Pilot, location of sites, DAC status of sites, and days by application phase. The Cadmus team will continue to work with the Utilities to expand our collection of Pilot data for future evaluation years.

Table 106 and Table 107 provide the count of construction complete sites in SDG&E's Schools Pilot and Parks Pilot, respectively, by completion status.

Table 106. EY2021 SDG&E Schools Pilot Complete Site Count By Status

Site Status	EY2021
Utility Construction Complete	1
Activated	1
Operational	-
Closed Out	-

Table 107. EY2021 SDG&E Parks Pilot Complete Site Count By Status

Site Status	EY2021
Utility Construction Complete	5
Activated	5
Operational	4
Closed Out	-

As shown above, at the end EY2021 SDG&E's Schools Pilot had one activated site that was not yet operational and the Parks Pilot had five activated sites, four of which were operational, all within city and county parks. As show in Figure 102, all EY2021 sites were located in DACs.

Figure 102. SDG&E Schools Pilot (Left) and Parks Pilot (Right) Activated Charging Locations

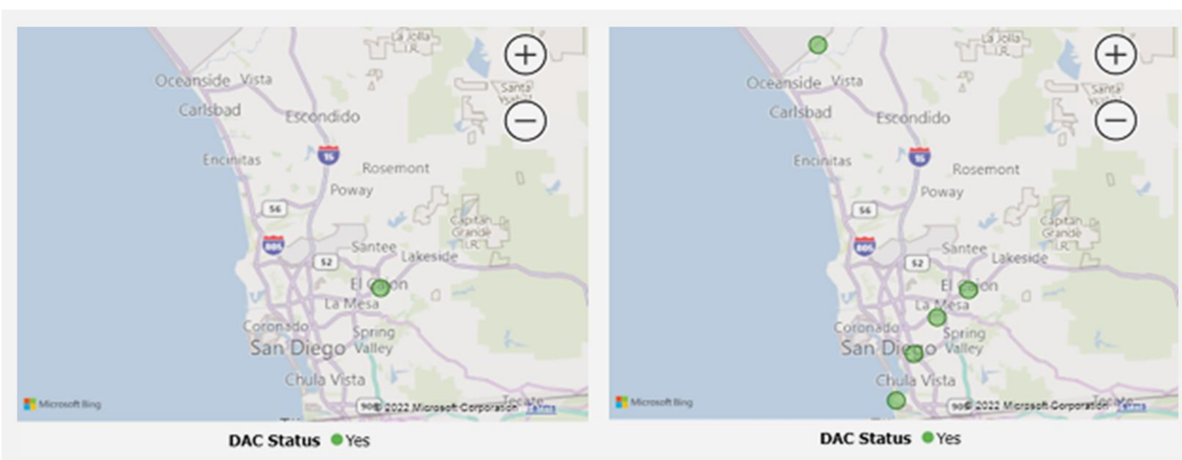


Table 108 presents site-level data by Pilot, DAC and activation status, and number of ports and chargers for the six activated sites. The number of ports ranges from four to 10 per site while the number of chargers ranges from three to six.

Table 108. SDG&E Schools Pilot and Parks Pilot Activated Site Data

Pilot Name	Site	DAC Status	Activated	Operational	Number of Ports	Number of Chargers
Schools Pilot	1	Yes	Yes	No	8	5
Parks Pilot	1	Yes	Yes	Yes	10	6
	2	Yes	Yes	Yes	4	3
	3	Yes	Yes	Yes	4	3
	4	Yes	Yes	Yes	8	5
	5	Yes	Yes	No	4	2

The one activated Schools Pilot site finished the full phase cycle in 674 days from application reviewal to activation. The longest phase for the Schools Pilot site was the application reviewal, at 269 days. The shortest phase was for activation, which was completed in a single day.

The five activated Parks Pilot sites finished the full phase cycle in a median of 510 days from application reviewal through activation. The longest phase was the design and permitting, at 191 days, while the shortest phase was activation, at nine days.

Table 109 shows the median number of days by phase for both the Schools Pilot and Parks Pilot sites.[110]

Table 109. Schools Pilot and Parks Pilot Median Number of Days by Phase

Phase Status	Schools Pilot	Parks Pilot [a]
Application Reviewal	269	40
Site Assessment	189	159
Contract Issuance	22	22
Design and Permitting	142	191
Construction Complete	52	64
Activation	1	9

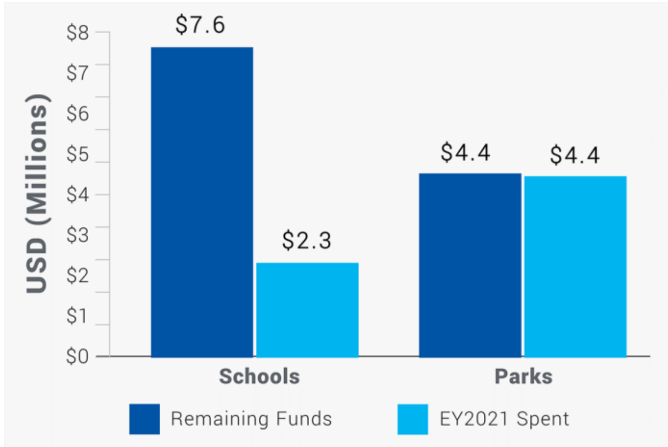
[a] All five activated Parks sites are included in this table.

Budget Summary

As shown in Figure 103, through the end of 2021 SDG&E spent $2.3M of $9.9M on the Schools Pilot and $4.4M out of $8.8M on the Parks Pilot.

[110] The full phase cycle of days may not sum to the total median number of days by phase due to potential overlapping days of phase durations.

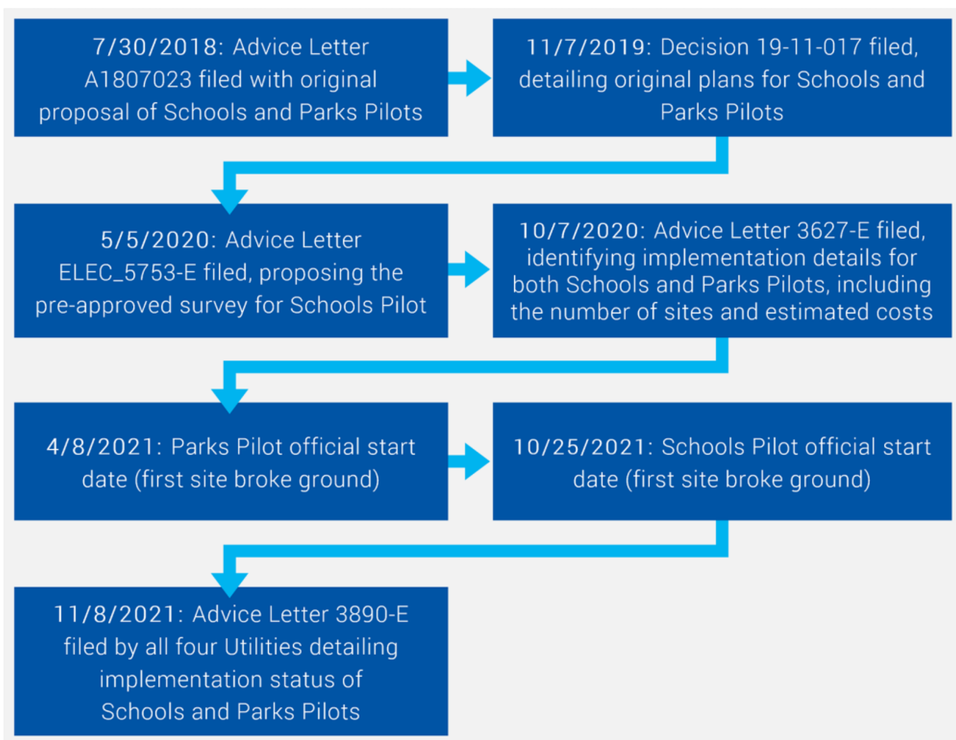
Figure 103. Budget Remaining versus Spend through 2021



Timeline

Since the inception of the Schools and Parks Pilots in 2018, there have been several updates and milestones, as shown in Figure 104.

Figure 104. Timeline of Key Schools Pilot and Parks Pilot Milestones



6.2.2. Findings

As discussed in the *Overview* section, SDG&E has one activated site for the Schools Pilot; however, it was not operational in EY2021. In addition, SDG&E has five activated sites for the Parks Pilot, of which four

were operational. Although impact data were limited to the activated and operational Parks Pilot sites, the Cadmus team assessed the preliminary impacts associated with the SDG&E Parks Pilot for EY2021 including incremental EV adoptions, site visits, grid impacts, petroleum displacement, GHG and criteria pollutant reductions, and health impacts. We also conducted a TCO contextual analysis and determined insights from the Utility website review and staff interviews. These findings are provided below.
Table 110 provides an overview of the estimated annual impacts for the SDG&E Parks Pilot EY2021 activated sites. Impact estimates within the table are based on the three EY2021 operational sites that had sufficient data for annualization.

Table 110. SDG&E Parks Pilot EY2021 Summary Impacts

Impact Parameter	Annual Estimate	Impact to DACs, %
Population of Activated Sites	5	100%
Sites Included in Analysis (#)	3	100%
Charging Ports Installed (#)	16	100%
Electric Vehicles Supported (#)	N/A	N/A
Electric Energy Consumption (MWh)	29.95	100%
Petroleum Displacement (GGE)	2,643	100%
GHG Emission Reduction (MT GHG) [b]	18.02	100%
PM_{10} Reduction (kg)	0.10	100%
$PM_{2.5}$ Reduction (kg)	0.09	100%
ROG Reduction (kg)	1.69	100%
CO Reduction (kg)	53.80	100%

[a] Impact estimates are based on EY2021 operational sites that had sufficient data for annualization.
[b] Includes CO_2, CH_4, and N_2O multiplied by their respective GWP as defined by IPCC AR5 (see the Methodology section for more details).

Incremental EVs Adoption

The team estimated the effect of the public charging stations on EV adoption for neighboring populations[111] with a two stage analysis: (1) historical analysis of public EV charging impacts on vehicle

[111] 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 availability of EV charging equipment at convenient locations (for midday charging away from home) is expected 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 availability of nearby charging infrastructure is expected to lower the cost of EV ownership by providing alternatives to home charging. It is expected 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 lift EV ownership through both channels and that there may be positive interactive effects between the channels that lift the overall impact of public charging networks. The Cadmus team focused on analyzing the second channel. We will analyze the impacts for the first channel separately when data become available.

ownership and (2) analysis of ownership attributable to SDG&E Parks Pilot investments. See the Methodology section for the analysis discussion.

Using the impact estimates from the Stage 1 analysis, the Cadmus team estimated the impact of California Utility investments in public charging on EV ownership. In 2021, four charging stations in SDG&E's Parks Pilot became activated and operational. We estimated the impact of these stations on annual EV registrations.

Based on the composite measure of public charging access, we calculated the change in access to the charging stations for each census block group (CBG) whose access was affected by SDG&E's investment. As shown in Table 111, we found that the average change in the composite measure of access was 8.46 per affected CBG, and the average change in the number of chargers was 6.20 per affected CBG. Normalized EV annual registration per 1,000 households was 9.53 in the affected CBGs between 2015 and 2020.[112]

Table 111. Summary Statistics for CBGs Affected by the Parks Pilot Utility EV Charging Stations

	CBG Mean (Standard Deviation)			
	Change in Composite Measure of Access	Change in Number of Chargers	Normalized Annual EV Registrations	Number of Households
Parks Pilot	8.46	6.20	9.53	352.50
	(3.28)	(2.39)	(6.63)	(170.30)
CBGs (N)	10	10	10	10

Notes: The change in composite measure of access, change in number of chargers, and number of households are average for the affected CBGs. The changes are measured between 2015 and 2020. Sample standard deviations are in parentheses.

We combined 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 to estimate the impact of the Parks Pilot Utility charging investments on EV ownership. The impacts of the SDG&E investments on EV registrations will depend on how much the investments increased access in the affected CBGs and the number of households in the CBGs.

Table 112 reports the estimates of the annual EV registrations attributable to the Utility Parks Pilot charging investments.[113] Based on the OLS long differences model, the effect of the SDG&E investments in charging facilities was to increase annual EV registrations by 2.34 vehicles. Based on the IV-2SLS long differences model, the effect of the Utility investments was to increase annual EV registrations by 5.13 vehicles. These estimates assumed that the four activated Parks Pilot facilities operate for a whole year.

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[112] 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.

[113] 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 112. Annual EV Registrations Attributable to Utility Public Charging Stations

	Annual Increase of EV Registrations Driven by the Utility Program	
	OLS	IV-2SLS
Parks Pilot	2.34	5.13
	(0.64)	(2.99)

Note: The table shows the annual EV registrations attributable to the Utility investments in public charging infrastructure over all affected CBGs. Estimates were based on the OLS and IV-2SLS long differences models. We 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 10 largest cities. The long differences estimates are five-year estimates, which we divided by five to annualize. For each affected CBG, we 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, multiplied by the number of CBG households (in thousands). Robust standard errors clustered at the block group level are in parentheses.

The SDG&E Parks Pilot investments in public charging on EV registrations had economically meaningful impacts on EV ownership in EY2021. Across all 10 affected CBGs, the average annual number of EV registrations is about 95, so the impact of the SDG&E Parks Pilot, based on the preferred IV-2SLS regression estimate, is to lift EV registrations by about 5.4% (5.13 / (10 * 9.53)). Over five years, the SDG&E investments in four public charging stations will lift EV registrations by about 25 EVs.

Site Visit Findings

The team visited all five Parks Pilot EY2021 activated sites, four of which were operational in 2021. The team also visited the one activated, but not operational, site for the Schools Pilot. While on the site, we assessed signage, payment mechanisms, pricing, number and placement of charging ports at each location, kilowatt capacity per charger, and how the site fit into the local charging context.

Parks Pilot: As shown in Table 113, two sites featured L2 and DCFC charging stations, while other sites only had L2 charging stations.

Table 113. SDG&E Parks Pilot Summary by Site

Site	Number of DCFC Ports	Number of L2 Ports	ADA-Accessible	Nearby Facilities	Charger Power (kW)	Total Charging Capacity (kW)
1	0	4	1	Sports fields, playground, single-family and multifamily homes	L2: 7.2	28.8
2	2	8	2 DCFC spaces	Sports fields, playground, pool, multifamily homes	L2: 7.2 DCFC: 62.5	182.6
3	0	4	1	Community garden, passive park, municipal buildings, historic society admin building, place of worship	L2: 7.2	28.8
4	2	6	2 spaces, DCFC and L2	Community center, playground, downtown retail, county administration offices, public library and senior housing high-rise, East County Chamber of Commerce Office	L2: 7.2 DCFC: 62.5	168.2
5	0	4	1	Sports fields, playground, single-family homes, community center	L2: 7.2	28.8

Modest EV charging wayfinding signage was posted at two of the sites. For example, one site had signage for one direction of traffic at the entrance to the parking lot but no signage at the other entrance. As shown in Table 113, all sites had nearby facilities, ranging from playgrounds to a community garden, where EV drivers could spend time while charging. Four of the sites were near multifamily housing while the remaining site was near single-family homes.

All five sites used the ChargePoint network with sessions initiated by mobile application or a ChargePoint RFID card. The chargers screen displays a short video highlighting payment options (by credit card or ChargePoint application. In addition, all five sites provided retail TOU pricing, with the same price per kilowatt-hour for L2 and DCFC stations. To help educate customers, SDG&E posted a graphic showing representative TOU periods and charging rates. Additionally, the charging stations clearly identify pricing and ChargePoint notifies drivers before the price changes between TOU periods. Figure 105 presents an example of a TOU display on top of the charging station and a full color screen display of price status.

Figure 105. SDG&E Parks Pilot EV Charging Station Example Pricing Display

As shown in Figure 106, SDG&E installed separate metering and services for L2 and DCFC. While potentially taking a larger footprint, this approach allows for easier differentiation between the two modes of charging compared to a single service and meter.

Figure 106. SDG&E Parks Pilot Site with Two Transformers and Two Meter Pedestals to Serve DCFC and L2 Charging

Charging stations were generally placed to maximize charging accessible to multiple spaces, including placement between two rows of parking. For example, as shown in Figure 107, one dual-port charging station was able to reach at least four parking spaces. This design improves driver convenience and utilization when most chargers are in use. The use of dual-port stations also helps to keep construction costs down as less trenching is required.

Figure 107. SDG&E Parks Pilot Site with Charging Stations Located to Reach Multiple Parking Spaces

Figure 108 depicts another example of charging ports with high access. A dual-port charging station is centered between four head-to-head parking spaces, with relatively long cords (18 to 25 feet) that can reach across two parking spaces. This style of charging station placement provides parking options for EV drivers, as well as opportunities for multiple charging sessions without drivers having to move their vehicles.

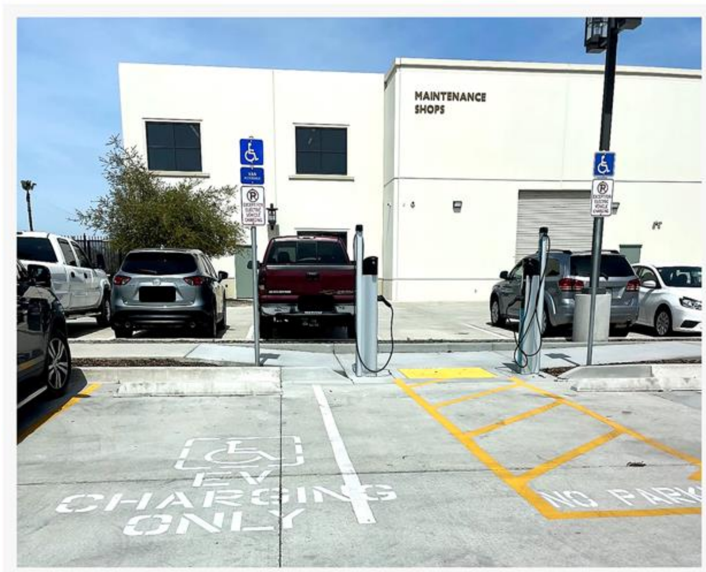
Figure 108. SDG&E Parks Pilot Los Palmas Park High Access Level 2 Charging

Figure 109 shows example of ADA-accessible charging station. The site is compliant with the building code where the ADA path of travel must be clear and level and wheel stops protect the charging station from direct impact.

Figure 109. SDG&E Parks Pilot Site Example of ADA-Accessible Charger

Schools Pilot: The team also visited the single activated, but not operational, Schools Pilot site for EY2021. This site is located at a district office complex, which includes administrative offices, a maintenance shop, and a fleet yard, as well as an affiliated charter school. The district's primary middle school is located one block north. The site is private and not open to the public. While on the site, we assessed signage, payment mechanisms, and the placement of chargers. Figure 110 shows an example of ADA-accessible EV charging space at this location.

Figure 110. SDG&E Schools Pilot Site with ADA-Accessible Parking Spaces



The Parks Pilot and Schools Pilot sites are on a commercial EV-TOU rate, which typically has higher charging fees but a simpler structure than the SDG&E grid-integrated rate (dynamic day-ahead hourly pricing) that was provided to the SDG&E Power Your Drive Pilot.

As shown in Figure 111, the Schools Pilot site layout was similar to some of the Parks Pilot site layouts, with the dual-port chargers (3) located along a central aisle to maximize the number of spaces each charging port could reach. Two additional single-port stations were located next to ADA-accessible spaces with an appropriate path of travel. Each port provides 7.2 kW for a total site capacity of 57.6 kW.

Figure 111. SDG&E Schools Pilot Site with Dual-Port Chargers

Grid Impacts

The team estimated grid impacts for the SDG&E Parks Pilot based on power consumed by the four operational sites installed in EY2021 combined with charging session data from the electric vehicle service providers (EVSP). Table 114 presents a summary of the estimated grid impacts by EY2021, an annual estimate, and a 10-year forecast.

Table 114. SDG&E Parks Pilot Grid Impacts

Impact Parameter	Evaluation Year 2021	Annual Estimate [a]	10-Year Projection [a]
Operational Sites	4	3	3
Electric Energy Consumption, MWh	11.83	29.95	299.45
On-Peak MWh (4 p.m. to 9 p.m.) (and % of total)	2.88 (24%)	N/A	N/A
Maximum Demand, kW (with date and time)	58.2, 12/18/21 1:30 p.m.	N/A	N/A
Maximum On-peak Demand, kW (with date and time)	54, 11/14/21 7:15 p.m.	N/A	N/A

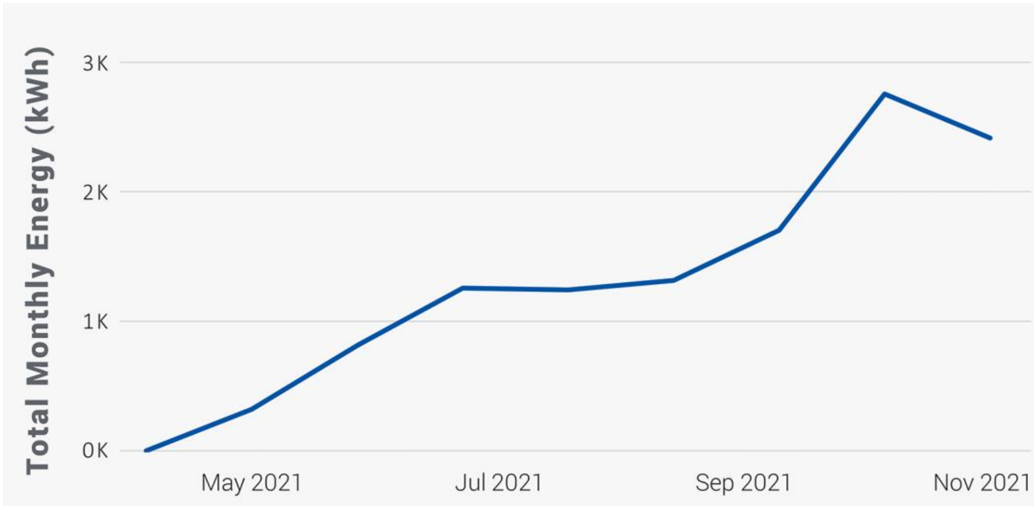
[a] The team used three of the operational sites for this estimate. This number differs from other EY2021 numbers because one site had less than two months of use and did not meet the annualization criteria described in the Methodology section.

The remainder of this section provides detailed findings on the actual monthly consumption, maximum demand, and load curves for EY2021.

As shown in Figure 112, actual consumption for EY2021 ramped up as SDG&E installed the four operational sites in the Parks Pilot and the public became aware of their availability. As was shown in Table 113, these sites represented 437.2 kW of installed charging capacity through the Parks Pilot throughout 2021 while the actual demand, shown in Table 114, reached a maximum of only 58.2 kW.

Figure 112 illustrates that actual monthly consumption for all operational sites in EY2021 continually increased from April through November 2021, with a drop in December. As most of these sites are adjacent to residential neighborhoods and can support both residential and recreational EV drivers, this drop in December may reflect less travel in the residential sector due to the holidays.

Figure 112. SDG&E Parks Pilot 2021 Monthly Energy Consumption



Three quarters of the total energy consumption is from the Imperial Beach Sports Park's four L2 charging ports, which was the first Parks Pilot site (activated in May 2021). Stoney's Neighborhood Park was activated several months later with eight more L2 charging ports in addition to two DCFC, which contributed to increased energy consumption. Figure 113 presents daily port utilization trends

Figure 113. SDG&E Parks Pilot Port Utilization by Day Type and Time

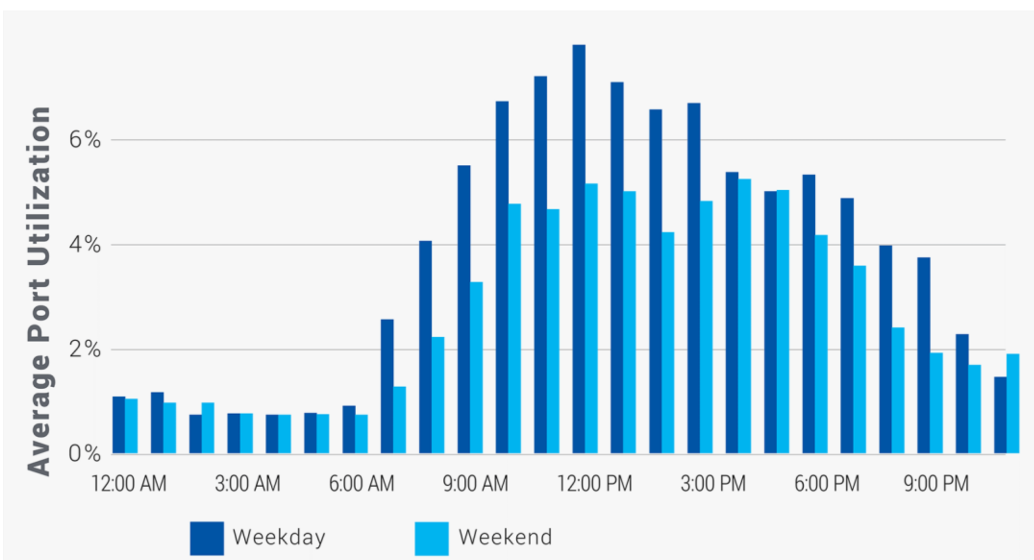
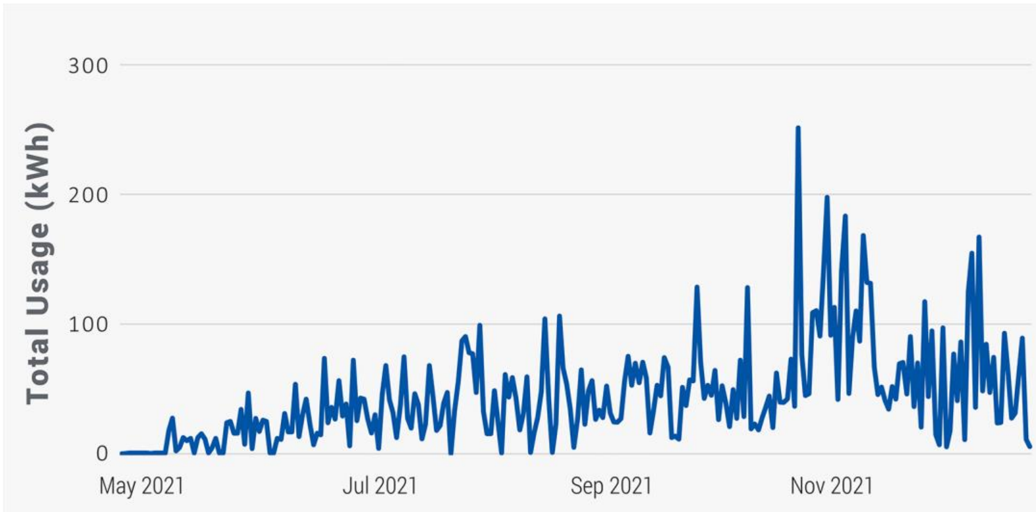


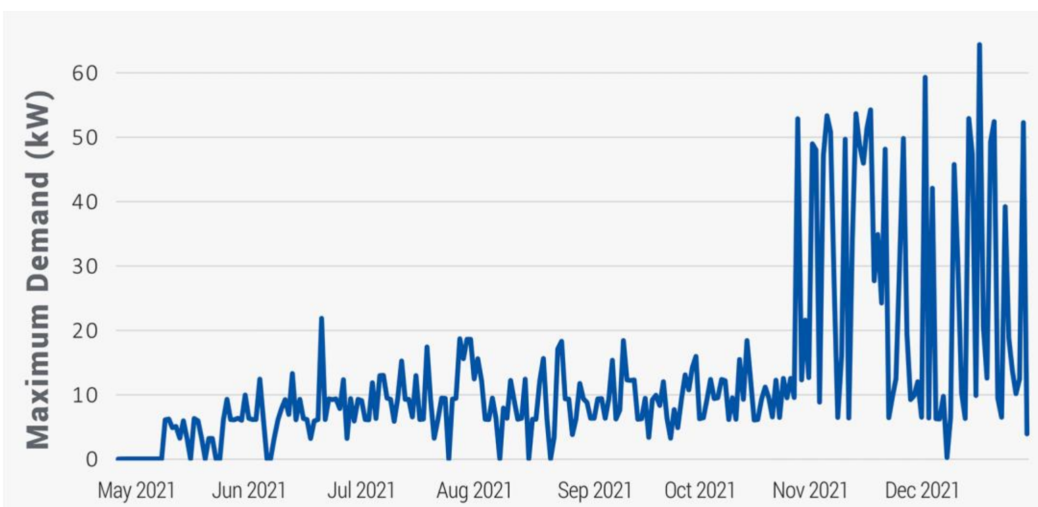
Figure 114 shows sporadic daily consumption (peaking at 250 kWh while the average is below 100 kWh); however, consumption may increase and level out as the sites mature and drivers become more aware of these charging options.

Figure 114. SDG&E Parks Pilot Daily Energy Consumption Trends



As shown in Figure 115, Stoney's Neighborhood Park accounts for an abrupt increase in maximum daily power demand starting in November 2021. This figure identifies maximum demand reaching 64 kW on December 18, 2021, followed closely by 60 kW on December 14, compared to 437.2 kW of installed EV charging capacity.

Figure 115. SDG&E Parks Pilot Maximum Daily Demand (kW)



In Figure 116, Parks Pilot charging appears to take place during the morning from 9 a.m. to 12 p.m., as well as some overnight charging, which may be from nearby residents.

Figure 116. SDG&E Parks Pilot Load Curve on August 12, 2021 Highlighting Overnight Charging

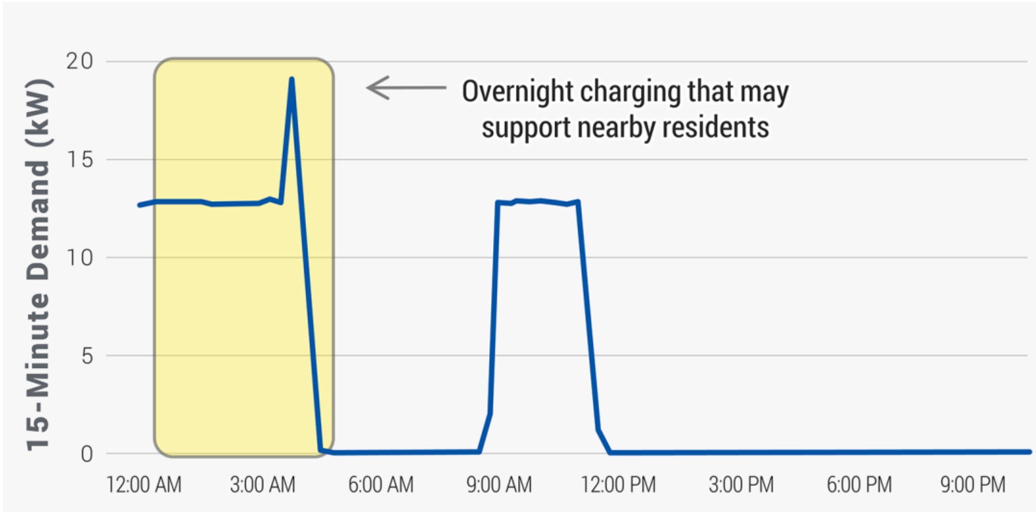
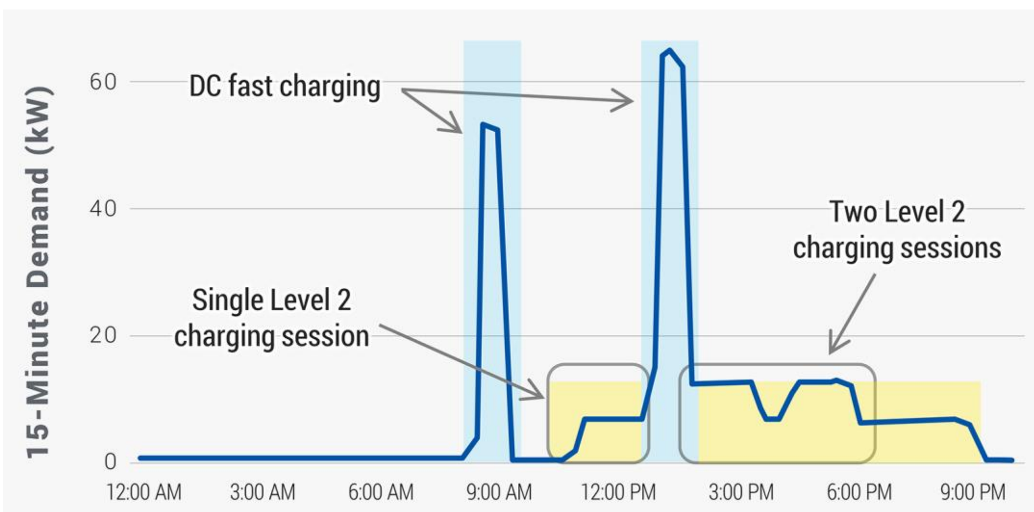


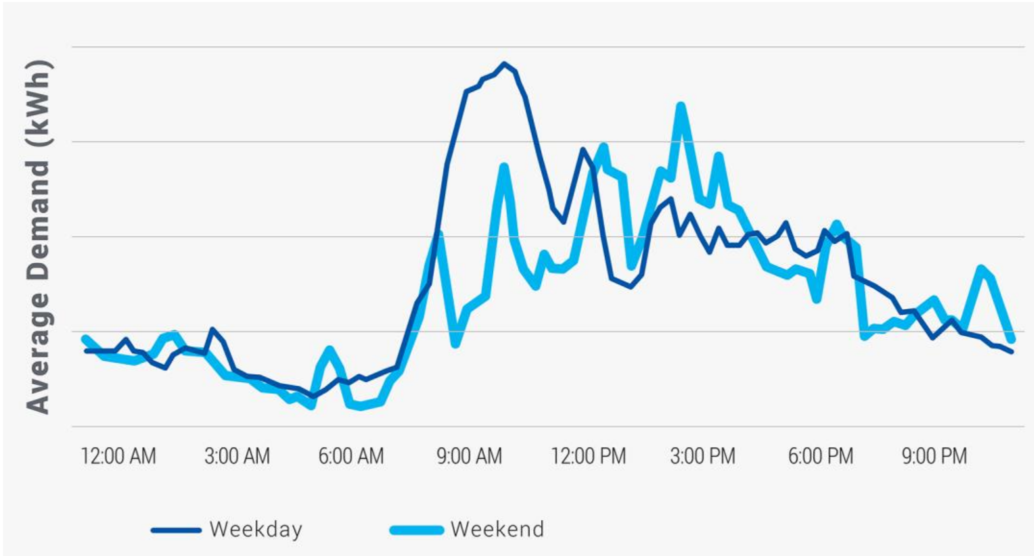
Figure 117 represents charging sessions during the highest demand day for SDG&E's Parks Pilot (December 14, 2021). Data shows charging from single and concurrent L2 sessions as well as DCFC sessions. The spike in DCFC charging is evident in mid-morning and mid-afternoon, whereas the L2 charging is more consistent throughout the afternoon and evening.

Figure 117. SDG&E Parks Pilot December 14, 2021 Load Curve Highlighting Distinct DCFC and Level 2 Charging



As shown in Figure 118, based on the limited operational data for EY2021, charging patterns appear inconsistent. As such, aggregate and average load curves do not show a strong trend in charging patterns; however, they do highlight common charging times in EY2021.

Figure 118. SDG&E Parks Pilot Average Charging Port Demand by Time of Day



Petroleum Displacement

The team estimated program-induced petroleum displacement related to the four Parks Pilot operational sites for EY2021 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 SDG&E Parks Pilot.
Table 115 presents the petroleum displacement resulting from the four Parks Pilot operational sites in EY2021, along with annualized and 10-year totals, by impact location.

Table 115. SDG&E Parks Pilot Petroleum Displacement Summary

Location	Evaluation Year 2021		Annualized	10-Year Projected Impact
	Total Usage (kWh)	Petroleum Displacement (GGE)		
In DAC	11,828	1,044	2,643	26,432
Outside of DAC	-	-	-	-
Total	**11,828**	**1,044**	**2,643**	**26,432**

As shown above, the four operational sites resulted in an annualized impact of just over 1,000 gallons of gasoline, all located in SDG&E-defined DACs. Based on current operational sites, the program would result in displacing more than 26,000 gallons over a 10-year period.

Greenhouse Gas and Criteria Pollutant Impact

The team calculated reduced emissions from displaced fossil fuel use from ICE vehicles that were not in service because of the SDG&E Parks 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 116 presents the GHG reduction resulting from the four operational Parks Pilot sites in EY2021, along with annualized and 10-year totals, by impact location. All four sites are within DACs. Overall, the Pilot resulted in a 74% reduction of GHG with 100% occurring in DACs.

Table 116. SDG&E Parks Pilot GHG Reductions Summary

Location	Evaluation Year 2021		Annualized	10-Year Projected Impact	% GHG Reduction
	Total Usage (kWh)	GHG Reduction (MT)	GHG Reduction (MT)	GHG Reduction (MT)	
In DAC	11,828	6	18	180	74%
Outside of DAC	-	-	-	-	-
Total	**11,828**	**6**	**18**	**180**	**74%**

Overall, of the local emissions, the Pilot had the highest impact in reducing CO, resulting in an estimated annualized reduction of 54 kg on an annualized basis (and DACs account for 100%; see Table 117).

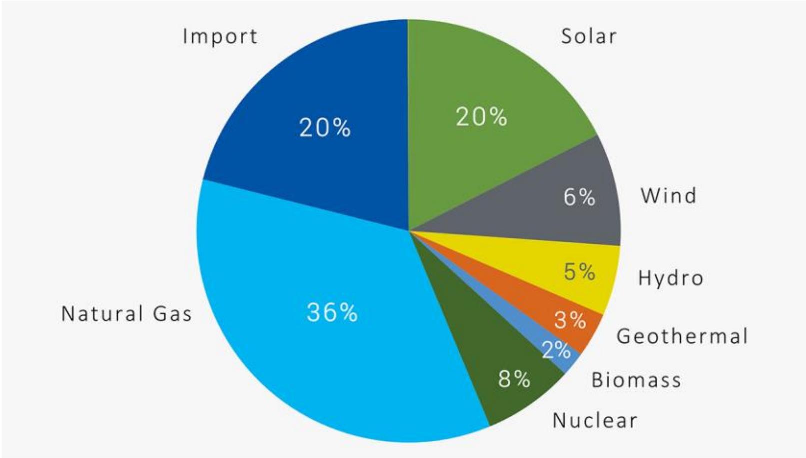
Table 117. SDG&E Parks Pilot Local Emissions Reductions

Emissions Reductions	Net Reduction		
	Evaluation Year 2021	Annualized	10-Year Projected Impact
PM_{10} (kg)	0.03	0.10	0.96
$PM_{2.5}$ (kg)	0.03	0.09	0.88
ROG (kg)	0.58	1.69	16.88
CO (kg)	18.57	53.80	538.01

The current mix of electricity from the CAISO grid used to support the SDG&E Parks Pilot sites is shown in Figure 119.[114] Based on the real-time grid conditions when the EV charging occurred, the overall energy mix contained about 44% zero emissions or renewable sources of electricity (including solar, wind, hydro, geothermal, biomass, and nuclear) and 36% 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.

[114] The power associated with imports comes from a mixture of hydro, nuclear, and natural gas plants located outside the CAISO grid.

Figure 119. SDG&E Net Electricity Mix



Health Impacts

The team calculated health benefits related to reductions in $PM_{2.5}$ (as shown in the *Greenhouse Gas and Criteria Pollutant Impact* section) that resulted from EY2021 program activity. These health benefits include:

- Mortality: incidence and valuation ($)
- Work loss days: reduction in days lost incidence and valuation ($)
- Emergency room visits: cardiovascular and respiratory incidence and valuation ($)
- Hospital admissions: respiratory benefits incidence and valuation ($)

As part of this analysis, we also examined the health benefits specifically within DACs, which may be disproportionately burdened by sources of pollution (including air pollution from ICE vehicles). However, the amount of $PM_{2.5}$ reduction that resulted from the EY2021 Parks Pilot annualized activity was not substantial enough to detect a change within DACs or otherwise for this reporting period. EPA's BenMAP, which the team used to run the health impacts analysis, is only capable of estimating health impacts at reductions in concentrations down to the sixth decimal place. A significant number of project site reductions were at or past the seventh digit, resulting in undetectable impacts. While some project sites had $PM_{2.5}$ air concentration reductions at the sixth decimal place, the team opted to run BenMAP with a cut-off at the fifth decimal place in an attempt not to overstate potential impacts at such a low level of precision.

Total Cost of Ownership

The Cadmus team analyzed key industry cost trends for public charging due to the limitations of the EY2021 cost data and to set the stage for EY2022 TCO analysis. This section provides context to the financial costs associated with installing EV infrastructure.

Infrastructure costs include BTM and TTM costs, as well as the cost for the charger and related materials. As shown in Table 118, these cost categories vary in the degree of variance, with BTM and

TTM costs typically being the most significant cost driver and having the largest degree of variance on a per-site basis.

Table 118. Infrastructure Costs

Category	Degree of Cost Variance	Context and Rationale
Behind-the-Meter Costs	High	BTM includes site excavation for service line extensions to connect charging stations to the relevant meter. Costs may vary depending on lengths for trenching and cabling. BTM costs are also impacted by the cost of labor and any relevant supply chain and labor shortages. [a]
To-the-Meter Costs	High	TTM costs may vary depending on current capacity available for site hosts and, particularly, if a new transformer is required to supply power for EV charging. Costs may also vary depending on lengths for trenching and cabling. TTM costs are also impacted by the cost of labor and any relevant supply chain and labor shortages. [a]
Charger Costs	Moderate	Per-unit charger costs may decline with a greater deployment of chargers per site. However, there are potential impacts from supply chain constraints and costs that may vary by charger power level. With current supply chain constraints, charger manufacturing costs may be affected, possibly increasing overall costs. [b]
Material Costs	Moderate	Material costs may include the cost of panels, meters, and the cabling required to connect the charger to the Utility distribution system. Similar to the cost of the charger, material costs are subject to supply chain constraints and may increase overall costs. [c]

[a] PG&E. February 2022. "Program Advisory Council Meeting Q4 2021." Presentation.
[b] California Energy Commission. Accessed March 2022. "CALeVIP DC Fast Chargers, Average Rebate, Unit Cost, and Total Project Cost per Charger." and California Energy Commission. Accessed March 2022. "CALeVIP Level 2, Average Rebate, Unit Cost, and Total Project Cost Per Connector Installed."
[c] PG&E. February 2022. "Program Advisory Council Meeting Q4 2021." Presentation.

Significant TTM costs include transformer upgrades and costs related to upgrading and maintaining the distribution system.[115] Significant BTM costs can include trenching, site excavation for service line extensions, and cabling requirements to connect charging stations to the relevant meter. In the context of the Utility-sponsored public charging programs, Utility staff across programs noted higher-than-expected infrastructure costs, occurring both BTM and TTM. Specifically, Utility staff noted significant variable costs such as the need for transformer upgrades and longer-than-anticipated lengths for trenching.[116]

Material costs for charging stations are rising at least in part due to the ongoing COVID-19 pandemic and global disruptions on supply chains.[117] This increase was noted during a PAC meeting in which stakeholders mentioned that significant increases in material costs (such as copper wire and panels) are impacting contractors' ability to hold pricing past

> Ongoing supply chain constraints and labor shortages will increase infrastructure costs.

115 PG&E. February 2022. "Program Advisory Council Meeting Q4 2021." Presentation.

116 PG&E. February 2022. "Program Advisory Council Meeting Q4 2021." Presentation.

117 White House (Helper, Susan, and Evan Soltas). June 2021. "Why the Pandemic has Disrupted Supply Chains."

three to six months.[118] Related to material costs, the cost of the charger itself is subject to price volatility with global supply chain constraints disrupting manufacturing processes. In addition, in California, the shortage in labor supply and high labor rates in the construction industry can create additional costs for EV charging deployment.[119] It can be difficult to quantify the supply chain impacts to material and labor costs, as revealing these costs may be detrimental to vendors' competitive advantage, allowing for competitors to adjust their prices accordingly.[120]

In addition to infrastructure costs, the installation of EV chargers also includes a number of soft costs with a range of impacts on the site development. Soft costs can also be difficult to quantify, as some cost categories may apply across a Utility program as opposed to a single site location. As shown in Table 119, potential site delays and opportunity costs have the largest degree of variability for soft costs related to EV charging deployment.

Table 119. Soft Costs for EV Charging

Category	Degree of Cost Variance	Rationale
Site Delays	High	Delays in building out EV charging are difficult to predict and the financial impact of such delays can be difficult to quantify. A delay may increase site costs as it may require extending the timeline for BTM and/or TTM construction and result in an increased labor cost. [a]
Opportunity Costs	High	Utilities implementing transportation electrification programs invest time to engage site hosts in the program process, conduct site visits, and so on. Utilities will need to coordinate with property owners and key decision-makers, and this coordination effort is specific to each site. There is a time cost associated with the uncertainty of the permitting process and delays, as well as multiple revisions and meeting schedules which can result in extending the timeline for approval across sites. For instance, Utility staff noted that certain site schedules have to adhere to school board or city council meeting timelines to receive the relevant approvals to move sites forward. [b] This time could be spent on other sites. Opportunity costs are critical to consider and difficult to quantify, particularly as costs may vary by site based on the level of complexity. [c]
Permitting	Moderate	Permitting costs can vary as unexpected permits from cities and/or counties have been required.
Site Design	Moderate	Sites may ask for multiple iterations to refine the design, change the location of charging stations, and/or to change the number of ports. These adjustments may require additional site visits.
Taxes	Low	Taxes are a relatively fixed cost.
Operations and Maintenance	Low	Operations and maintenance costs occur on a routine basis and are relatively fixed to the type of charger installed.
Communication/ Networking	Low	Networking costs are built into the cost of installing the charging infrastructure and are billed on a fixed reoccurring basis.

118 SCE. March 18, 2022. "SCE Transportation Electrification Program Advisory Council." Presentation.

119 Public Policy Institute of California (Johnson, Hans). March 2022. "Who's Leaving California-and Who's Moving In?"

120 Rocky Mountain Institute (Nelder, Chris, and Emily Rogers). 2019. "Reducing EV Charging Infrastructure Costs."

Category	Degree of Cost Variance	Rationale
Marketing and Customer Outreach Costs	Low	Marketing and outreach costs are considered in Utility cost methodologies. However, marketing costs are commonly applied across programs and may be difficult to link with a single site location. [d]

[a] PG&E. July 2021. "Program Advisory Council Meeting Q2 2021." Presentation.
[b] SCE. March 18, 2022. "SCE Transportation Electrification Program Advisory Council." Presentation.
[c] Rocky Mountain Institute (Nelder, Chris, and Emily Rogers). 2019. "Reducing EV Charging Infrastructure Costs."
[d] PG&E, SCE, and SDG&E. Report Filed on March 31, 2022. "Joint IOU Electric Vehicle Load Research and Charging Infrastructure Cost Report 10th."

Our research indicates that soft costs can contribute significantly to the overall cost of public charging stations, particularly for public DCFC sites, which have high levels of energy demand and can be more complex installations.[121] Soft costs are difficult to consider on a per-site basis. Utilities often quantify soft costs such as program management and ME&O on a program level; yet more fixed soft costs are quantifiable on a site level (such as site design costs, taxes, permitting, operations, maintenance, and networking and communication costs).

However, complex sites will require a greater investment of time and resources, thus increasing the site-related soft costs. This level of complexity will depend on variable factors including the decision-makers involved, the power level of the installed charging, and any site delays. Related to this investment of time and resources, there is a high degree of variability in opportunity costs for Utilities engaged in transportation electrification programs. These technologies are relatively nascent and Utilities expend effort to engage site hosts, conduct site visits, and make adjustments to improve these programs. This time could be spent on other Utility activities.

> EV charger site costs vary as the result of uncertainties is both infrastructure and soft costs. Additionally, an increase in soft costs can compound infrastructure costs.

Soft costs are interrelated to infrastructure costs. In the context of Utility-sponsored public charging programs, Utility staff have specifically noted that BTM labor costs can be complicated by site host BTM construction delays. Reasons for these delays can include RFP challenges, internal decision-making related to paying for BTM work, and lack of familiarity with BTM construction. These BTM delays are a common driver of overall site completion delays.[122] As sites are delayed, other costs may accumulate without the financial impacts being readily quantified. Current supply chain constraints may increase the costs of infrastructure while also increasing soft costs due to resulting delays.

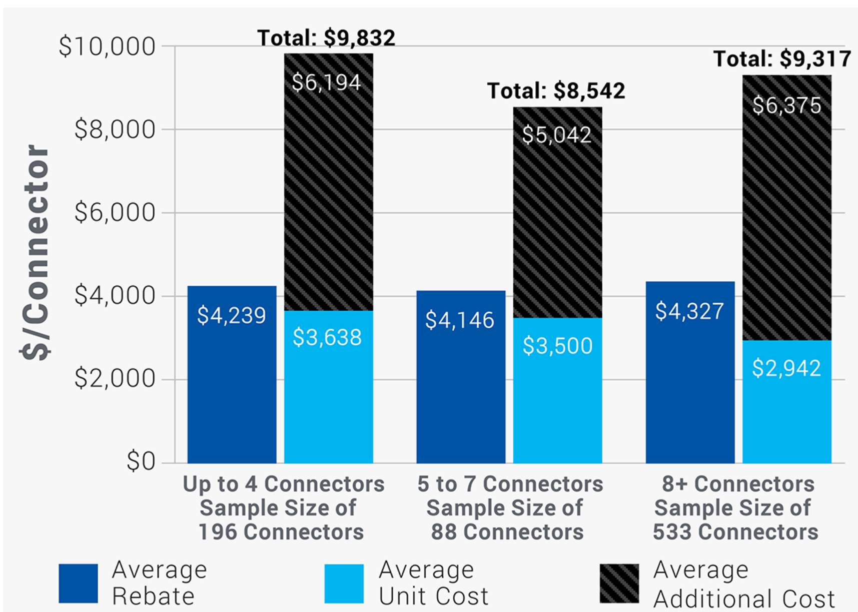
[121] Rocky Mountain Institute (Nelder, Chris, and Emily Rogers). 2019. "Reducing EV Charging Infrastructure Costs."

[122] PG&E. July 2021. "Program Advisory Council Meeting Q2 2021." Presentation.

In addition to considering the EV infrastructure and soft costs discussed above, the team also examined a cost case study based on the California Electric Vehicle Infrastructure Project (CALeVIP). CALeVIP offers incentives to acquire and install EV charging infrastructure at publicly accessible sites throughout California. The 2021 CALeVIP data on L2 costs (Figure 120) and DCFC costs (Figure 121) showcases the decline in per-unit costs (shown in blue) and the variance in total per charger costs (shown in gray).[123] Based on CALeVIP data shown in Figure 120, L2 per-unit costs decrease in sites with a greater number of chargers per site. Similar to L2 data, DCFC per-unit costs decrease in sites with a greater number of chargers per site (Figure 121). However, for both DCFC and L2 charging, the soft costs and remaining infrastructure costs—beyond the charger itself—(shown as the *average additional costs* in the gray bars) do not reflect a direct relationship between the number of chargers per site and the total cost per charger per site.

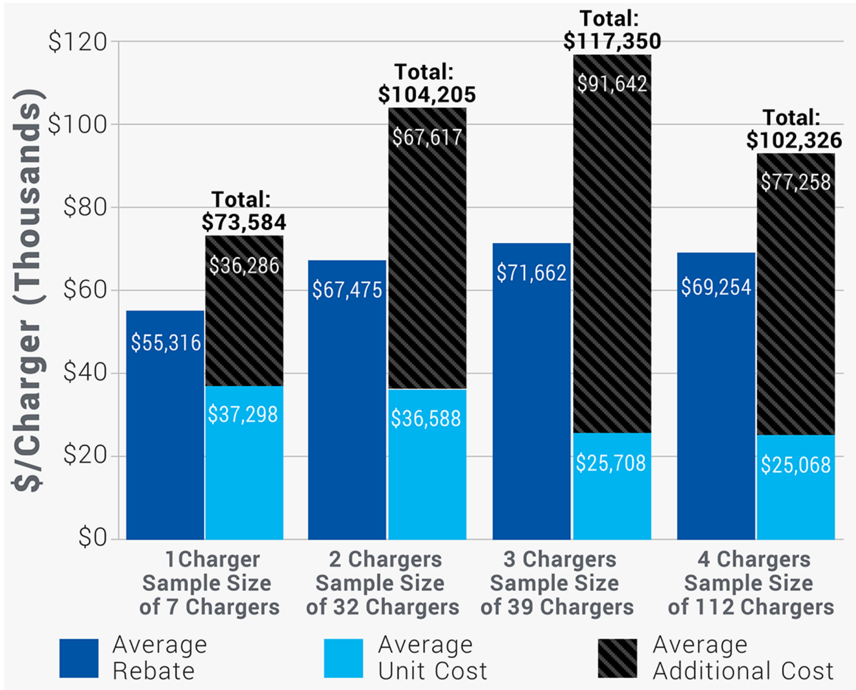
Per-unit charger costs will likely decline with greater numbers of chargers per site. Unlike per-unit costs, total costs per charger may not decline with a greater number of chargers per site.

Figure 120. CALeVIP Level 2 Charger Costs



[123] California Energy Commission. Accessed March 2022. "CALeVIP DC Fast Chargers, Average Rebate, Unit Cost, and Total Project Cost per Charger." and California Energy Commission. Accessed March 2022. "CALeVIP Level 2, Average Rebate, Unit Cost, and Total Project Cost Per Connector Installed."

Figure 121. CALeVIP DCFC Costs



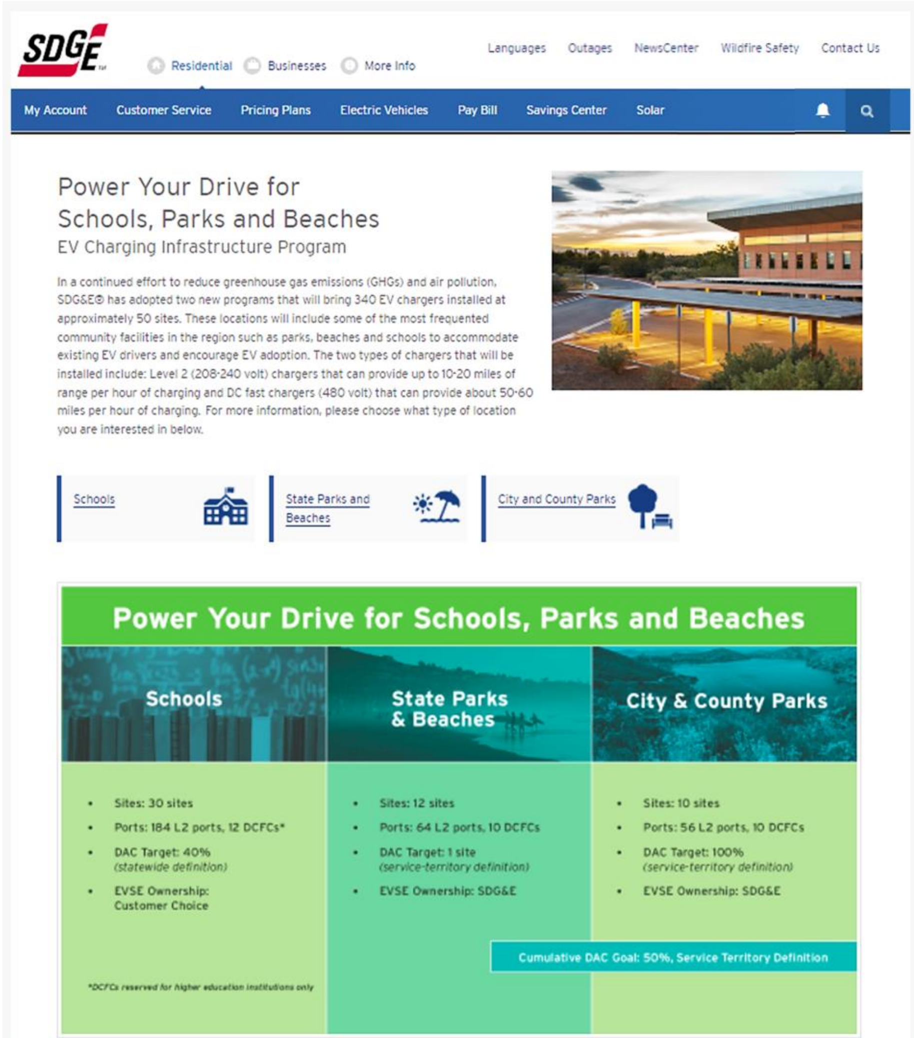
Utility Web Page Insights

The team conducted a high-level review of SDG&E's web pages in April 2022 to identify what information was available for the Schools and Parks Pilots:

- Power Your Drive for Schools, Parks and Beaches (main page assessed; screenshot shown in Figure 122)
- Power Your Drive for Schools
- Power Your Drive for State Parks and Beaches
- Power Your Drive for City and County Parks

Overall, the pages were set up similarly. The pages clearly outline the overall purpose of the Pilots, the number of sites, and eligibility requirements with concise, simple, and digestible text. However, the navigation for some links to specific page sections did not bring viewers to the top of the referenced section, which may cause confusion for viewers.

Figure 122. Screenshot of SDG&E's Power Your Drive for Schools, Parks and Beaches Web Page



Utility Insights

Over the course of EY2021, the Cadmus team interviewed staff for SDG&E's Schools and Parks Pilots twice (once in September 2021 and again in March 2022), in addition to monthly check-ins about the status of the Pilots and quarterly joint Utility calls for the Pilots. Through these conversations, SDG&E staff identified key insights from what they experienced in 2021.

Schools Pilot and Parks Pilot

SDG&E staff reported that the expected site cost were higher than anticipated. In particular, staff noted that opportunity costs were trending significantly higher. For example, construction labor and material costs have increased as inflation has risen and COVID-19 disrupted supply chains and the labor force. In addition, though staff had expected that some trenching would have to be done at each site, they found that more trenching was consistently needed than originally expected (and budgeted). Relatedly, SDG&E staff noted that there was more interest in DCFCs than L2 chargers, but since DCFCs are more expensive than L2 chargers, the Pilots' budgets could not accommodate additional DCFCs.

When SDG&E was completing preliminary work to identify prospective school districts, parks, and beaches to target for enrolling in the Schools and Parks Pilots, staff had two priorities for site selection: cost-effectiveness (which includes physical features of the sites) and potential utilization. Staff reflected that when they reviewed potential sites, they also assessed what was around the chargers to identify if it would be a good place for public charging infrastructure. For example, they preferred sites that were close to other popular public places, such as multifamily housing, shopping centers, community centers, grocery stores, or places of worship.

SDG&E staff conducted outreach to raise awareness about the Schools and Parks Pilots among school districts, parks, and beaches. After raising awareness, they struggled to overcome negative perceptions about SDG&E programs. For example, staff noted that SDG&E had previously implemented the Power Your Drive Pilot, which experienced delays and ended up running over budget, resulting in SDG&E having to pull some approved sites from the program. However, the Schools and Parks Pilot staff worked to rectify the relationships with site hosts who were hesitant to engage with another SDG&E EVSE program by both explaining how the Schools and Parks Pilots were going to be managed and by connecting customers with their account managers if they were not already connected. Staff reported that once they established positive relationships with customers, they began to get a steady pipeline of interested site hosts.

Staff reported that as SDG&E recruited participants into the Schools and Parks Pilots, it was important that site hosts felt like they were getting the greatest benefit possible from the Pilots. Therefore, after a school district or municipality had been identified to have potential sites, SDG&E staff gave them the opportunity to pick five sites where they would most want EVSE installed. From there, using key eligibility criteria,[124] SDG&E staff narrowed the list down to two sites to conduct site walks and ultimately decide on which one would be best suited for the Pilot. Staff reflected that while this process worked well overall, there were some conflicting priorities between SDG&E and the site host. For example, the location that site hosts preferred was not always the best fit or the most cost-effective. Ultimately, staff reported that SDG&E did its best to balance site host priorities with realistic costs that could be allocated to a given site.

Schools Pilot

When moving forward with interested schools to begin implementing the Schools Pilot, staff reported that while interest was high, there were some barriers to getting site hosts through the application process and into the construction phase. This barrier happened because when the Schools Pilot was rolling out, schools were dealing with the impacts and uncertainty caused by COVID-19. Therefore, the priority of ensuring school staff and student health and safety—such as deciding between on-site and online learning—limited the schools' capacities to work with SDG&E on getting the EV charging infrastructure installed. Staff found that this limited capacity (paired with limited funding) also contributed to the trend that most interested schools opted for the SDG&E turn-key version of the program.

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[124] Further detail on key eligibility considerations can be found in the *Implementation* section.

SDG&Es staff identified two main challenges when working with K–12 schools to install public charging infrastructure.

- **Safety considerations.** Many schools were concerned about student safety if chargers were always accessible to the public. Additionally, staffed noted that schools were concerned about vandalism if school grounds were left open to the public after school hours. Therefore, SDG&E staff offered alternative participation options that allowed the schools to keep the chargers limited to private use by faculty, staff, and/or parents (depending on the school's preference). SDG&E staff noted that other community areas—such as colleges and universities or community centers—may not be as burdened with unique safety considerations.
- **Competing interests.** Staff indicated that K–12 schools in the Pilot also seemed to be more interested in electrifying school bus fleets than installing light-duty vehicle charging. In part, staff thought this was due to the fact that there are often limited parking spaces available for faculty and staff and if EVSE were installed, the number of spaces would be reduced even further.

Parks Pilot

Similar to the Schools Pilot, SDG&E staff found that a barrier to enrolling site hosts into the Parks Pilot was that these staff had priorities that were more pressing than moving forward in the Parks Pilot, including implications for how the sites had to adapt to COVID-19. Some site hosts were hesitant to enroll in the Pilot due to uncertainty about future redevelopment plans for the site. As an example, where SDG&E was able to adapt to the redevelopment concern, one site faced a unique challenge where the local water Utility was also planning construction at the site. Being a "good neighbor," SDG&E deferred to the water Utility and delayed construction of EVSE until the water construction work had been completed.

SDG&E staff were also unable to accept some interested city and county sites that were not located in or adjacent to DACs, which they were mandated to prioritize.

Staff reported that SDG&E, in conjunction with the other Utilities, has engaged the California Department of Parks and Recreation to finalize participation agreement language that could be used for all state parks served in the Pilot. However, staff reflected that likely due to multiple staff changes at the California Department of Parks and Recreation, SDG&E staff have had trouble keeping the participation agreement approval moving through the Department approval process. When Department staff transitions occur, SDG&E staff often have to re-orient the new staff member on the purpose of the Pilot and all steps completed to date. (SDG&E has run into staff turnover issues among municipal parks as well.)

6.2.3. Lessons Learned

The team identified a number of lessons learned from EY2021. These lessons, presented below with key supporting findings and recommendations, may be applied to future Pilot years and to other similar efforts.

Schools Pilot and Parks Pilot

Unexpected market impacts and site design requirements resulted in higher-than-expected Schools and Parks Pilots' site costs and limited participation.

SDG&E began the Schools and Parks Pilots during the COVID-19 pandemic. COVID-19 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 SDG&E 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. Though SDG&E staff conducted research ahead of Pilot design, these expenses were then compounded by inadvertent inaccuracies in Pilot design estimates. For example, while designing actual sites, SDG&E found that the typical trench length assumption had been underestimated. Additionally, site hosts are typically more interested in DCFCs than the Pilot budget can handle.

Staffing constraints contributed to conflicting priorities from site hosts, which resulted in site delays or withdraws.

The Schools and Parks Pilots require the site host to make a commitment that often spans several months. Site hosts must not only be willing to install EVSE on their property, but—at a minimum—they must also work with SDG&E to coordinate site walks, approve the site design, and review and approve contracts, easements, and other critical documents. SDG&E said that many site hosts of both the Schools Pilot and the Parks Pilot had staffing constraints that either delayed or completely prevented participation.

In EY2021, SDG&E's Parks Pilot was most influenced by staff turnover at the California Department of Parks and Recreation. When Department staff transitions occur, Utility staff often must re-orient the new staff member to the purpose of the Parks Pilot and all steps completed to date. Even within city and county Parks Pilot sites, the lack of bandwidth for current site staff can result in implementation delays as site staff struggle to prioritize COVID-19 safety considerations and other redevelopment plans. For example, one site faced a unique challenge where the local water utility was also planning construction at the site. Being a "good neighbor," SDG&E staff deferred to the water utility and delayed construction of EVSE until the water construction work had been completed.

The Schools Pilot was also influenced by staff constraints, including turnover and bandwidth concerns. In 2021, these constraints were exasperated by COVID-19. Since the Pilot began, schools have been burdened with making ever-changing decisions regarding virtual versus on-site learning, mask mandates, and similar choices. SDG&E staff noted that the priority of ensuring school staff and student health and safety limited the schools' capacities to work with SDG&E on getting the EV charging infrastructure installed. Additionally, some potential site hosts told SDG&E that they decided to focus on electrifying bus fleets instead of providing charging for light-duty vehicles (meaning the site staff did not have the capacity to manage both needs at a similar time).

Positive, direct outreach built customer confidence in SDG&E and the Pilots.

As part of raising awareness for the Schools and Parks Pilots, SDG&E staff helped potential site hosts overcome negative perceptions about the Pilots based on a previous SDG&E pilot that had to be closed prematurely. Staff worked to rectify the relationships by spending direct time with the site host explaining how the Schools and Parks Pilots were going to be managed differently and by connecting customers with their account manager (if they were not already connected). As a result staff were able to clear up concerns and re-establish positive relationships, ultimately keeping the Pilot on track to meet its goals. In addition, SDG&E staff continued to build their positive reputation even after recruitment by partnering with site hosts to develop promotional materials, such as community-based video advertisements for chargers that had been installed in a city park.

Schools Pilot Only

K–12 schools experience unique barriers to installing public EVSE.

The intent of the Schools Pilot is to install publicly available chargers at K-12 schools to increase charging available to staff, students, parents, and the greater community. However, several schools expressed concern about student safety if the chargers were accessible to the public 24/7. Therefore, in order to stay on track with Pilot site and charger targets, SDG&E staff offered alternative participation options that allowed the schools to limit use of the chargers to faculty, staff, and/or parents (depending on the school's preference). SDG&E staff noted that other community areas—such as colleges and universities or community centers—may not be as burdened with unique safety considerations.

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 and planned activities, and timeline.

Pilot Description

SDG&E designed this Pilot to accelerate the market growth and adoption of V2G technologies, to support the goal of enabling EVs to function as distributed energy resources, to potentially improve the Utility load factor, and to reduce GHGs and criteria pollutants. With the V2G Pilot, SDG&E also aims 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 buses 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 super-off peak utility rates. Electric school buses also have large batteries for energy storage.

The critical barriers for school bus fleets are electric bus reliability, vehicle and infrastructure costs, and the uncertainty and complexity of V2G technology integration. While V2G technology utilization and development are not within Utility control, the Pilot could have a positive impact on these factors and increase confidence in electric school buses and V2G technology by providing several components:

- TOU pricing structure or other programs for the site host to participate in
- Planning, design, and ongoing data collection and management of the Pilot
- 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 intends 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 used, and demonstrate successful implementation of V2G technology.

Pilot Implementation

In 2017, SDG&E solicited a request for information as the V2G Pilot was being conceptualized and selected finalists to participate in a request for proposal. It selected First Priority GreenFleet's proposal, which included the bus OEM (Lion Electric), site host (Cajon Valley Union School District [CVUSD]), and EVSE 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 utilize EVs as distributed energy resources to improve 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 would be the first to employ V2G-enabled school buses to participate in the CAISO energy market utilizing 25 kW (discharging) V2G bidirectional chargers.

In August 2019, the Commission approved the Pilot with a budget of $1.7 million. In April 2020, SDG&E filed Advice Letter 3528-E requesting modifications to the Pilot which the Commission accepted in May 2020. AL 3528-E requested three modifications to the Pilot:

- Install V2G charging stations at an existing service line rather than a separate service line
- Use DCFC EVSE rather than alternating current
- Reduce the number of V2G buses from 10 to 6

In a second Advice Letter, SDG&E assumed site management from First Priority Green Fleet and due to Rule 21 requirements, transferred the charging provider from BTC Power to Nuvve. Nuvve offers a DCFC charger produced by Rhombus, which utilizes a ground-mounted inverter as opposed to an onboard inverter. The final Pilot team includes several organizations:

- **SDG&E:** Site manager
- **CVUSD:** Site host
- **Lion Electric:** School bus provider
- **Nuvve:** Charging provider
- **Baker Electric:** Construction manager
- **ViriCiti:** School bus telematics provider

Figure 123 shows the layout of the CVUSD site, with the school bus parking area and charger locations for this Pilot circled in red.

Figure 123. CVUSD Site Layout

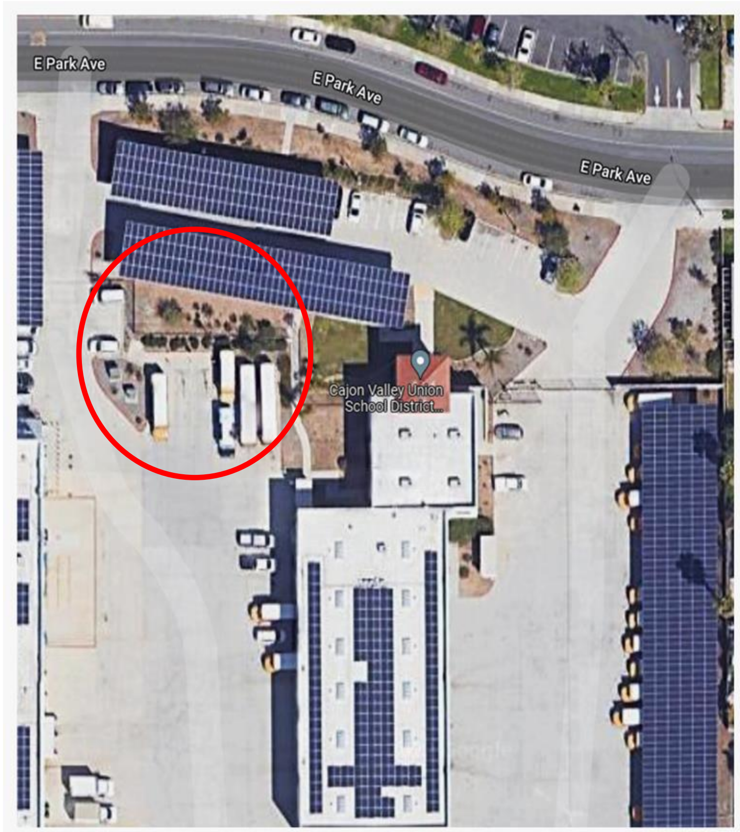

Table 120 shows the Lion Electric school buses CVUSD procured for this Pilot. The five LionC buses were retrofitted from L2 unidirectional capability-only to be DCFC V2G-capable. The LionD bus had DCFC V2G capability off of the production line.

Table 120. CVUSD V2G Pilot School Bus Summary

Quantity	Manufacturer	Model	Battery Capacity, kWh	Driving Range, mi	Charge/Discharge Rate, kW	Charging Time, hours
5	Lion	LionC	132	100	25	5 to 9
1	Lion	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 buses. The Rhombus chargers meet V2G certification and regulation standards, including:

- UL 1741: Standard for inverters, converters, controllers and interconnection system equipment for use with distributed energy resources
- IEEE1547: The technical specifications for, and testing of, the interconnection and interoperability between utility electric power systems and distributed energy resources

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 buses are limited to 45 kW.

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 require all six chargers to export at least 17 kW simultaneously, which would likely be a rare occurrence. However, the site is eligible for SDG&E's Critical Peak Pricing program, where critical peak events are called when energy and demand charges spike. Participating sites are not required to reduce demand but when they do, they avoid increased electrical costs during these events. The site is also planning to participate in SDG&E's Emergency Load Reduction Program (ELRP), described in detail in the *Pilot Timeline and Status* section below.
- Due to parking space length constraints at CVUSD's other V2G site installed under the Power Your Drive for Fleets program, CVUSD moved three of their 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 are limited to a 25 kW charge/discharge rate.
- Nuvve and Lion Electric's adoption of ISO 15118-20 during the term of this Piot required extended the software development timeline to allow for bidirectional operation.

Pilot Timeline and Status

The Nuvve chargers were installed and operational with unidirectional capability in the summer of 2021. SDG&E expected the site to be bidirectional-capable by fall 2021 but there were multiple delays with the various technology integrations. As of the writing of this report, the site is now fully commissioned and operational.

The site will participate in SDG&E's ELRP, which offers compensation for load shedding and customers capable of exporting power to the grid (such as through EVs) between 4 pm and 9 pm from May 1 to October 31. These events are communicated to Nuvve and the customer the evening before the event. SDG&E provides $2.00 per kilowatt-hour exported or shed compared to a baseline and events are triggered about 30 hours to 60 hours per year. During 2021, there were 14 hours of ELRP events. ELRP requires a minimum power output of 25 kW per hour, which is calculated as an average demand over the hour. Since CVUSD's routes typically end by 4:30 p.m., the vehicles will likely be able to participate by discharging when they return to the bus yard.

SDG&E is planning three test phases during the V2G Pilot data collection, as shown in Table 121.

Table 121. Preliminary V2G Pilot Test Phases

Test Phase	Description	Timing
1	TOU charging and resiliency testing in the event of a building power shutoff	Summer 2022 and beyond (after commissioning)
2	ELRP participation	Summer/fall 2022 (ELRP events occur from May 1 through October 31)
3	Critical Peak Pricing participation	Summer/fall 2022 (Critical Peak Pricing events occur from May 1 through October 31)

6.3.2. Findings

As discussed in the *Overview* section, the V2G Pilot was not activated in EY2021. As a result, the Cadmus team did not complete any visual site visits in EY2021 and anticipates enough progress by the V2G team to complete the first round of impact analysis including grid impacts, petroleum displacement, GHG and criteria pollutant reductions, health impacts, and TCO analysis as part of EY2022. This report provides limited insights based on in-depth interviews and market research completed for EY2021, including preliminary insights from Utility staff.

Site Visits

Due to delays in site commissioning, the Cadmus team did not conduct site visits during EY2021. We plan to perform verification site visits after successful commissioning during EY2022. However, photos of the buses and installed chargers were provided by the site host for reference. Figure 124 and Figure 125 show CVUSD's Lion Electric buses and Nuvve chargers, respectively.

Figure 124. Lion Electric School Buses

Photos provided by Cajon Valley Union School District.

Figure 125. Nuvve DCFC

Photo provided by Cajon Valley Union School District.

Utility Insights

The team spoke with the SDG&E Pilot representative during fall 2021. This section summarizes initial Utility insights into V2G challenges and lessons learned.

Pilot Design and Execution

At the time of Pilot design, primary participant motivation for V2G was grant funding from CARB, which required transportation electrification proposals to include V2G. By offering to install V2G-enabling infrastructure and provide maintenance and operations for the full term of the Pilot in exchange for low-carbon fuel credits and future V2G revenue, SDG&E was able to create proposals that were compelling to school districts.

The Pilot experienced a minor delay with permitting due to not having the construction contractor name on the permit, which was required by the local Authority Having Jurisdiction. The initial permit requested by the design engineers had expired before construction began and needed to be renewed. Because the construction agency had taken over, they needed to submit a new permit, which delayed the start of construction.

Internally, the V2G Pilot followed SDG&E's Stage Gate Process to optimize efficiency, quality, and safety.

SDG&E noted an unexpected cost with the electrical conduit for the Rhombus DCFCs. After installing standard conduit at approximately $2 per foot, they had to remove and reinstall new conduit. The installation manual for Rhombus chargers specified a steel conduit to mitigate electromagnetic interference that costs approximately $70 per foot. Because many of the site team members and engineers said a standard conduit would have been appropriate, the site team decided to install a higher-grade but less rigid conduit that cost $14 per foot.

V2G Technology and Costs

SDG&E recommended early communication between charging providers and bus manufacturers. SDG&E noted that there was an interoperability challenge between the Lion Electric buses and Nuvve DCFCs late in the implementation process and the buses needed to be retrofitted to accept DCFC and bidirectional charging. The cost of these retrofits was not included in the original Pilot cost estimate.

SDG&E also noted challenges with Rule 21,[125] which was a new interconnection process for their Clean Transportation and Customer Generation Team. To reduce the management burden on the site host, SDG&E administered the Rule 21 interconnection process for the Pilot and assisted Nuvve in navigating the process to establish a precedent and documented procedure. SDG&E recommended that an experienced EVSP or Utility point of contact continue to administer Rule 21 applications for all future customer-owned V2G projects.

Market Scale-Up

In terms of scalability, SDG&E is not currently marketing V2G specifically. However, V2G efforts are being facilitated within the PYDFF program. At the time of this report, two other V2G school bus projects have been constructed, for a total of three V2G sites becoming operational in SDG&E territory in 2022. Four other sites are in the pipeline, to be constructed late in 2022 and early 2023.

SDG&E recommended the following items to accelerate adoption of V2G technology and to scale up the V2G market sector:

- Approve a V2G-specific rate and supplemental EVSE rebate for V2G EVSE currently under regulatory proceedings
- Expedite AC V2G regulatory pathways or increase the allowance of additional V2G Pilots in the interim
- Develop and approve larger V2G infrastructure programs with financial incentives to support customers in adoption of V2G technology

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[125] Electric Rule 21 is a tariff that describes the interconnection, operating and metering requirements for generation facilities to be connected to a utility's distribution system. The tariff provides customers wishing to install generating or storage facilities on their premises with access to the electric grid while protecting the safety and reliability of the distribution and transmission systems at the local and system levels.

Site Host Insights

The Cadmus team gathered insights from CVUSD in fall 2021 regarding their initial pilot experience.

V2G Pilot Involvement

CVUSD initially became aware of the Pilot through SDG&E's monthly regional meetings for school districts around the same time that First Priority Green Fleet helped them secure funding for their first five Lion Electric buses. Regarding site costs, board approval was not difficult to obtain since grants covered all the electric bus costs. SDG&E paid for the electrical infrastructure and charging equipment. The Rule 21 requirements required CVUSD to purchase higher-cost insurance, and these costs were reimbursed by SDG&E. SDG&E also covered the cost of a five-year warranty for the equipment during the Pilot term.

Based on initial estimates, CVUSD expects approximately 40% maintenance cost savings compared to a diesel counterfactual fleet. However, since automatic charging controls are not yet in place and drivers are charging the buses immediately when returned to the yard, the site's overall electric bill has increased.

In additional to this Pilot, CVUSD has other concurrent transportation electrification sites with SDG&E, including additional Nuvve V2G chargers, electric warehouse box trucks, and L2 chargers for employees and staff vehicles.

Electric School Buses

The site host emphasized that it is important to make sure electric buses are used on suitable routes. CVUSD's routes change on a regular basis, but a typical route for the electric buses is approximately 75 miles per day, split between a morning run and an afternoon run. Morning runs typically occur between 6:30 am and 9:30 am and afternoon runs are between 1:00 pm and 4:30 pm. The site's initial Lion Electric buses, which include five LionC buses and one LionD bus, have recommended ranges between 50 miles and 70 miles when incorporating safety power, which typically turns on at 30% charge. The electric buses are not used for special events such as field trips or after-school sports. So far, all the Lion Electric buses have been able to complete their routes without issue, but the site has back-up vehicles on hand in case of emergencies. However, Lion Electric has had multiple recalls since CVUSD received their buses, which have impacted operations.

The site host dedicated resources to provide driver training on electric buses and all their drivers are capable of driving every bus on the site. CVUSD also provides tip sheets for drivers and conducts regular proficiency and refresher trainings for those who have less experience with electric buses. They are also participating in a knowledge sharing partnership with Twin Rivers School District.

Preliminary Insights

The site host indicated that patience is important with transportation electrification sites, especially with COVID-related supply chain delays. The site host also noted that learning about the new electric buses, charging technologies, and charge optimization has taken time, both for the operations managers and for drivers.

While construction was faster than expected, the site host noted that the bus retrofits, software upgrades, and commissioning has taken longer than planned. However, the site for four additional V2G chargers appears to be moving smoother than the site for this Pilot, using the lessons learned and pathways established from this Pilot.

Vendor Insights

The section includes details of the Pilot background, challenges, lessons learned, and recommendations from the three primary vendors: Baker Electric, Nuvve, and Lion Electric.

Baker Electric

The Cadmus team interviewed the Baker Electric site manager in fall 2021, who was involved with the Pilot from the start and focuses exclusively on EV-related construction sites. This section presents key insights from the interview.

- **Design and Safety Standards:** Baker Electric described challenges between the original design and equipment and Utility standards:

  As discussed in the *Utility Insights* section, the original design called for all underground installations to be PVC but Rhombus requires conduits to be rigid due to electromagnetic interference, and the conduit had to be replaced. Baker Electric recommended including input from all software and hardware providers during the design process to mitigate this issue in the future.

  After the site had been nearly completed, the Utility required the NEMA 3-R switchgear pad to be higher off the ground to meet their meter requirements. Their solution was to drill and set a new pad on top of the existing pad. The city inspector also required a visual stripe along the edge of the concrete pad. Baker Electric's feedback is to maintain processes to ensure that designs align with codes and standards, especially when site teams are busy.
- **Pilot Costs:** Baker Electric reported higher electrical commissioning costs than expected. The RFP required eight hours of commissioning but it took 40 hours, largely due to technology interoperability challenges.
- **V2G Technology:** While Baker Electric had worked on small-scale proof-of concept projects with Nuvve, this was the company's first full-scale V2G site. However, from Baker Electric's perspective, the site was similar to a unidirectional installation with the exception of the meters and installation details.
- **Market Growth:** Baker Electric expects to see more V2G-related sites over the next five years: it has received RFPs from various public entities and is working on several fleet sites with Nuvve. V2G projects have been sporadic and typically small with one or two chargers. However, Baker Electric is seeing more energy storage and solar installations at transportation sites.
- **Future-Proofing:** Some of the transportation fleets Baker Electric has worked with are future proofing by adding space on switchgear pads for battery storage systems or interconnections for solar PV. Larger corporations with more capital typically opt for future proofing and public- or grant-funded sites tend to choose the lowest-cost option.

Lion Electric

The Cadmus team interviewed the Lion Electric site managers in early 2022, who provided the following preliminary Pilot insights.

- **Bus Retrofits:** To accept onboard DC power, the original Lion Electric buses needed to have hardware and software retrofits. Each bus received a module to allow DCFC power to bypass onboard AC/DC converters as well as new software to enable module operation. This was the first time Lion Electric buses have used DCFC and during module design, Lion Electric expected to be able to transmit close to 60 kW; however, during testing they found that only 25 kW could be safely transmitted. While there were module hardware and software limitations, the vehicles' LG batteries were also a limiting factor due to their chemical composition. Lion Electric is now working on another version of the module that should accept up to 60 kW, and CVUSD's new Lion Electric buses have BMW batteries, which should accept a higher rate of charge.
- **Pilot Costs:** The COVID-19 pandemic and supply chain breakdown had a large impact on Pilot costs due to the materials being delayed. This resulted in longer lead times and higher costs for materials, shipping, and site management.
- **Technology Standards:** Electric vehicles are typically governed by SAE International standards,[126] while charging hardware providers must meet Underwriters Laboratory standards. Electric bus and charging providers have found it challenging to align on requirements. Lion Electric recommended that the CPUC develop a standard for EVs and chargers. Grid integration is also missing a standard platform between the Utility, chargers, and the electric vehicles, which makes it challenging to develop cost-effective control strategies.
- **Battery Optimization:** While battery technology improvements are great for customers and EV adoption, it is challenging for vehicle manufacturers to track all those changes. Lion Electric's engineers work with their customers to project degradation rates based on use patterns and are testing optimal charge and discharge control strategies to elongate battery life and performance.
- **Market Scale-Up:** Lion Electric noted that the demand for V2G applications is increasing from both school bus and trucking fleets. They plan to continue to expand their school bus offering and focus on trucking fleets with routes that typically travel less than 200 miles per day and return to base.

Nuvve

The Cadmus team interviewed the Nuvve team in late 2021 to collect preliminary Pilot insights.

- **V2G Technology:** Nuvve partnered with Rhombus, which offers a DCFC with smart inverter standards, to test the Pilot demand response and cost-effectiveness of V2G when responding to price signals from external markets. Nuvve offers a customized software platform for Rhombus' DCFCs, which allows for aggregating load across charging sites. Given the site's minimal load, there could be an option to manage load broadly as CVUSD adds charging equipment.

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[126] SAE International. Accessed April 2022. "About SAE International." https://www.sae.org/about/

- **Interoperability:** Nuvve has experienced challenges with bus and DCFC interoperability. The Pilot team initially thought that the retrofitted Lion Electric buses could discharge at 60 kW, but during testing Lion found they could only discharge at 25 kW. Nuvve also needed to develop a software upgrade between the DCFCs and batteries.
- **Pilot Costs:** Nuvve had not experienced any unexpected costs other than additional management expense from Pilot delays, and expressed appreciation for the Utility's cooperation.
- **Site Selection:** Nuvve said a number of the site characteristics are not ideal for V2G: (1) the on-site load does not meet the minimum of 100 kW to participate in the CAISO market; (2) the Utility was unable to aggregate this site with other sites through their scheduling coordinator system; and (3) the site is on an exclusionary rate structure that prevents participation in the market. Due to these reasons, the Pilot team is exploring other value streams that may not be as cost-effective as designed. Nuvve recommended reviewing the site load and rate structure during the design phase.
- **Grid Integration:** Due to these challenges, the new V2G integration plan to participate within the ELRP and Critical Peak Pricing program had changed the business model and will provide less potential revenue for the site. After commissioning is complete, Nuvve first plans to test vehicle battery charging and discharging, then will work with the Utility on ELRP and Critical Peak Pricing program participation. Nuvve has seen the challenge independent system operators and Utilities are facing with shifting from integrating demand response to on-site generation. Each Utility has different processes and requirements on interconnection agreements and each site has its own intricacies and challenges for how to reconcile energy and value streams. Nuvve recommends that the CPUC and Utilities simplify the process by creating standards and guidelines for site selection and integration.

Market Research

During EY2021, the Cadmus team conducted research into the impacts of V2G operation on EV batteries. This section provides a summary of the papers we reviewed.

The authors of a 2017 study on bidirectional charging battery impacts tested nickel aluminum cobalt cathode 3350 mAh cells in laboratory conditions simulated for both driving and daily V2G applications.[127] The V2G protocol for the experiments were to use the batteries twice a day for ancillary grid service with one-quarter of the rated power of the battery pack. For testing, the study team applied a discharge step for one hour, up to twice a day during the peak periods of electricity use in North America. They also used a charging protocol that involved L2 charging for eight hours at home and access to a DCFC at work, which can charge for four hours, as well as a driving cycle protocol based on real world driving data, a one hour round trip, and a calendar aging cycle.

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[127] Dubarry, Matthieu, Arnaud Devie, and Katherine McKenzie. August 2017. "Durability and Reliability of Electric Vehicle Batteries under Electric Utility Grid Operations: Bidirectional Charging Impact Analysis." *Journal of Power Sources* (358): p. 39–49. https://www.sciencedirect.com/science/article/pii/S0378775317306365

They found that a V2G step twice a day increased the capacity loss by 75% and resistance by 10% compared to degradation due to typical usage over a six year time frame for most conditions (under 20% degradation). A V2G step once a day accelerated the capacity loss by 33% and increased the resistance by 5% compared to degradation due to typical usage over a six year time frame. Forecasting the measurement results would decrease the lifetime of the battery packs to under five years. They also found that delaying the charging of the battery in V2G compared to immediate charging had no significant effect on capacity retention (<5%) and little impact on increased resistance (<5%). The authors also found a beneficial temperature dependence on delaying charging, which was negligible at room temperature but significant in warmer climates.

Another 2017 paper presented a comprehensive battery aging model based on data collected from over 50 long-term aging tests in which commercial batteries were cycled under a wide range of temperatures, states of charge, and change-in-state of charge conditions, as well as a variety of charging and discharging conditions.[128] They used $LiNiCoAlO_2$ cathode 18650 cells with a charge of 3 Ah. The authors concluded that by intelligently optimizing the condition of the battery during rest periods using V2G operations, there may be an opportunity to positively impact the health of an EV battery. They concluded that using smart control algorithms, battery management system capacity and power degradation could be reduced by up to 12% and they determined that it is possible to receive net cost benefits from V2G for individual vehicle or fleet owners.

The authors of these two studies collaborated to explore the seemingly conflicting results of their individual V2G studies.[129] Understanding battery degradation rates is key to the economic viability of using V2G. Capacity fade should not be the only consideration when assessing battery degradation after use because it can omit key information that affects the nonlinear degradation modes in the battery. These modes do not necessarily manifest in capacity loss in the initial stage of battery use but can have prominent impacts toward the end of life. These factors must be taken into account when assessing the battery during use in driving and V2G operations and in calendar aging.

In the optimal V2G facilitated integrated vehicle and smart-grid system study (Uddin, August 2017), it is assumed that there is communication between a smart grid and the vehicle's battery management system that can make requests for power based on the EV user's upcoming driving needs. This assumption does not reflect current technology. The study showing V2G degrading the battery at a rapid rate is based on technology that exists today, with no specialized charging software and no communication with the grid to optimize charging.

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128 Uddin, Kotub, Tim Jackson, Widanalage D. Widanage, Gael Chouchelamane, Paul A. Jennings, and James Marco. August 15, 2017. "On the Possibility of Extending the Lifetime of Lithium-Ion Batteries through Optimal V2G Facilitated by an Integrated Vehicle and Smart-Grid System." *Energy* (133): p. 710–722. https://www.sciencedirect.com/science/article/pii/S0360544217306825

129 Uddin, Kotub, Matthieu Dubarry, and Mark B. Glick. February 2017. "The Viability of Vehicle-to-Grid Operations from a Battery Technology and Policy Perspective." *Energy Policy* (113): p. 342–347. https://www.sciencedirect.com/science/article/pii/S0301421517307619

There are several key takeaways from these three papers:

- Without intelligent or optimized algorithmic control of charging, additional V2G cycling leads to increased battery degradation.
- Delaying charging at higher outdoor air temperatures (≥77°F) could help to extend battery life and/or slow degradation. However, this extended life could also be attributed to other characteristics in the battery such as electrolyte composition and the size of the electrode and nickel/cobalt doping. While this finding requires further investigation, any algorithmic control of V2G charging/discharging patterns should take temperature dependencies into account.
- Other studies[130] have found that delaying charging can actually extend battery life, whereas these three studies have found it to be negligible. The differences in cell design, including electrolyte composition, the size of electrodes, and the level of nickel and cobalt doping, are likely responsible for this discrepancy, and a battery's individual cell design choices will likely govern the effectiveness of delaying charging.

A older 2009 study on V2G utilization and battery degradation modeled battery degradation with a scenario of a household vehicle used for trips and V2G applications while not on trips.[131] The research team conducted modeling using survey data about driving, then tested cells in laboratory settings based on the cycling trip information from the model. The cells used in this experiment were A 123 Systems $LiFePO_4$ cathode cells. The authors found that depth of discharge did not have nearly as great of an effect on the lifetime of the cells as previously reported and that higher cycling caused more rapid capacity loss. For combined V2G and driving operations, the study found that cycling at lower rates causes less capacity loss and will contribute smaller amounts of battery degradation than driving. Battery technology has evolved in the 13 years since this study was conducted. However, this study is one of the only publicly available studies on this topic, and the results may still be relevant to present V2G operation.

Battery Supplier Insights

The Cadmus team developed a set of interview questions and reached out to various vehicle battery suppliers, including A123 Systems, LG Chem, Tesla, and BYD to schedule in-depth interviews to explore V2G integration impacts on electric bus battery capacity and optimal charging strategies and conditions. The contacted manufacturers did not respond in time for this evaluation report. We will include insights from battery suppliers in the EY2022 report.

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[130] National Renewable Energy Lab (Smith, Kandker, Matthew Earleywine, Eric Wood, Jeremy Neubauer, and Ahmed Pesaran). January 6, 2012. "Comparison of Plug-In Hybrid Electric Vehicle Battery Life Across Geographies and Drive Cycles." https://www.osti.gov/biblio/1044471

[131] Peterson, Scott B., Jay Apt, and J.F. Whitacre. April 15, 2010. "Lithium-Ion Battery Cell Degradation Resulting from Realistic Vehicle and Vehicle-to-Grid Utilization." *Journal of Power Sources* (195) 8. p. 2385–2392. https://www.sciencedirect.com/science/article/pii/S0378775309017443

6.3.3. Lessons Learned

There were several EY2021 preliminary lessons learned from the V2G Pilot.

A lack of standards for V2G technologies resulted in vehicle and charger interoperability and grid interconnection challenges, a reduction in potential profit for the site, and Pilot delays.

The CPUC should work with Utilities to develop a V2G site standard or guidelines for technologies and grid integration to simplify Underwriters Laboratory and SAE International coordination and develop V2G-specific rates to help improve cost-effectiveness for participants.

The Pilot was designed and the site was selected before considering grid interconnection and technology interoperability requirements.

Utilities should work directly with all involved standards groups and vehicle manufacturers and EVSE hardware and software vendors early in the Pilot design process to ensure compatibility. All equipment should be selected before design is complete to avoid complications. In this Pilot, construction was almost complete when the SDG&E’s standards team requested a taller charger mounting pad to meet their electrical safety standards. Utilities should also consider V2G interconnection requirements and cost-effectiveness with each interested participant during the design phase. This consideration will ensure that participants receive compatible systems, meet Rule 21 interconnection and safety requirements, and are on V2G-friendly or V2G-specific electric rates.

Pilot delays resulted in minimal vehicle and charger utilization during EY2021.

Utilities, participants, and vendors should account for potential delays in V2G implementation in site timelines and site management budgets, including supply chain issues with buses and hardware, software commissioning challenges, and challenges with grid interconnection applications.

7. Liberty Transportation Electrification Programs

This section provides process and impact evaluation findings and lessons learned for Liberty's EV Bus Infrastructure project and Schools and Parks Pilots.

7.1. EV Bus Infrastructure Programs

7.1.1. Liberty Utilities EV Bus Infrastructure Project

In October 2018, CPUC Decision 18-09-034[132] authorized Liberty Utilities to complete a transit electrification site for the Tahoe Transit District (TTD). The initial plan included two Proterra (Rhombus) 60 kW DCFCs for three Proterra buses at Lake Tahoe Community College (LTCC), where the buses could charge overnight. The site was budgeted at $223,000 based on Liberty estimates. Liberty expanded the site scope based on the customer's updated charging specifications. The scope update 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, they provided distribution upgrades totaling $876,272 to support TTD in their fleet electrification efforts. TTD received Congestion Mitigation and Air Quality funds to purchase two Proterra battery electric buses, which, paired with California's Transportation Development Credits and Proposition 1B (transportation bond measure), fully funded the cost of those buses. TTD also received a Low Emission-No Emission Section 5339(c) grant, which fully funded the purchase of a third Proterra bus.

While the site grew and expanded in scope, Liberty maintained their commitment to continue supporting the site through completion. Liberty's contribution consisted of traditional Utility-side upgrades including a significant line extension since there was a long distance between the distribution supply and the transformer. The site also required a new transformer and 3,000 amp switchgear. As required in this location, Liberty completed the work around the construction restrictions that are in place during winter in the Tahoe basin.

TTD's plan was to have the three electric buses charge overnight on the DCFCs located at the LTCC bus stop and that they would use the pantographs (also to be installed at the LTCC bus stop) between runs. There were two bus shelters at the stop and an equipment shed behind the bus stop that houses the charging equipment. Figure 126 depicts the installation of the transformer behind the LTCC bus stop and the completed installation of the transformer and switchgear at that site.

Liberty noted an additional change in specification from Proterra, from 500 kW pantograph chargers to 450 kW pantograph chargers, due to supply chain issues. Figure 127 shows the location of the DCFCs at the LTCC bus shelters. The DCFC are shown as stub outs in this picture circled in red and the pantograph arms (without the charging connectors installed) are circled in blue.

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[132] 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

Figure 126. Crane Setting the Transformer behind the Bus Stop (left) and the (later) Fully Installed Transformer and Switchgear (right)

Figure 127. Lake Tahoe Community College Bus Shelters

Site Status

At the end of EY2021, the site had two 60 kW Proterra DCFCs that were fully installed and operational. The infrastructure to support the pantograph chargers and the charger arms were installed, but the charging connectors were not yet installed. The three Proterra transit buses had been used for training purposes only, and had not been actively deployed on routes. As such, the site had not been fully activated and was not fully operational.

The installation process and all distribution upgrades were completed in March 2021, which concluded Liberty's role in setting up the infrastructure for the project. The Utility expects 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.[133]

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[133] Liberty Utilities (Calpeco Electric) LLC. December 6, 2021. "Rule 24 Electric Vehicle Infrastructure." https://california.libertyutilities.com/uploads/CalPeco%20Tariffs/CalPeco%20Rule%2024.pdf

7.2. Schools and Parks Pilots

7.2.1. Overview

This overview provides a detailed description of the Liberty Schools and Parks Pilots, as well as summaries of the Pilot implementation process, ME&O activities, EY2021 sites, budget status, and a major milestone timeline. Following the overview, we present the EY2021 finding and lessons learned.

Pilot Description

> **Schools Pilot Targets**
>
> - 56 L2 and 2 DCFC charging stations
> - 17 schools

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 fleet vehicles and electric school buses for parents, teachers, and students. At the time of Decision 19-11-017, Liberty identified 17 potential sites, with 15 at K–12 schools, one at LTCC, and one bus barn for the Lake Tahoe School District. If all 17 sites ultimately participate, the Schools Pilot will result in charging stations installed at every school in Liberty's service territory. There are no DAC requirements for the Liberty Pilots, as there are no CES 4.0–defined DACs in the service territory.[134] Per Decision 19-11-017, across all sites, Liberty planned to install 56 L2 charging ports and two DCFCs. Liberty's ownership model for all charging stations in the Schools Pilot includes EVSE, network software, transformers, permitting, electrical work, and trenching. Liberty also installs safety bollards and snow melt and lighting equipment, where appropriate.

> **Schools Design Goal**
>
> Empower schools to offer public charging to staff, students, parents, and the greater community.

> **Parks Pilot Targets**
>
> Five dual-pedestal charging stations with two charging ports each at three sites.

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 the proximity to town and regional centers, retail centers, beaches, recreation areas, education facilities, and large marinas. Through the Pilot, Liberty will 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 Design Goal**
>
> Encourage state parks and beaches to charge their own EV fleets and offer charging to staff and patrons with light-duty vehicles.

[134] 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 growing demand for EV charging from residents and visitors to the Lake Tahoe region. Through these Pilots, Liberty will increase the share of electric vehicle miles traveled in the Tahoe region, which supports the community's move toward their sustainability and environmental improvement objectives, including reducing GHG emissions 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. Therefore, once the Pilots were approved, Liberty did not need to spend time identifying potential sites. Instead, staff focused their efforts on enrolling schools and parks. Liberty also noted that prior to beginning implementation, staff had to establish internal processes to track contract status, draft common contract language, and conduct additional similar administrative tasks to ensure the smooth implementation of the Schools and Parks Pilots over time.

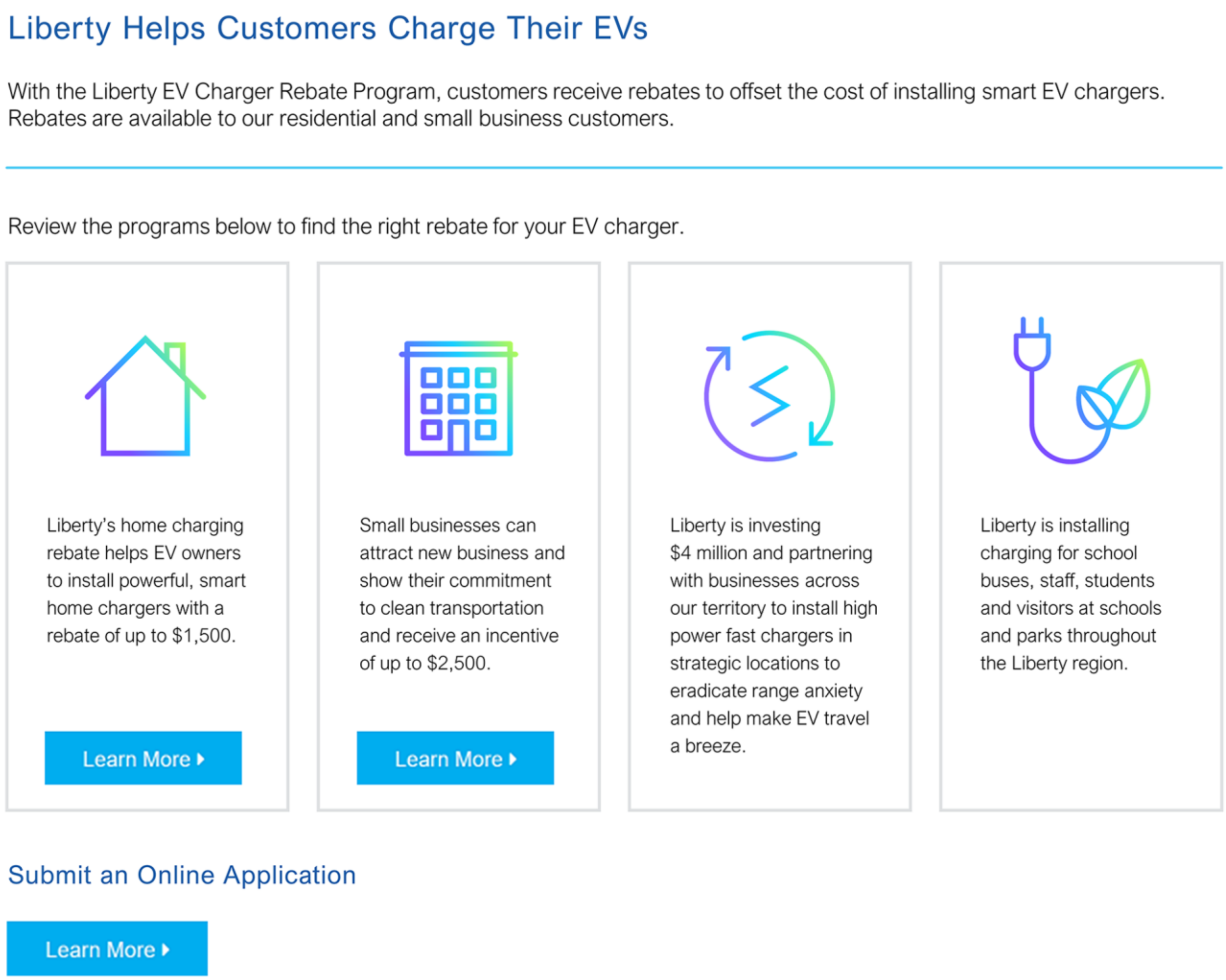
Figure 128 details Liberty's implementation process for all sites in both the Schools and Parks Pilots.

Figure 128. Schools and Parks Pilots Implementation Process

ME&O Summary

Schools and Parks Pilots: Liberty conducted minimal outreach through a web page in EY2021 (see the screenshot in Figure 129) and a frequently asked questions document that were designed by the Pilot manager. Though Liberty has been engaging with schools that will participate in the Schools Pilot, Liberty has not been able to move forward with engaging any Parks Pilot sites.

Figure 129. Liberty Website with Schools and Parks Pilots Information



Site Summary

Liberty did not have any activated or constructed Schools Pilot or Parks Pilot sites in EY2021.

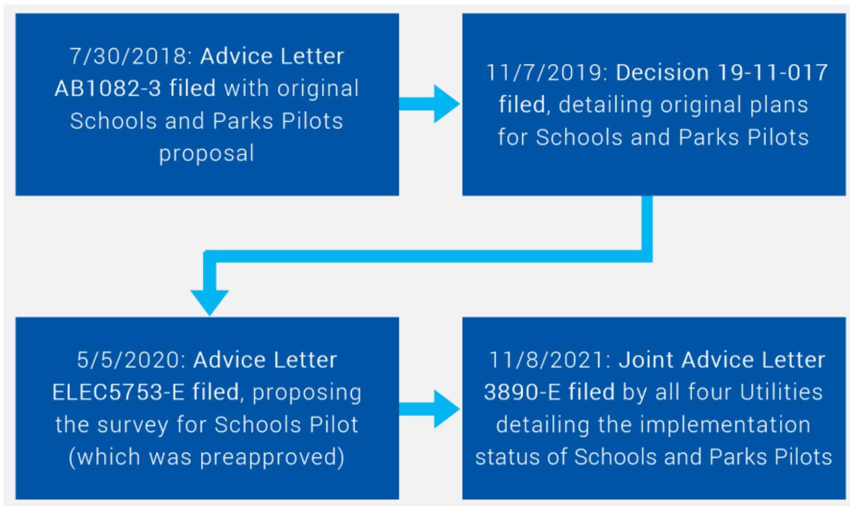
Budget Summary

Through EY2021, Liberty spent $19,135 of $3.9M on the Schools Pilot and has spent none of the approved $0.78M Parks Pilot funds.

Timeline

Since inception of the Schools and Parks Pilots in 2018, there have been several updates and milestones, shown in Figure 130. Neither Pilot has officially started. The start dates will be established when the first site in each Pilot (respectively) breaks ground and starts construction.

Figure 130. Timeline of Key Schools and Parks Pilots Milestones



7.2.2. Findings

As discussed in the *Overview* section, neither the Liberty Schools Pilot nor the Parks Pilot had any activated sites in EY2021. As a result, the Cadmus team did not complete any visual site visits in 2021 and will complete the first round of impacts assessment—including incremental EV adoptions, petroleum displacement, GHG and criteria pollutant reductions, health impacts, and grid impacts—as part of the EY2022 analysis and reporting. The subsections below provide limited insights based on analyses completed for 2021 including TCO contextual analysis and preliminary insights from the Utility website review and staff interviews.

Total Cost of Ownership

The Cadmus team analyzed key industry cost trends for public charging due to limitations of the EY2021 cost data and to set the stage for the EY2022 TCO analysis. This section provides context to the financial costs associated with installing EV infrastructure.

Infrastructure costs include BTM and TTM costs, as well as the cost for the charger and related materials. As shown in Table 122, these cost categories vary in the degree of variance, with BTM and TTM costs typically being the most significant cost driver and having the largest degree of variance on a per-site basis.

Table 122. Infrastructure Costs

Category	Degree of Cost Variance	Context and Rationale
Behind-the-Meter Costs	High	BTM includes site excavation for service line extensions to connect charging stations to the relevant meter. Costs may vary depending on lengths for trenching and cabling. BTM costs are also impacted by the cost of labor and any relevant supply chain and labor shortages. [a]
To-the-Meter Costs	High	TTM costs may vary depending on current capacity available for site hosts and, particularly, if a new transformer is required to supply power for EV charging. Costs may also vary depending on lengths for trenching and cabling. TTM costs are also impacted by the cost of labor and any relevant supply chain and labor shortages. [a]
Charger Costs	Moderate	Per-unit charger costs may decline with greater deployment of chargers per site. However, there are potential impacts from supply chain constraints and costs that may vary by charger power level. With current supply chain constraints, charger manufacturing costs may be affected, possibly increasing overall costs. [b]
Material Costs	Moderate	Material costs may include the cost of panels, meters, and the cabling required to connect the charger to the Utility distribution system. Similar to the cost of the charger, material costs are subject to supply chain constraints and may increase overall costs. [c]

[a] PG&E. February 2022. "Program Advisory Council Meeting Q4 2021." Presentation.
[b] California Energy Commission. Accessed March 2022. "CALeVIP DC Fast Chargers, Average Rebate, Unit Cost, and Total Project Cost per Charger." and California Energy Commission. Accessed March 2022. "CALeVIP Level 2, Average Rebate, Unit Cost, and Total Project Cost Per Connector Installed."
[c] PG&E. February 2022. "Program Advisory Council Meeting Q4 2021." Presentation.

Significant TTM costs include transformer upgrades and costs related to upgrading and maintaining the distribution system.[135] Significant BTM costs can include trenching, site excavation for service line extensions, and cabling requirements to connect charging stations to the relevant meter. In the context of the Utility-sponsored public charging programs, Utility staff across programs noted higher-than-expected infrastructure costs, occurring both BTM and TTM. Specifically, Utility staff noted significant variable costs such as the need for transformer upgrades and longer-than-anticipated lengths for trenching.[136]

> Ongoing supply chain constraints and labor shortages will increase infrastructure costs.

Material costs for charging stations are rising at least in part due to the ongoing COVID-19 pandemic and global disruptions on supply chains.[137] This increase was noted during a PAC meeting in which stakeholders mentioned that significant increases in material costs (such as copper wire and panels) are impacting contractors' ability to hold pricing past three to six months.[138] Related to material costs, the

[135] PG&E. February 2022. "Program Advisory Council Meeting Q4 2021." Presentation.

[136] PG&E. February 2022. "Program Advisory Council Meeting Q4 2021." Presentation.

[137] White House (Helper, Susan, and Evan Soltas). June 2021. "Why the Pandemic has Disrupted Supply Chains."

[138] SCE. March 18, 2022."SCE Transportation Electrification Program Advisory Council." Presentation.

cost of the charger itself is subject to price volatility with global supply chain constraints disrupting manufacturing processes. In addition, in California, the shortage in labor supply and high labor rates in the construction industry can add additional costs for EV charging deployment.[139] In addition, it can be difficult to quantify the supply chain impacts to material and labor costs, as revealing these costs may be detrimental to vendors' competitive advantage (allowing for competitors to adjust their prices accordingly).[140]

In addition to infrastructure costs, the installation of EV chargers includes a number of soft costs that can have a range of impacts on the site development. Soft costs can also be difficult to quantify, as some cost categories may apply across a Utility program as opposed to a single site location. As shown in Table 123, potential site delays and opportunity costs have the largest degree of variability for soft costs related to EV charging deployment.

Table 123. Soft Costs for Installing EV Chargers

Category	Degree of Cost Variance	Rationale
Site Delays	High	Delays in building out EV charging are difficult to predict and the financial impact of such delays can be difficult to quantify. A delay may increase site costs as it may require extending the timeline for BTM and/or TTM construction and result in an increased labor cost. [a]
Opportunity Costs	High	Utilities implementing transportation electrification programs invest time to engage site hosts in the program process, conduct site visits, and so on. Utilities will need to coordinate with property owners and key decision-makers, and this coordination effort is specific to each site. There is a time cost associated with the uncertainty of the permitting and delays, as well as multiple revisions and meeting schedules that can result in extending the timeline for approval across sites. For instance, Utility staff noted that certain site schedules have to adhere to school board or city council meeting timelines to receive the relevant approvals to move sites forward. [b] This time could be spent on other sites. Opportunity costs are critical to consider and difficult to quantify, particularly as costs may vary by site based on the level of complexity. [c]
Permitting	Moderate	Permitting costs can vary as unexpected permits from cities and/or counties are required.
Site Design	Moderate	Sites may require multiple iterations to refine the design, change the location of charging stations, and/or change the number of ports. These adjustments may require additional site visits.
Operations and Maintenance	Low	Operations and maintenance costs occur on a routine basis and are relatively fixed to the type of charger installed.
Taxes	Low	Taxes are a relatively fixed cost.

[139] Public Policy Institute of California (Johnson, Hans). March 2022. "Who's Leaving California-and Who's Moving In?"

[140] Rocky Mountain Institute (Nelder, Chris, and Emily Rogers). 2019. "Reducing EV Charging Infrastructure Costs."

Category	Degree of Cost Variance	Rationale
Communication/ Networking	Low	Networking costs are built into the cost of installing the charging infrastructure and are billed on a fixed reoccurring basis.
Marketing and Customer Outreach Costs	Low	Marketing and outreach costs are considered in Utility cost methodologies. However, marketing costs are commonly applied across programs and may be difficult to link with a single site location. [d]

[a] PG&E. July 2021. "Program Advisory Council Meeting Q2 2021." Presentation.

[b] SCE. March 18, 2022. "SCE Transportation Electrification Program Advisory Council." Presentation.

[c] Rocky Mountain Institute (Nelder, Chris, and Emily Rogers). 2019. "Reducing EV Charging Infrastructure Costs."

[d] PG&E, SCE, and SDG&E. Report Filed on March 31, 2022. "Joint IOU Electric Vehicle Load Research and Charging Infrastructure Cost Report 10th."

Our research indicates that soft costs can contribute significantly to the overall cost of public charging stations, particularly for public DCFC sites, which have high levels of energy demand and can have more complex installations.[141] Soft costs are difficult to consider on a per-site basis. Utilities often quantify soft costs such as program management and ME&O on a program level, yet fixed soft costs are based on the site (such as site design costs, taxes, permitting, operations, maintenance, and networking and communication costs).

Complex sites will require a greater investment of time and resources, thus increasing the site-related soft costs. This level of complexity will depend on variable factors including the decision-makers involved, the power level of the installed charging, and any site delays. Related to this investment of time and resources, there is a high degree of variability in opportunity costs for Utilities engaged in transportation electrification programs. These technologies are relatively nascent and Utilities expend effort to engage site hosts, conduct site visits, and make adjustments to improve these programs. This time could be spent on other Utility activities.

EV charger site costs vary as the result of uncertainties is both infrastructure and soft costs. Additionally, an increase in soft costs can compound infrastructure costs.

Soft costs are interrelated to infrastructure costs. In the context of Utility-sponsored public charging programs, Utility staff have specifically noted that BTM labor costs can be complicated by site host BTM construction delays. Reasons for these delays can include RFP challenges, internal decision-making related to paying for BTM work, and lack of familiarity with BTM construction. These BTM delays are a common driver of overall site completion delays.[142] As sites are delayed, other costs may accumulate without the financial impacts being readily quantified. Current supply chain constraints may increase the costs of infrastructure while also increasing soft costs due to resulting delays.

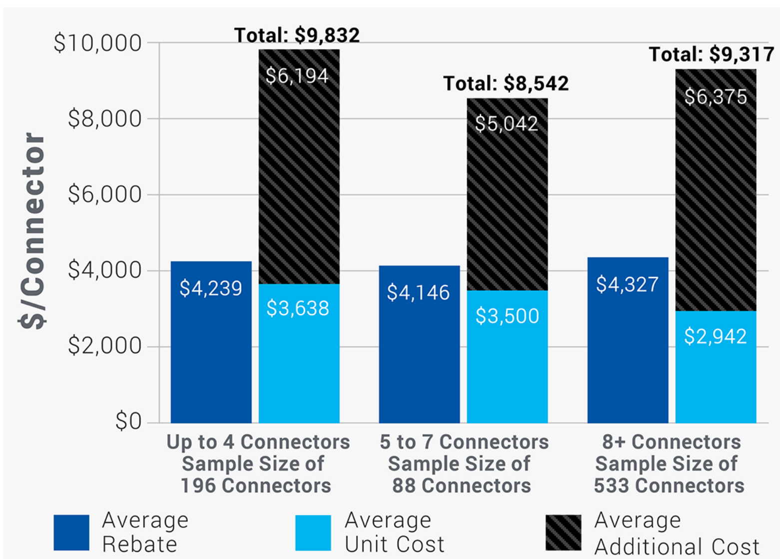
141 Rocky Mountain Institute (Nelder, Chris, and Emily Rogers). 2019. "Reducing EV Charging Infrastructure Costs."

142 PG&E. July 2021. "Program Advisory Council Meeting Q2 2021." Presentation.

In addition to considering the EV infrastructure and soft costs discussed above, the team also examined a cost case study based on the California Electric Vehicle Infrastructure Project (CALeVIP). CALeVIP offers incentives to acquire and install EV charging infrastructure at publicly accessible sites throughout California. The 2021 CALeVIP data on L2 costs (Figure 131) and DCFC costs (Figure 132) showcases the decline in per-unit costs (shown in blue) and the variance in total per charger costs (shown in gray).[143] Based on CALeVIP data shown in Figure 131, L2 per-unit costs decrease in sites with a greater number of chargers per site. Similar to L2 data, DCFC per-unit costs decrease in sites with a greater number of chargers per site (Figure 132). However, for both DCFC and L2 charging, the soft costs and remaining infrastructure costs—beyond the charger itself—(shown as the *average additional costs* in the gray bars) do not reflect a direct relationship between the number of chargers per site and the total cost per charger per site.

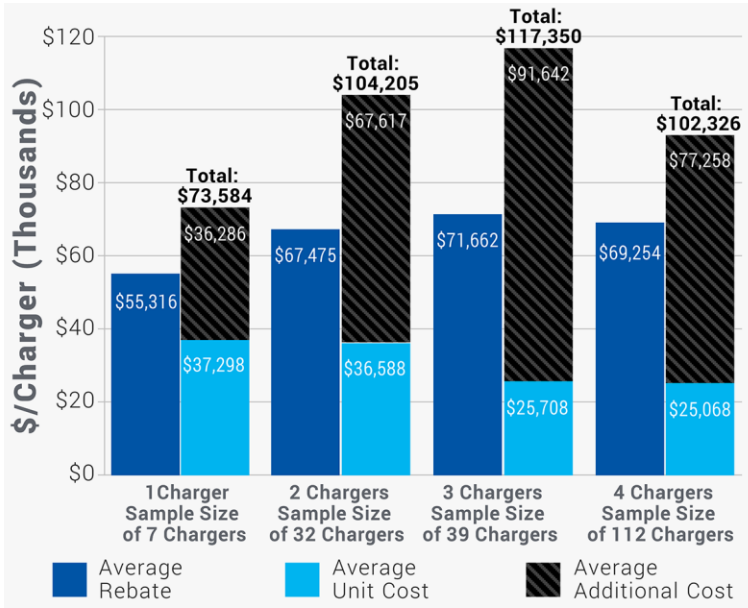
> Per-unit charger costs will likely decline with greater numbers of chargers per site. Unlike per-unit costs, total costs per charger may not decline with a greater number of chargers per site.

Figure 131. CALeVIP L2 Charger Costs



[143] California Energy Commission. Accessed March 2022. "CALeVIP DC Fast Chargers, Average Rebate, Unit Cost, and Total Project Cost per Charger." and California Energy Commission. Accessed March 2022. "CALeVIP Level 2, Average Rebate, Unit Cost, and Total Project Cost Per Connector Installed."

Figure 132. CALeVIP DCFC Costs



Utility Web Page Insights

The team conducted a high-level review of Liberty's website in April 2022 to identify what information was available for the Schools and Parks Pilots. We found a web page, "EV Charger Rebates," that looks trustworthy and has a clean and simple layout that conveys the Pilots' existence. At the same time, the site only provides minimal detail about the Schools and Parks Pilots, such as what is offered and the current status. Additionally, since the Power Clerk page does not look like other Liberty web pages, the page may have reduced credibility with viewers.

Utility Staff Insights

Over the course of EY2021, the Cadmus team interviewed Liberty program staff twice about the Schools and Parks Pilots (once in September 2021 and again in March 2022), in addition to monthly check-ins about the status of the Pilots and quarterly joint Utility calls.[144] Through these conversations, Liberty staff identified key insights they experienced in 2021.

Schools Pilot and Parks Pilot

Before rolling out the Pilots, Liberty staff established processes and systems needed to make implementation as smooth as possible. Liberty had not historically run similar programs, and therefore needed to create processes and systems. To create these processes, staff coordinated with other internal departments such as Distribution Engineering, Project Management, Regulatory, Procurement, Legal, and Construction (once sites were to the point where they were ready for construction). Liberty staff noted that the intake, design, and review processes worked well, in particular saying that despite setbacks (detailed below), the team has proven to be resilient in trying to solve site host concerns and

[144] The Cadmus team began conducting Schools Pilot and Parks Pilot joint Utility quarterly calls in Q4 2021.

overcome logistical barriers. Additionally, staff reflected that the Liberty team manages the implementation processes (such as status tracking) over time and improves these as needed. For example, additional environmental concerns—such as snow and wildfire management—have caused delays in both program design and permitting. To mitigate the impact of these considerations on site timelines, Liberty staff will engage the Liberty Wildfire Management team early in the site evaluation.

Additionally, Liberty staff identified that the expected costs for the sites have been higher than anticipated. In particular, staff reported that estimated opportunity costs have been trending significantly higher than they were previously. In addition, construction labor and material costs have increased as inflation has risen and COVID-19 disrupted supply chains and the labor force. For example, though staff expected some trenching at each site, more trenching has been needed than was originally expected and budgeted. Additionally, staff reported that although permitting costs were expected, construction costs to meet ADA requirements have been unexpectedly high. Staff explained that these higher costs have limited their ability to conduct the level of marketing, education, and outreach that was originally outlined in Decision 19-11-017. However, staff were able to put together some frequently asked question documents to assist site hosts.

Finally, staff reported a lapse in activity while there was an internal staff transition. This gap occurred from January to November 2020, when a new Schools and Parks Pilots manager was brought on board. After the Pilots resumed activity and Liberty staff re-engaged with potential site host in December 2020, staff reported that there was a significant decrease in site host interest across their service territory. In one case, a school had to move forward with installing EVSE on their own. For most other sites, there were several reasons why site hosts became less interested:

- **Loss of Pilot champion**. Staff noted that turnover was prominent enough at schools and parks in Liberty's service territory to impact the Pilots. Previously interested staff no longer worked at the school or park, meaning that Liberty staff had to start over with the new site host staff and orient them to the Pilot and the scope, goals, and commitments needed from the site host.
- **Schools Pilot: Safety consideration.** Staff reported that some schools expressed concern about student and campus safety if chargers were available to the public 24/7.
- **Schools Pilot: Competing interests**.
    - Staff reflected that schools tended to be more interested in EVSE for school bus fleets and in electrifying buses than they were in installing EVSE for light-duty vehicles. Staff also noted that only one of Liberty's Schools Pilot site participants is eligible to receive EVSE for bus fleets, and that site is still planning to move forward.
    - Staff reported that schools began to deprioritize the Pilot due a perceived lack of demand for two reasons. First, the schools indicated that not enough school staff or parents collectively own EVs to warrant installing public charging infrastructure on school grounds. Second, staff said that schools appeared to be understandably preoccupied with the impacts and uncertainty caused by COVID-19. The priority of ensuring school staff and student health and safety limited the schools' capacities to work with Liberty on getting the EVSE installed.

Despite these setbacks, Liberty's Pilot staff were successful at re-engaging potential site hosts in 2021. When needed, staff re-educated contacts and stakeholders, which sometimes helped move the site along in the process in terms of conducting site walks and starting to socialize contract and easement documents. In an effort to better understand the current priorities for potential site host, Liberty Pilot staff also conducted additional research, such as attending school board meetings (for the Schools Pilot).

Parks Pilot

Prior to Decision 19-11-017 Liberty had engaged state park site hosts at the local level to identify sites that could be served through the Parks Pilot; however, the Pilot has still not been able to move forward. Liberty staff identified that the sole focus on implementing the Parks Pilot in state parks has delayed activity. Staff reported that the other Utilities implementing the Parks Pilot (PG&E, SCE, and SDG&E) have engaged the California Department of Parks and Recreation to determine participation agreement language that could be used for all state parks. However, likely due to multiple staff changes at the California Department of Parks and Recreation, the staff at PG&E, SCE, and SDG&E have had trouble keeping the participation agreement approval moving through the Department approval process. When Department staff transitions occurred, the Utilities often have to re-orient the new staff member on the purpose of the Pilot and all steps completed to date. Since Liberty's Parks Pilot is the smallest of the four, Liberty is waiting for the other Utilities to establish processes with the California Department of Parks and Recreation, knowing that the resolution will be applicable for its Pilot as well.

Finally, Liberty staff shared some insight into what the parks in Liberty's service territory may be considering for their participation in the Parks Pilot. Specifically, though site hosts appear willing to participate and get the chargers installed in the parks, it does not seem likely that the EVSE installed through the Parks Pilot will alone motivate parks in Liberty's territory to transition their fleet from ICE trucks to EVs.

7.2.3. Lessons Learned

The team identified a number of lessons learned from EY2021. These lessons, presented below with key supporting findings and recommendations, may be applied to future Pilot years and to other similar efforts.

School Pilot and Parks Pilot

EVSE pilots in regions with extreme climate variability may experience additional barriers to EV adoption.

The Tahoe region experiences a wide range of fluctuating temperatures over the course of the year. Those who live in the region must always account for both harsh cold winters with many feet of snow as well as the risk of wildfires. Therefore, the placement of EV charging infrastructure must consider these factors. For example, additional safety measures may be needed, such as snow bollards, to mitigate customer concerns. It also means that Liberty staff must consult with other departments of expertise, such as Liberty's Wildfire Management Department, to make sure that site designs do not add additional fire risk and that they are built with wildfire resiliency to the extent possible.

Unexpected market impacts and site design requirements resulted in higher-than-expected site costs and limited participation.

Liberty began the Schools and Parks Pilots during the COVID-19 pandemic. COVID-19 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 Liberty 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. Though Liberty staff conducted research ahead of Pilot design, these expenses were then compounded by inadvertent inaccuracies in Pilot design estimations. For example, while designing actual sites, Liberty found that the typical trench length assumption had been underestimated. Similarly, more construction is needed than what was estimated to meet ADA permit requirements.

Staffing constraints contributed to conflicting priorities from site hosts, which resulted in site delays or withdraws.

Participating in either the Schools or Parks Pilot requires the site host to make a commitment that often spans several months. Site hosts must not only be willing to install EVSE on their property, but—at a minimum—they must also work with Liberty to coordinate site walks, approve site design, and review and approve contracts, easements, and other critical documents. Liberty experienced that many site hosts of both the Schools Pilot and the Parks Pilot had staffing constraints that either delayed or completely prevented participation.

In EY2021, Liberty's Parks Pilot was most influenced by staff turnover at the California Department of Parks and Recreation. When Department staff transitions occur, Utility staff often must re-orient the new staff member to the purpose of the Parks Pilot and all steps completed to date.

The Schools Pilot was also influenced by staff constraints. In addition to turnover, Schools Pilot site host staff were constrained by their available bandwidth. In 2021, this was exasperated by COVID-19. Since the Pilot began, schools have been burdened with making ever-changing decisions regarding virtual versus on-site learning, mask mandates, and similar choices. Liberty staff noted that the priority of ensuring school staff and student health and safety limited the schools' capacities to work with Liberty on getting the EV charging infrastructure installed. On top of this, some schools deprioritized the Pilot when school staff expressed that not enough school staff or parents collectively own EVs to warrant needing public charging infrastructure installed on school grounds.

Schools Pilot Only

K–12 schools experience unique barriers to installing public EVSE.

The intent of the Schools Pilot is to install publicly available chargers at K–12 schools to increase charging available to staff, students, parents, and the greater community. However, staff reported that several schools Liberty tried to recruit for the program expressed concern about student safety if the chargers were accessible to the public 24/7. Despite potential interest in installing EV charging infrastructure, those schools ultimately opted out of enrollment.

Additionally, public K–12 schools often need multiple layers of approval before signing a contract for sites like those designed under the Schools Pilot. Often, approval must come from the school board (which, in some cases, means the site may be open to scrutiny and public comment) or from specific personnel who may not work at the site. These multiple layers add complication and time to enrollment and implementation processes.

Adaptability in the Pilot enrollment process enabled Liberty staff to meet customer needs.

In addition to setting up procedures from scratch to coordinate with other internal departments, Pilot staff took the time to learn from sites that had already gone through the application process. For example, Pilot staff realized in 2021 that their designs were not taking all wildfire mitigation and adaptation risks into account. Therefore, Liberty began to involve its Wildfire Management team earlier in the design process. By updating their Schools and Parks Pilots' implementation process in real time, these process became more efficient and customer-friendly with each application processed.

Appendix A. Data Collection Instruments

SRP MDHD Bundle Utility Stakeholder Interview Guides

Interviewee Name:
Interviewee Organization: Liberty, PG&E, SCE, SDG&E
Date of Interview:
Interviewers: _______________ (Cadmus)

The table below presents the cross-cutting and bundle-specific research objectives that will be explored in this utility staff interview guide.

Objective Sources and Research Questions	Corresponding Guide Questions
Objective 1: Acceleration of TE	
1. What barrier(s) did the TE investment overcome? What barrier(s) remain, if any?	B10, B21, B30, B38
2. Are the programs on track to serve the number of partners authorized in the decision?	B1, B2, B4, B14, B23, B25, B34, B36
Objective 2: Maximize Benefits	
3. For a representative sample of fleets within each program and in each market segment, what were the changes to total cost of ownership? Ongoing costs of fueling and maintenance?	B3, B4, B5, B16, B17, B18, B25, B26, B29, B36, B37, B42
4. What were the costs of the project to the Utility and the site hosts or fleets?	
5. What drives cost variations?	
6. How can the level of program satisfaction be characterized (on average, range, evolution over time)? How does it vary by market segment?	C2, C3, C10, C11, C19, C20, C29, C30
Objective 3: Maximize Learnings	
1. What were the differences between the originally approved design and actual implementation?	B1, C1, B14, C9, B23, C17, B34, C27
2. How could speed of implementation be improved (e.g., recruitment, design, construction)?	C7, C25, C35
3. How could (PROGRAM) efficiencies lead to lower cost for the same impact?	D1
4. What factors improve return on investment or profitability for participants?	B5, B18, B26, B42
5. Which fleet types, vehicles, applications, or routes are best suited for electrification and how?	B2
6. How are you working with OEMs to support customer participation?	B7, C2
7. What strategies have led to viable sites and successful deployments?	D1
8. Are any strategies leading to more applications that are poor matches for the program (e.g., consultants trying to bring in fleets and overpromising what the program can offer)?	B7, B28, B44
9. How can the Utilities share pipeline lessons from their different approaches and experiences?	D12
10. How should the programs be scaled up or down over time?	D11
11. Does the volume of interest from partners and effectiveness of the program warrant increased magnitude of activity? Does it warrant different levels of incentive, rebate, or participation payments?	D5, D8
12. Is the market maturing enough to spur rapid naturally occurring uptake?	D11

[TEXT LIKE THIS] indicates "programming" or "logic" – basically, it tells you the conditions under which you should say a question or where you should be inserting something specific – like [PROGRAM] should be said as the program's name when you're reading the question out loud.

[TEXT LIKE THIS] indicates instructions for the interviewer. These are usually 'probe' instructions, helping the interviewer remember what key points to touch on if the interviewee doesn't answer themselves.

In this guide, **text like this** indicates text that was used for the purposes of providing an example for this template.

Utility	Program Covered in This Guide	Corresponding Guide Questions
Liberty	EV Bus Program	A, B14-B22, C9-C16, D, E
PG&E	EV Fleet	A, B1-B13, C1-C8, D, E
SCE	SCE CRT	A, B23-B34, C17-C26, D, E
SDG&E	Power Your Drive for Fleets	A, B34-B47, C27-C36, D, E

A. Introduction and Interviewee Information

Thank you [all] for joining us today. We are here to talk about the design and status of the **[Liberty's EV Bus Program, PG&E's EV Fleet Program, SCE's CRT Program, and SDG&E's Power Your Drive Fleets.]** The overarching purpose of this interview is to formally document the early stages of the programs, as well as roles and responsibilities supporting the programs. We may ask you to confirm or clarify information that has come up during earlier team calls, in PAC presentations, or from your latest SB 350 report. Part of what we are doing during this interview is stepping back to take a fresh look from the beginning of the programs to make sure we capture all relevant information with the evaluation in mind. Some of the questions you may not yet have insights to, and we completely understand. Before we get started, do you have any questions for me?

A1. First, what [are/is] your role(s) at **[Liberty][PG&E][SCE][SDG&E]**?

A2. What role(s), if any, did you have in the design of the programs?

[IF NONE: Is there someone else we should talk to who was involved with the initial program design? **[If so, capture name and contact information]**

Great. Next, we are going to move into detailed questions about the program. I'll ask you about the design, implementation, and then early lessons learned.

B. Program Design Questions

PG&E, EV Fleet Program

B1. Let's start with program design. We understand that this program serves a variety of fleets, including Distribution, Shuttle Bus, Transit, Municipal, and Public-School Fleets. From the Q3 PAC update, we read that the program currently has 79 signed contracts (equating to ~1,340 EVs) and 25 activated sites. Is this correct?

1. When did the program design process begin?
2. We understand that PG&E plans to ask to change program design to extend goal due date 2 years to 2026 and also remove numeric goal for sites. Have there been any design changes since the beginning of the program? **[PROBE FOR CHANGES AND RATIONALE] (note that there haven't been any changes to the program as of now since it started in 2019, until last week)**

B2. We understand that there were 153 applications, eventually narrowed down to 84 (67 viable contracts plus 17 sites). Can you speak about site selection criteria (i.e., cost threshold and other factors)?

B3. Who was involved when deciding the design of **the EV Fleet Program**? **[PROBE FOR SPECIFIC PROGRAM LOGISTICS]**

1. How was the incentive and rebate structure determined for **the EV Fleet Program**? Do you feel like the incentive caps and rebate levels are set at appropriate levels to meet program goals?

B4. It is our understanding that **$236.3 million** was approved for the program, and roughly **$22.4 million** has been spent so far. Is that correct?

The SB 350 report notes how the budget is allocated between infrastructure and non-infrastructure spending (e.g., on program management, education, rebates, etc. - so this question should be about how that budget has been spent, and how the budget requirements are impacting the program. E.g., does the 15% minimum spend on transit agencies hinder their ability to serve other customers?

Now I want to ask you a few questions about early insight on costs.

B5. Though the evaluation team will be looking at the detailed costs on a quantitative level, we wanted to get your current perspective on the project costs **We know that many kinds of costs can accumulate for these projects. In addition to the cost of the equipment, there are permit, construction, installation, maintenance, and rebates.** What are the **most prominent** costs of the **EV Fleet Program** to **PG&E**? (see Table 9 in SB 350 report - Program Cost Summary – however, this info has been redacted – as evaluators though we should be able to see these costs)

1. What are the **most prominent** costs of the program for **site hosts**?
2. We understand it's still early in the program, but do you have ideas on what might drive the differences in these costs?

B6. **[IF NOT COVERED IN B2]** What strategies have led to successful site selection and deployment? (see Table 11 in the SB 350 report on Lessons Learned to build off this question.)

B7. Are there any recruitment strategies leading to an excess of applications, or poor matches? *(PROBE: Has anyone overpromised on what can be offered?*)

1. How are you working with OEMs to support customer participation?

B8. **[IF NOT COVERED IN B2]** How was the incentive and rebate structure determined for **the EV Fleet Program**?

B9. What are the challenges or barriers that you hope **the EV Fleet Program** will overcome?

B10. We understand that the main goal of the EV Fleet Program is to accelerate the EV fleet transition for organizations by streamlining site design and permitting, construction, maintenance, and incentives. Are there any other goals the program hopes to achieve?

B11. We understand another goal of the program is to target disadvantaged communities (DACs) with charging infrastructure. Currently, we understand that 30 of the 79 contracts are in DACs. Is this correct, and what other aspects of the program were crafted specifically for, or to benefit, DACs, if any?

1. How were the goals decided for **the EV Fleet Program**?

B12. Did the different decision guidance for the DAC budget share adjustment enable spending down more of the budget and deploying more widespread TE infrastructure? *(PROBE: Ask about redeployment of unspent DAC budget*)

B13. Are there other benefits you expect the program to realize besides the stated goals?

[SKIP TO SECTION C, PG&E EV Fleet Program]

Liberty, EV Bus Program

B14. Let's start with program design. We understand that the main goals are to electrify transit buses for the Tahoe Transit District and have two different kinds of chargers installed at the Lake Tahoe Community College. Is this correct?
1. How were the goals decided for the EV Bus Program?
2. When did program design process begin?
3. Have there been any design changes since the beginning? **[PROBE FOR CHANGES AND RATIONALE]**

B15. Who was involved when deciding the design of **the EV Bus Program**?

B16. How was the incentive and rebate structure determined for **the EV Bus Program**?

B17. What was your approved budget for this program?

Now I want to ask you a few questions about early insight on costs.

B18. Though the evaluation team will be looking at the detailed costs on a quantitative level, we wanted to get your current perspective on the project costs. **We know that many kinds of costs can accumulate for these projects. In addition to the cost of the equipment, there are permit, construction, installation, and maintenance costs.** What are the **most prominent** costs of the program to **Liberty**?
1. What are the **most prominent** costs of the program for TTD? For Lake Tahoe Community College (if any)?
2. Do you have ideas on what might drive the differences in these costs?

B19. What strategies have led to successful site selection and deployment? How did you select the Tahoe Lake Community College?

B20. How was the incentive and rebate structure determined for **the EV Bus Program**?

B21. What are the challenges or barriers that you hope **the EV Bus Program** will overcome?

B22. Are there any other benefits that the program expects to realize that are not part of the stated goals?

[SKIP TO SECTION C, Liberty EV Bus Program]

SCE Charge Ready Transport

B23. Let's start with program design. We understand that this program is designed to support the availability of charging infrastructure for MDHD vehicles. Is this correct?
1. When did program design begin?
2. We understand that SCE plans to ask to change program design to extend goal due date 2 years to 2026 and also remove numeric goal for sites. Have there been any design changes since **the beginning**? **[PROBE FOR CHANGES AND RATIONALE]**

B24. Who was involved when deciding the design of **Charge Ready Transport**?

B25. From the most recent PAC update, we understand that SCE is currently working on 112 sites to support 3,100 MDHD vehicles with a goal of 870 sites and 8,490 converted or procured EVs. Is this correct?
1. How much of the **$356.4 million budget** has been spent to date?

Now I want to ask you a few questions about early insight on costs.

B26. Though the evaluation team will be looking at the detailed costs on a quantitative level, we wanted to get your current perspective on the project costs. **We know that many kinds of costs can accumulate for these projects. In addition to the cost of the equipment, there are permit, construction, installation, and maintenance costs.** What are the **most prominent** costs of the program to **SCE**?
1. What are the **most prominent** costs of the program for **site hosts?**
2. We understand it's still early in the program, but do you have ideas on what might drive the differences in these costs?

B27. What strategies have led to successful site selection and deployment?

B28. Are there any recruitment strategies leading to an excess of applications, or poor matches? *(PROBE: Has anyone overpromised on what can be offered?)*

B29. How was the incentive and rebate structure determined for the **Charge Ready Transport Program**?

B30. What are the challenges or barriers that you hope **the Charge Ready Transport** will overcome?

B31. We understand that the main goal of this program is to increase charging infrastructure for MDHD vehicles. Are there any other goals the program hopes to achieve?

B32. We understand another goal of the program is to make charging infrastructure **available to fleets in DACs.** Have there been any challenges with meeting this goal? **We also read about the 50% EVSE rebate available to DAC communities. How has this level of incentive been received?** What other aspects of the program were crafted specifically for, or to benefit, DACs, if any?
   1. How were the goals decided for **the SCE Charge Ready Transport**?

B33. Are there any other benefits the program hopes or expects to realize aside from those stated in the goals?

[SKIP TO SECTION C, SCE Charge Ready Transport]

SDG&E Power Your Drive for Fleets

B34. Let's start with program design. We understand that this program is designed to help fleet owners and operators transition to electric vehicles seamlessly.
   1. When did program design begin?
   2. Have there been any design changes since? **[PROBE for changes and rationale]**

B35. Who was involved when deciding the design of **the Power Your Drive for Fleets**?

B36. It is our understanding that of the approved budget (**$107 million for direct costs,** 155 million for all costs) with the goal of installing 300 make-ready chargers for 3000 MDHD vehicles. From the most recent PAC update, we read that SDG&E is working on 25 charging sites which will support 592 MDHD vehicles, and that $2.5 million total has been spent to date. Is this correct?
   1. How much has been spent to date?

B37. How was the incentive and rebate structure for SDG&E Power Your Drive for Fleets determined?

B38. What are the challenges and barriers you hope to overcome?

B39. We understand that the main goal of the program is to help fleet owners and operators transition seamlessly to electric vehicles. Are there any other goals the program hopes to achieve?

B40. Another stated goal is to target DACs with charging infrastructure**, and that 32% of the sites are currently in DACs.** What other aspects of the program were crafted specifically for, or to benefit, DACs, if any?
   1. How were the goals decided for the SDG&E Power Your Drive for Fleets?

B41. Are there any other benefits you expect to realize other than those stated in the goals?

Now I want to ask you a few questions about early insight on costs.

B42. Though the evaluation team will be looking at the detailed costs on a quantitative level, we wanted to get your current perspective on the project costs. **We know that many kinds of costs can accumulate for these projects. In addition to the cost of the equipment, there are permit, construction, installation, and maintenance costs.** What are the **most prominent** costs of the program to **SDG&E**?

1. What are the **most prominent** costs of the program for **site hosts?**
2. We understand it's still early in the program, but do you have ideas on what might drive the differences in these costs?

B43. What strategies have led to successful site selection and deployment?

B44. Are there any recruitment strategies leading to an excess of applications, or poor matches? (PROBE: Has anyone overpromised on what can be offered?)

B45. We understand that the main goal of this program is to increase charging infrastructure for MDHD vehicles. Are there any other goals the program hopes to achieve?

[SKIP TO SECTION C, SDG&E Power Your Drive for Fleets]

C. Program Implementation Questions

PG&E EV Fleet Program

C1. What is the status of the program projects? **[REQUEST A SUMMARY OF ALL PROGRAM PROJECTS IF POSSIBLE AND NOT ALREADY RECEVIED BY CADMUS]**
Please share a brief overview of each of the four key implementation steps:
- Applications:
- Contracted Sites:
- Final Design:
- Constructed:
- Activated:

C2. What about the process has gone well so far?

C3. What about the process has been more challenging so far?

C4. What steps are being taken to overcome these challenges?

C5. What, if any, customer feedback have you received about the program to date?

C6. **Aside from targeting counties with high populations of DACs,** what steps are being taken to make sure DACs will be/were successfully targeted and included in the execution of the program?

C7. What, if anything, can be done to increase the speed of implementation? [PROBE for ways to speed up recruitment, ongoing design, construction]

C8. What are the immediate next steps for the program? **[PROBE for timing of these steps]**

[SKIP TO SECTION D]

Liberty EV Bus Program

Now, let's talk about implementing the **Liberty EV Bus Program**.

C9. What is the status of the project? [REQUEST A SUMMARY OF ALL PROGRAM PROJECTS IF POSSIBLE AND NOT ALREADY RECEVIED BY CADMUS]
Please share a brief overview of each of the four key implementation steps:
- Applications:
- Contracted Sites:
- Final Design:
- Constructed:
- Activated:

C10. What about the process went well?

C11. What about the process has been more challenging so far?

C12. What steps are being taken to overcome these challenges?

C13. What, if any, customer feedback have you received about the program to date? **[REQUEST IF FEEDBACK IS DOCUMENTED]**

C14. What, if anything, could have been done to increase the speed of implementation? **[PROBE FOR WAYS TO SPEED UP RECRUITMENT, ONGOING DESIGN, CONSTRUCTION]**

C15. What are the immediate next steps for the program? **[PROBE FOR TIMING OF THESE STEPS]**

C16. Are there any goals or co-benefits that seem as though they may not be realized at the expected or target level based on progress to date?

[SKIP TO SECTION D]

SCE Charge Ready Transport

Now, let's talk about implementing the **Charge Ready Transport.**

C17. What is the status of the program projects? **[REQUEST A SUMMARY OF ALL PROGRAM PROJECTS IF POSSIBLE AND NOT ALREADY RECEVIED BY CADMUS]**

C18. What steps have been taken while implementing the program thus far?
Please share a brief overview of each of the four key implementation steps:
- Applications:
- Contracted Sites:
- Final Design:
- Constructed:
- Activated:

C19. What about the process has gone well so far?

C20. What about the process has been more challenging so far?

C21. What steps are being taken to overcome these challenges?

C22. What, if any, customer feedback have you received about the program to date? **[REQUEST IF FEEDBACK IS DOCUMENTED]**

C23. Are there any goals or co-benefits that seem as though they may not be realized at the expected or target level based on progress to date?

C24. What steps are being taken to make sure DACs will be/were successfully targeted and included in the execution of the program?

C25. What, if anything, can be done to increase the speed of implementation? **[PROBE FOR WAYS TO SPEED UP RECRUITMENT, ONGOING DESIGN, CONSTRUCTION]**

C26. What are the immediate next steps for the program? **[PROBE FOR TIMING OF THESE STEPS]**

[SKIP TO SECTION D]

SDG&E Power Your Drive for Fleets

Now, let's talk about implementing the **Power Your Drive for Fleets Program.**

C27. What is the status of program projects? **[REQUEST A SUMMARY OF ALL PROGRAM PROJECTS IF POSSIBLE AND NOT ALREADY RECEVIED BY CADMUS]**

C28. What steps have been taken while implementing the program thus far?
Please share a brief overview of each of the four key implementation steps:
- Applications:
- Contracted Sites:
- Final Design:
- Constructed:
- Activated:

C29. What about the process has gone well so far?

C30. What about the process has been more challenging so far? **[PROBE FOR CHALLENGES OF INTEREST, SUCH AS: WITH LONG WAIT TIMES TO USE CHARGING STATIONS]**

C31. What steps are being taken to overcome these challenges?

C32. What, if any, customer feedback have you received about the program to date? **[REQUEST IF FEEDBACK IS DOCUMENTED]**

C33. Are there any goals or co-benefits that seem as though they may not be realized at the expected or target level based on progress to date?

C34. What steps are being taken to make sure DACs will be/were successfully targeted and included in the execution of the program?

C35. What, if anything, can be done to increase the speed of implementation? **[PROBE FOR WAYS TO SPEED UP RECRUITMENT, ONGOING DESIGN, CONSTRUCTION]**

C36. What are the immediate next steps for the program? **[PROBE FOR TIMING OF THESE STEPS]**

[SKIP TO SECTION D]

D. Lessons Learned So Far

Now, let's talk about lessons learned so far from the **[Liberty EV Bus Program/PG&E EV Fleets Program/SCE CRT Program/SDG&E Power Your Drive for Fleets Program].**

Remind interviewers to first review the SB 350 report Lessons Learned section.

D1. We understand that it's still very early in the program, but can you think of any implementation efficiencies that could lead to lower costs for the same impact?

D2. Are there tools or strategies you think could make the program more efficient or easier to implement?

D3. Are there tools or strategies you think could make the program better or easier for participants?

D4. Have there been any steps taken to implement these tools or strategies?

D5. Has the level of interest from **fleet managers** given you any reason to think it is warranted to increase the magnitude of program activity?

D6. [IF YES] In what ways? **[PROBE FOR OPPORTUNITIES FOR CHANGES IN DESIGN, SUCH AS: DIFFERENT LEVELS OF INCENTIVE, REBATE, OR PARTICIPATION PAYMENTS]**

D7. [IF NO] What do you think could improve partner/participant interest? **[PROBE FOR OPPORTUNITIES FOR CHANGES IN DESIGN, SUCH AS: DIFFERENT LEVELS OF INCENTIVE/REBATE]**

D8. For the active projects, has the level of interest from **the drivers of the MDHD EVs** given you any reason to think it is warranted to increase the magnitude of program activity?

D9. **[IF YES]** In what ways? **[PROBE FOR OPPORTUNITIES FOR CHANGES IN DESIGN, SUCH AS: DIFFERENT LEVELS OF INCENTIVE, REBATE, OR PARTICIPATION PAYMENTS]**

D10. **[IF NO]** What do you think could improve customer interest? **[PROBE FOR OPPORTUNITIES FOR CHANGES IN DESIGN, SUCH AS: DIFFERENT LEVELS OF INCENTIVE, REBATE, OR PARTICIPATION PAYMENTS]**

D11. Knowing we are still in the early days of the program, do you think the program should be scaled up or down, if at all, over time?

D12. What would you say are the most important lessons learned from designing and implementing the program so far?

E. Closing

E1. What are you hoping to get out of the evaluation of these programs over the next few years?

E2. Is there anything else you'd like to mention that we haven't already covered?

Those are all our questions for today. Thank you so much again for your time, we really appreciate it. Have a great rest of your day!

SRP Evaluation: MDHD Fleet Manager Survey

Survey Purpose: This survey is designed to engage MDHD fleet managers whose fleets participated in one of the SRP-based utility-funded transportation electrification programs. The survey will assess their experience in the program, factors that led to successful electrification, the benefits and costs of electrification, and their view on broader market trends. The survey will be conducted via Qualtrics and implemented on a regular basis as more sites are completed.

After the first fielding period (Q1 2022), the evaluation team may consider splitting the survey into two components – one asking about program experience and attribution and the other focusing on experience with EVs and benefits/costs. The evaluation team may recommend this change since not all fleets will have had enough experience with using their EVs to accurately respond to questions about usage and benefits/costs. Depending on survey participation rates and count of completed sites, the evaluation team may also consider fielding the next survey as a phone survey instead of an online survey.

Research Objectives	Corresponding Question Numbers
1. Identify the factors that facilitate successful fleet electrification and lessons learned	
What innovations are developed by fleet partners to enable them to transition to EVs?	C1
What strategies lead to viable sites and successful deployments?	C2
What would fleet partners or managers have done differently if anything?	C9
2. Explore the benefits of TE for fleets and for fleet drivers	
Have fleet partners/managers heard from drivers in terms of their experience? Are there benefits associated with air quality, health, stress, and noise?	C4-C6, D1
How did TCO change after the fleet was electrified, if at all? What were the ongoing costs of fueling and maintenance before/after participating in the program?	E1-E2
3. Asses the experience of fleet partners and managers with the program and infrastructure	
How reliable and user-friendly is the electric vehicle charging equipment?	C3, C5
Have fleets experienced any operational tradeoffs or loss of flexibility, and if so, how severe are these impacts?	C3-C6, C9
How satisfied are fleet managers with the program overall? How does overall satisfaction vary by market segment?	B1-B4
4. Gauge market impacts, trends, and identify market barriers	
Which vehicle and market segments are seeing the most uptake? To what degree can we expect that to change as other incentives are scaled up or scaled back, and as technology and costs improve?	F1, F2, F7
What are the barriers to fleet electrification and how do these differ by vehicle or market segment?	F3, F4
How did the program change electrification within fleets, and do the fleets plan to accelerate TE-related procurement because of the experience?	0, F6, F8
5. Assess program attribution	
What type of transportation electrification project would participants have procured in absence of the utility program?	Not included this year

Target Audience: Fleet Managers

Desired number of completions: Census of all completed sites (construction complete, rebate paid) per utility. These are cumulative completion totals across the entire program cycle. We will determine completion targets during each fielding wave.

- Liberty: 1
- PG&E: 700
- SCE: 870
- SDG&E: 300

Estimated timeline for fielding: First wave of Fleet Manager survey anticipated in Q1 2022 for PG&E and SCE, and in Q4 2022 for SDG&E, with fielding to occur bi-annually after that (note the Liberty/TTD Fleet Manager will be surveyed only twice, in Q2 2022 and Q1 2023).

Variables to be Pulled into Survey:

- **Email**
- **FirstName**
- **LastName**
- **UTILITY (**Liberty/PG&E/SCE/SDGE&E; read-in)
- **PROGRAM_NAME (read-in; do not include "program")**
- **Organization**
- **Site_Type (transit, airport, school bus, port, forklift, etc.)**

Sample Collection Email

To: [EMAIL – Site Host]
From: [Cadmus]
CC: [Liberty/PG&E/SCE/SDG&E MDHD PM and Customer Account Manager]
Subject: Survey with fleet managers for the [UTILITY] fleet electrification program

Dear [FIRSTNAME AND LASTNAME],

Thank you for working with [UTILITY] to expand transportation electrification. As part of our evaluation for this program, we are surveying fleet managers from each completed project about their experience during installation, their fleet operations, and the benefits/costs of transportation electrification. Could you please provide the contact information (name, title, email, phone) for the most appropriate person within your organization so we may reach out to them and invite them to complete the 20-minute online survey? We are offering respondents a $50 gift card upon survey completion.

Survey results are anonymized and the utility will not be able to see respondents' individual responses.

Thank you,

CADMUS PERSON'S FIRST AND LAST NAME
THEIR TITLE
CADMUS GROUP

CLIENT CONTACT PERSON'S FIRST AND LAST NAME
THEIR TITLE
COMPANY NAME

Email Invitation

To: [EMAIL]
From: [Cadmus]
CC: [Liberty/PG&E/SCE/SDG&E MDHD PM and Customer Account Manager]
Subject: Your experience with the [Liberty/PG&E/SCE/SDGE&E] fleet electrification program

Dear [FIRSTNAME AND LASTNAME],

As part of [Liberty/PG&E/SCE/SDG&E]'s fleet electrification program evaluation, we invite you to share your opinion about your experience electrifying your fleet. Your experience can provide valuable feedback about how to improve the program experience for other fleets. Your input is very important to us and will be anonymized and only used for research purposes – utilities will not be able to see individual responses. **The survey will take about 20 minutes to complete**. For your completion of this survey, you are eligible to receive a $50 gift card (or request that we make a donation).

Click the link below to take the survey (or copy and paste into your browser):

[auto-generated link]

If you feel that someone else would be better positioned to answer this survey, could you please forward the email to that person and copy the people on this email?

If you have any questions about this research, or any difficulties taking the survey, please contact [Cadmus contact]at The Cadmus Group, the national research firm conducting this survey for the utilities. You can reach [Cadmus contact] at [Cadmus contact phone number]or [Cadmus contact email].

Thank you in advance for sharing your experiences and your time.

CADMUS PERSON'S FIRST AND LAST NAME
THEIR TITLE
CADMUS GROUP

CLIENT CONTACT PERSON'S FIRST AND LAST NAME
THEIR TITLE
COMPANY NAME

Reminder Invitation

To: [EMAIL]
From: [Liberty/PG&E/SCE/SDG&E] Feedback
Subject: Will still want to hear about your experience with the Liberty/PG&E/SCE/SDG&E] transportation electrification program!

Dear [FIRSTNAME AND LASTNAME],

We recently invited you to tell us about your experience with the [Liberty/PG&E/SCE/SDG&E] fleet electrification program. Your experience can provide us with valuable feedback that can help improve program experience for participating fleets. Your input is very important to us, will be kept confidential, and only used to improve our programs for customers like you. **Please take 20 minutes today to complete the survey**. For your participation in this survey, you are eligible to receive a $50 gift card (or request that we make a donation). Survey results are anonymized and the utility will not be able to see respondents' individual responses.

Click the link below to take the survey (or copy and paste into your browser):

[auto-generated link]

If you feel that someone else would be better positioned to answer this survey, could you please forward the email to that person and copy the people on this email?

If you have any questions about this research, or any difficulties taking the survey, please contact [Cadmus contact]at The Cadmus Group, the national research firm conducting this survey on our behalf. You can reach [Cadmus contact] at [Cadmus contact phone number] or [Cadmus contact email].

Thank you in advance for sharing your experiences and your time.

CADMUS PERSON'S FIRST AND LAST NAME
THEIR TITLE
CADMUS GROUP

CLIENT CONTACT PERSON'S FIRST AND LAST NAME
THEIR TITLE
COMPANY NAME

Survey Introduction and Screener

[RECOMMENDED: CLIENT-APPROVED LOGO TO APPEAR ON START SCREEN]

Welcome! Thank you for sharing your experience with the [PROGRAM NAME] program, offered by [Liberty/PG&E/SCE/SDG&E]. This survey will take about 20 minutes to complete and will ask questions about fleet electrification and the benefits of transportation electrification. Your responses will remain confidential.

[SCREEN OUT TERMINATION MESSAGE:] Those are all the questions we have. Thank you.

A. Overview and Background Information

To begin, we'd like to ask you some general background questions.

A1. What types of vehicles/equipment do you have in your fleet? **[SELECT ALL THAT APPLY]**

1. School bus
2. Transit bus
3. Medium-duty vehicles
4. Heavy-duty vehicles
5. Port cargo trucks
6. Airport ground support equipment
7. Forklifts
8. Truck refrigeration unit
9. Truck stop electrification technology
10. Other (#1) **[PLEASE SPECIFY]**
11. Other (#2) **[PLEASE SPECIFY]**
12. Other (#3) **[PLEASE SPECIFY]**

A2. Please specify the number of internal combustion engine and electric vehicles **currently in your fleet**:

	(1) Number of internal combustion engine vehicles	**(2) Number of electric vehicles currently in your fleet**
[VEHICLE SELECTED IN A1]		
[VEHICLE SELECTED IN A1]		
[VEHICLE SELECTED IN A1]		
[VEHICLE SELECTED IN A1]		
Other vehicle type; please specify: **[OPEN END]**		
Other vehicle type; please specify: **[OPEN END]**		
Total Vehicles	**[AUTOSUM]**	**[AUTOSUM]**

A3. Please specify the number of electric vehicles that you plan to acquire in the next 5 years and in the next 10 years

	(3) Number of electric vehicles you plan to acquire in the next 5 years	**(4) Number of electric vehicles you plan to acquire in the next 10 years**
[VEHICLE SELECTED IN A1]		
[VEHICLE SELECTED IN A1]		
[VEHICLE SELECTED IN A1]		
[VEHICLE SELECTED IN A1]		
Other vehicle type; please specify: **[OPEN END]**		
Other vehicle type; please specify: **[OPEN END]**		
Total Vehicles	**[AUTOSUM]**	**[AUTOSUM]**

A4. Are there any other types of vehicles/equipment you plan to electrify in the next 10 years? If so, please state the vehicle/equipment type, the number of vehicles, and the rough timeframe.

1. **[OPEN END]**

A5. Did your participation in the **[PROGRAM NAME]** program change the number of electric vehicles you acquired or planned to acquire?

1. Yes
2. No

A6. **[ASK IF A4=1]** How did your participation in the **[PROGRAM NAME]** program change the number of electric vehicles you acquired or planned to acquire? Please specify the vehicle type, the change in number of vehicles, and the timeframe.

1. **[OPEN END]**

A7. Since site completion, approximately how many medium- and heavy-duty internal combustion vehicles have been retired?

A8. Roughly what percent of your fleet's routes are within disadvantaged communities? If you are unsure about which communities are designated as disadvantaged, please reference this map from the CA State government and try to give your best guess.

1. **[DROPDOWN WITH PERCENTAGE RANGES OF 10% INCREMENTS]**

B. Program Experience

Now, we'd like to ask you a few questions about your experience in **[UTILITY] [PROGRAM NAME]** program.

B1. Thinking about your experience with the **[PROGRAM NAME]** program, how satisfied are you with the following? **[SELECT ONE PER ROW]**

	Very satisfied	Somewhat satisfied	Not too satisfied	Not at all satisfied
[SKIP FOR LIBERTY] Application process				
Application timeline				
Installation timeline				
[SKIP FOR LIBERTY] Amount of the rebate you received or expect to receive from [UTILITY] for the purchase of EV charging equipment				
Level of program services you received (i.e., provision of to-the-meter infrastructure by [UTILITY])				
[SKIP FOR LIBERTY] Timeline for receiving rebate(s) from [UTILITY]				
Experience working with [UTILITY] staff				
[PROGRAM NAME] program overall				

B2. Are there any other aspects of the **[PROGRAM NAME]** program that you were particularly **satisfied** with?
  1. **[OPEN ENDED]**

B3. Are there any other aspects of the **[PROGRAM NAME]** program that you were particularly **dissatisfied** with?
  1. **[OPEN ENDED]**

B4. On a scale from 0 to 10, with '10' being the most likely, how likely would you be to recommend this program to another company?
  1. **[RECORD 0-10 RATING; IF STATING "ALREADY DID RECOMMEND", CODE AS 10]**

C. Factors Leading to Successful Fleet Electrification and Lessons Learned

Now, we'd like to talk to you about the fleet electrification process.

C1. Why did your fleet decide to transition to EVs? Select all that apply. **[MULTIPLE RESPONSE] [RANDOMIZE 1-10]**
  1. Regulatory requirement
  2. Corporate/organizational sustainability goals or initiatives
  3. Expected fuel cost savings
  4. Expected maintenance cost savings
  5. Better technology
  6. Driver comfort/ preference
  7. Environmental benefits
  8. Rebates/incentives for EVs
  9. Rebates/incentives for EV charging infrastructure
  10. Operational benefits
  11. Other, please specify: **[OPEN ENDED]**

C2. How did you first learn about the **[PROGRAM NAME]** program? If there were multiple sources, please select the primary source.
  1. From **[UTILITY]**
  2. From an EV/ EVSE manufacturer
  3. From a contractor/engineer
  4. From another fleet
  5. Another source, please specify: **[OPEN ENDED]**

C3. How would you rate the reliability of the electric vehicles that are part of your fleet?
  1. Very reliable
  2. Somewhat reliable
  3. Not too reliable
  4. Not at all reliable

C4. How would you rate the ease with which your drivers operate the electric vehicles?

1. Very easy to use
2. Somewhat easy to use
3. Not too easy to use
4. Not at all easy to use

C5. How would you rate the reliability of the electric vehicle charging equipment?

1. Very reliable
2. Somewhat reliable
3. Not too reliable
4. Not at all reliable

C6. **[IF C5=3 OR 4]** What challenges have you had with the reliability of the electric vehicle charging equipment?

1. **[OPEN ENDED]**

C7. How would you rate the ease of using the electric vehicle charging equipment?

1. Very easy to use
2. Somewhat easy to use
3. Not too easy to use
4. Not at all easy to use

C8. Prior to joining the program, did you know that you needed upgrades to the electrical infrastructure from the utility grid to your meter to charge electric vehicles at your site?

1. Yes
2. No

C9. What entity owns the electric vehicle charging infrastructure at your site?

1. **My company/organization** owns the electric vehicle charging infrastructure
2. **The utility ([UTILITY])** owns the electric vehicle charging infrastructure

C10. Thinking about the complete process of electrifying your fleet, what would you have done differently if you were to go through it again, if anything?

1. **[OPEN ENDED]**

D. Additional Benefits of Transportation Electrification

Next, we would like to ask you questions about the benefits of transportation electrification and fleet drivers' experience.

D1. What ancillary benefits do you think will be realized for your community/fleet as a result of electrifying? These could be benefits to any party, such as your company, your drivers, or your community, among others. **[SELECT ONE PER ROW]**

	I think there will be significant benefits	**I think there will be some benefits**	**I think there will be no benefits**	**Not sure**
Improved air quality/health (i.e., breathing in less pollution)				
Improved driver comfort/convenience (i.e., easier to drive, smoother to ride in)				
Reduction in noise pollution (i.e., quieter when driving, accelerating)				

D2. What other benefits, if any, do you think will be realized for your community/fleet as a result of electrifying? These could be benefits to any party, such as your company, your drivers, or your community, among others.

1. **[OPEN END]**

E. Cost of Transportation Electrification

Next, we will ask about the operational and ownership costs of fleet electrification.

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.

Compared to before transitioning to EVs…

	Costs are now **lower**	Costs are **relatively equal**	Costs are now **higher**	Don't know
Vehicle maintenance costs (i.e., purchasing replacement parts, labor to complete repairs, and regular maintenance)				
Vehicle fueling costs (i.e., the cost of fuel)				
Vehicle fueling infrastructure costs (i.e., the costs of the equipment needed to fuel your fleet)				
Training – drivers				
Training – maintenance staff				

E2. Have these operational and maintenance costs been what you expected?

	Yes	No, lower than expected	No, higher than expected	Don't know
Vehicle maintenance costs (i.e., purchasing replacement parts, labor to complete repairs, and regular maintenance)				
Vehicle fueling costs (i.e., the cost of fuel)				
Vehicle fueling infrastructure costs (i.e., the costs of the equipment needed to fuel your fleet)				
Training - drivers				
Training – maintenance staff				

E3. Have there been any other impacts/costs you've incurred as a result of electrifying? This could include costs for items such as employee labor, equipment purchases, or space utilization, among others.

1. **[OPEN END]**

F. Market Impacts, Trends, and Market Barriers

Finally, we'd like to ask you about the broader market and what may be preventing further electrification.

F1. How well positioned do you think your industry/sector is for electrification?

1. Extremely well-positioned
2. Somewhat well-positioned
3. Neutral
4. Not too well-positioned
5. Not at all well-positioned

F2. Why did you give this rating?

1. **[OPEN ENDED]**

F3. Which of the following barriers to electrification did your fleet face before participating in the **[PROGRAM NAME]** program? **[MULTIPLE RESPONSE; RANDOMIZE 1 - 6]**

1. The cost of the EVs was prohibitive
2. The cost of installing EV charging infrastructure was prohibitive
3. It was challenging to find the right types of EVs for our needs
4. Our routes were too long for the EVs available
5. There was insufficient charging equipment on/near our routes
6. Finding qualified drivers or maintenance technicians for EVs
7. Other, please specify: **[OPEN ENDED]**
8. None of the above **[EXCLUSIVE]**

F4. You mentioned that the following were barriers to electrification before participating in the **[PROGRAM NAME]** program. Do any of these barriers **still exist after you participated in the program**? **[INSERT OPTIONS SELECTED IN F2; MULTIPLE RESPONSE; RANDOMIZE 1 - 6]**

1. The cost of the EVs is prohibitive
2. The EV charging infrastructure that was installed was insufficient
3. It is challenging to find the right types of EVs for our needs
4. Our routes are too long
5. There is insufficient charging equipment on/near our routes
6. Finding qualified drivers or maintenance technicians for EVs
7. Other, please specify: **[OPEN ENDED]**
8. None of the above

F5. Do you plan to accelerate procurement of EVs and related equipment because of your experience with the program?

1. Yes
2. No change
3. No, we plan to slow procurement

F6. **[IF 0= 1]** What aspect(s) of the program have impacted your decision to accelerate your procurement of EVs?

1. **[OPEN ENDED]**

F7. Are you satisfied with current EV options on the market for your sector?

1. Yes
2. No

F8. What are the limitations of current EV options for your sector?

1. **[OPEN ENDED RESPONSE]**

F9. The purchase price and operating costs (fuel and maintenance) of electric trucks may differ from those of diesel trucks. Given what you know or believe about requirements for fleets to purchase zero-emission medium- and heavy-duty trucks, do electric or diesel trucks seem like a riskier purchase in the **next 3 years**? **[RANDOMIZE ORDER]**

In the next **3 years**…

1. **Electric trucks** seem like a riskier purchase
2. **Diesel trucks** seem like a riskier purchase

F10. Given what you know or believe about requirements for fleets to purchase zero-emission medium- and heavy-duty trucks, do electric or diesel trucks seem like a riskier purchase in the **next 10 years**? **[RANDOMIZE ORDER]**

In the next **10 years**…

1. **Electric trucks** seem like a riskier purchase
2. **Diesel trucks** seem like a riskier purchase

G. Closing

G1. Those are all the questions we have. Thank you for your responses. To receive a $50 gift card for your participation, please enter your email address below. Alternatively, please check the "donation" option to have the $50 donated to the American Red Cross.

1. **Email address: [OPEN ENDED]**
2. **Please donate the $50 gift card**

End of Survey Message

In addition to this survey, we are also conducting interviews with a select number of fleet managers to dive deeper on some of these topics. We may reach out to you in the future about an interview.

Please click the next button to record your responses.

SRP Evaluation: MDHD Fleet Dropout Online Survey

This survey seeks to learn more from program applicants (site hosts, fleet managers, or other relevant staff) who ended or indefinitely paused their participation in the California Standard Review Projects to electrify Medium-Duty and/or Heavy-Duty (MDHD) fleet vehicles. Questions in this survey seek to understand applicants' experience with the program, including their initial interest as well as factors that contributed to ending or pausing participation. Additionally, this survey will seek to understand the applicants' perspective on the EV market overall and their fleet readiness for electrification. This survey is designed to take 15 minutes to administer through an online platform.

Research Objectives	Corresponding Question Numbers
1. Identify the factors that facilitate successful fleet electrification and lessons learned	
Why did the applicant decide to transition to EVs initially?	C1
How satisfied were applicants with the program overall? How does overall satisfaction vary by market segment?	B2-B5, B10-B11
Would applicants who dropped out of the program say that the utility EVSE rebate is set at an appropriate level/incenting the proper costs?	B6-B9
Why did applicants decide to drop out of the program?	B11-B14, C1
What factors would have facilitated applicant participation in the program, if any?	C2
What would applicants have done differently, if anything?	C3
2. Explore the benefits of TE for fleets	
To what extent do applicants view transportation electrification as being beneficial in regard to air quality, noise pollution, and comfort and convenience	C1
Did applicants who dropped out receive estimates as to how fleet electrification would impact TCO?	D1-D3
3. Gauge market impacts, trends, and identify market barriers	
What are the barriers to fleet electrification and how do these differ by vehicle or market segment?	E1

Target Audience: Utility customers who submitted an application and subsequently dropped out of the program.

Desired number of completions: Census of all sites that dropped out of the program (specific numbers TBD based on program data)

Estimated timeline for fielding: First wave of Fleet Dropout survey anticipated in Q1 2022 for PG&E and SCE, and in Q4 2022 for SDG&E, with fielding to occur bi-annually after that.

Variables to be Pulled into Survey

- **Email**
- **FirstName**
- **LastName**
- **UTILITY (PG&E, SCE, SDG&E; read-in)**
- **PROGRAM_NAME (read-in; does not include "program" i.e., "EV Fleet" for PG&E)**
- **Organization**

Email Invitation

To: [EMAIL]
From: [Cadmus]
CC: [PG&E/SCE/SDG&E MDHD PM and Customer Account Manager]
Subject: Survey regarding your experience with the [PG&E/SCE/SDGE&E] [PROGRAM NAME] program

Dear [FIRSTNAME AND LASTNAME],

Thank you for applying for the [PG&E/SCE/SDG&E] [PROGRAM NAME] program. Our records indicate you did not complete an EV charging project. Through the following survey, you can provide valuable feedback about how to improve the program experience for fleets in the future. Your input is very important to us and will be kept confidential and only used for research purposes. **The survey will take no more than 15 minutes to complete**. For your participation in this survey, you are eligible to receive a $50 gift card.

Click the link below to take the survey:

[auto-generated link]

Or you may copy and paste the URL below into your internet browser: [auto-generated URL]

If you have any questions about this research, or any difficulties taking the survey, please contact [Cadmus contact] at The Cadmus Group, the national research firm conducting this survey on the utility's behalf. You can reach [Cadmus contact] at [Cadmus contact phone number] or [Cadmus contact email].

Thank you in advance for sharing your experiences and your time.

CADMUS PERSON'S FIRST AND LAST NAME
THEIR TITLE
CADMUS GROUP https://www.youtube.com/watch?v=kxgj5af8zg4

CLIENT CONTACT PERSON'S FIRST AND LAST NAME
THEIR TITLE
COMPANY NAME

Reminder Invitation

To: [EMAIL]
From: [Cadmus]
CC: [PG&E/SCE/SDG&E MDHD PM and Customer Account Manager]
Subject: Still interested in your experience with the [PG&E/SCE/SDG&E] [PROGRAM NAME] program!

Dear [FIRSTNAME AND LASTNAME],

We recently invited you to tell us about your experience with the [Utility] [PROGRAM NAME] program. Your experience can provide us with valuable feedback that can help improve program experience for participating fleets. Your input is very important to us, will be kept confidential, and only used to improve our programs for customers like you. **Please take 15 minutes today to complete the survey**. For your participation in this survey, you will receive a $50 gift card.

Click the link below to take the survey:

[auto-generated link]

Or you may copy and paste the URL below into your internet browser: [auto-generated URL]

If you have any questions about this research, or any difficulties taking the survey, please contact Athena Dodd at The Cadmus Group, the national research firm conducting this survey on the utility's behalf. You can reach Athena at (303) 389- 2539 or athena.dodd@cadmusgroup.com.

Thank you in advance for sharing your experiences and your time.

CADMUS PERSON'S FIRST AND LAST NAME
THEIR TITLE
CADMUS GROUP

CLIENT CONTACT PERSON'S FIRST AND LAST NAME
THEIR TITLE
COMPANY NAME

Survey Introduction and Screener

[RECOMMENDED: CLIENT-APPROVED LOGO TO APPEAR ON START SCREEN]

Welcome! Thank you for sharing your experience with the [PROGRAM NAME] program, offered by [UTILITY]. This survey will take 15 minutes to complete and will ask questions about factors that facilitate fleet electrification, barriers for fleet electrification, program experience, benefits of transportation electrification, and market impacts. To thank you for your participation, you are eligible to receive a $50 gift card upon completion of the survey.

Your responses will remain confidential.

[SCREEN OUT TERMINATION MESSAGE:] Those are all the questions we have. Thank you for taking the time to complete this survey.

A. Overview and Background Information

To begin, we'd like to ask you some general background questions on your fleet.

A1. What types of vehicles/equipment do you have in your fleet? **[SELECT ALL THAT APPLY]**

1. School bus
2. Transit bus
3. Medium-duty vehicles
4. Heavy-duty vehicles
5. Port cargo trucks
6. Airport ground support equipment
7. Forklifts
8. Truck refrigeration unit
9. Truck stop electrification technology
10. Other (#1) **[PLEASE SPECIFY]**
11. Other (#2) **[PLEASE SPECIFY]**
12. Other (#3) **[PLEASE SPECIFY]**

A2. For each type of vehicle/equipment in your fleet, please specify the number of internal combustion engine vehicles in your fleet, and the number of electric vehicles in your fleet.

	(1) Number of internal combustion engine vehicles	**(2) Number of electric vehicles already in your fleet**
[VEHICLE SELECTED IN A1]		
[VEHICLE SELECTED IN A1]		
[VEHICLE SELECTED IN A1]		
[VEHICLE SELECTED IN A1]		
Other vehicle/equipment type; please specify: **[OPEN END]**		
Other vehicle/equipment type; please specify: **[OPEN END]**		
Total Vehicles	**[AUTOSUM]**	**[AUTOSUM]**

A3. Of the internal combustion engine vehicles in your fleet, please specify the number of vehicles you **considered electrifying through the [PROGRAM NAME] program**, and the number you **considered electrifying outside of the [PROGRAM NAME] program**.

	(3) Vehicles/equipment you originally planned to electrify through the program	**(4) Vehicles/equipment you originally planned to electrify outside of the program**
[VEHICLE SELECTED IN A1]		
[VEHICLE SELECTED IN A1]		
[VEHICLE SELECTED IN A1]		
[VEHICLE SELECTED IN A1]		
Other vehicle/equipment type; please specify: **[OPEN END]**		
Other vehicle/equipment type; please specify: **[OPEN END]**		
Total Vehicles	**[AUTOSUM]**	**[AUTOSUM]**

A4. Of all the vehicles in your fleet that you originally planned to electrify when you applied to the **[PROGRAM NAME]** program, how many have you electrified? Please specify the number of each type of vehicle.

[VEHICLE TYPE DROPDOWN CHOICES: School bus, Transit bus, Medium-duty vehicles, Heavy-duty vehicles, Port cargo trucks, Airport ground support equipment, Forklifts, Truck refrigeration unit, Truck stop electrification technology**]**

	(1) Number you said you planned to electrify in the prior question	**(2) Number of vehicles/equipment actually electrified**
[INSERT VEHICLE TYPES LISTED IN A1]	**[INSERT SUM OF COLUMNS 3 AND 4 FROM A1]**	
[INSERT VEHICLE TYPES LISTED IN A1]	**[INSERT SUM OF COLUMNS 3 AND 4 FROM A1]**	
…		

A5. **[ASK FOR ANY OPTION IN 0 COLUMN 2>0]** How important was your experience with the **[PROGRAM NAME]** program on your decision to electrify vehicles outside of the **[PROGRAM NAME]** program?

	[DROP DOWN LISTS OR RADIO BUTTONS] **1. Very important** **2. Somewhat important** **3. Not too important** **4. Not important at all**
[VEHICLE SELECTED IN A1]	
[VEHICLE SELECTED IN A1]	
[VEHICLE SELECTED IN A1]	
[VEHICLE SELECTED IN A1]	
Other vehicle/equipment type; please specify: **[OPEN END]**	
Other vehicle/equipment type; please specify: **[OPEN END]**	

A6. Are there any other vehicles not listed in the prior questions that you planned to electrify? If so, please state the vehicle/equipment type, the number of vehicles, and the rough timeframe.

1. **[OPEN END]**

B. Program Experience

The following questions seek to understand your interest and experience in the **[PROGRAM NAME]** program.

B1. Why did your fleet initially intend to transition to EVs? Select all that apply. **[RANDOMIZE 1-9; MULTIPLE RESPONSE]**

1. Regulatory requirement
2. Corporate/organizational sustainability goals or initiatives
3. Expected fuel cost savings
4. Expected maintenance cost savings
5. Better technology
6. Driver comfort/ preference
7. Environmental benefits
8. Rebates/incentives for EVs
9. Rebates/Incentives for EV charging Infrastructure
10. Other, please specify: **[WITH WRITE IN OPTION]**

B2. How satisfied were you with the application timeline for the **[PROGRAM NAME]** program?

1. Very satisfied
2. Somewhat satisfied
3. Not too satisfied
4. Not at all satisfied

B3. How satisfied were you with the application process for the **[PROGRAM NAME]** program?
1. Very satisfied
2. Somewhat satisfied
3. Not too satisfied
4. Not at all satisfied

B4. How satisfied were you with the level of program services (i.e., provision of to-the-meter infrastructure) from **[UTILITY]** offered as a part of the **[PROGRAM NAME]** program?
1. Very satisfied
2. Somewhat satisfied
3. Not too satisfied
4. Not at all satisfied
5. I wasn't aware of the program services offered as part of the program

B5. How satisfied were you with the amount of the rebates offered from **[UTILITY]** as a part of the **[PROGRAM NAME]** program?
1. Very satisfied
2. Somewhat satisfied
3. Not too satisfied
4. Not at all satisfied
5. I wasn't aware of the amount of the rebates offered as part of the program

B6. Did you install any EV charging equipment without the rebates offered from **[UTILITY]** as a part of the **[PROGRAM NAME]** program?
1. Yes **[ASK B7]**
2. No

B7. **[ASK IF B6=1]** Did you receive any rebates or incentives to cover some of the cost of the EV charging equipment? If so, please specify where the rebates or incentives came from.
1. Yes, please specify: **[OPEN END]**
2. No

B8. In your opinion, what kinds or levels of services should the [**PROGRAM NAME]** program be offering? **[RANDOMIZE 1-4; MULTIPLE RESPONSE]**
1. Increased technical support on electric vehicles
2. Increased technical support on EV charging equipment
3. Increased utility-side make-ready infrastructure support
4. Increased customer-side make-ready infrastructure support
5. Other, please specify: **[OPEN ENDED]**

B9. In your opinion, what types of costs should the [**PROGRAM NAME]** program rebates apply to? **[RANDOMIZE 1-3; MULTIPLE RESPONSE]**

1. Construction costs
2. EVSE costs
3. Vehicle costs
4. Other, please specify: **[OPEN ENDED]**

B10. What aspect(s) of the **[PROGRAM NAME]** program, if any, were you particularly **satisfied** with? **[RANDOMIZE 1-6; MULTIPLE RESPONSE]**

1. Application process
2. Application timeline
3. Amount of rebate offered for purchase of EV charging equipment
4. Level of program services you received (i.e., provision of to-the-meter infrastructure)
5. Timeline for receiving rebates
6. Experience with working with **[UTILITY]** staff
7. Other, please specify: **[OPEN ENDED]**
8. None of the above

B11. Are there any aspects of the **[PROGRAM NAME]** program that you were particularly dissatisfied with? **[HIDE OPTIONS SELECTED IN B10; RANDOMIZE 1-6; MULTIPLE RESPONSE]**

1. Application process
2. Application timeline
3. Amount of rebate offered for purchase of EV charging equipment
4. Level of program services you received (i.e., provision of to-the-meter infrastructure)
5. Timeline for receiving rebates
6. Experience with working with **[UTILITY]** staff
7. Other, please specify: **[OPEN ENDED]**
8. None of the above

B12. Did your organization proceed with any of the intended EV charging outside of this program?

1. Built project as intended
2. Built project scaled down from intended plan:
   (a) What would have been different from the intended plan? **[OPEN ENDED]**
3. Decided not to incorporate EVs into the fleet
4. Put project on temporary hold **[ASK B14]**
5. Other, please specify: **[OPEN ENDED]**

B13. **[ASK IF B12=1, 2, 5]** How important was your experience with the **[PROGRAM NAME]** program on your decision to build EV charging infrastructure outside of the **[PROGRAM NAME]** program?

1. Very important
2. Somewhat important
3. Not too important
4. Not at all important

B14. **[ASK IF B12=4]** If project is on temporary hold, which of the following best represents its current status?
1. Pending funding from a specific source (or sources), please specify: **[OPEN ENDED]**
2. Pending further action from the utility, please specify: **[OPEN ENDED]**
3. Pending for some other reason, please specify: **[OPEN ENDED]**

C. Reasons for Dropping Out of the Program

Next, we would like to ask you questions about why you decided to end your participation in the program.

C1. What were the main reasons why your organization decided to stop participating in the program? Select all that apply. **[SELECT ALL THAT APPLY] [RANDOMIZE 1-13]**
1. Vehicle costs
2. Charging equipment costs
3. Behind-the-meter make-ready costs
4. To-the-meter make-ready costs
5. Inability to obtain easements
6. Lack of availability of electric vehicle models
7. Inadequate incentives
8. Lack of utility technical support for behind-the-meter make-ready process
9. Required too much time
10. Training requirements
11. Driver hesitancy
12. Return-on-investment was too long
13. Other organizational priorities for funds/other stakeholder input
14. Other, please specify: **[WITH WRITE IN OPTION]**

C2. What factors would have enabled your continued participation in the program, if any? Select all that apply. **[RANDOMIZE 1-5; SELECT ALL THAT APPLY]**
1. Higher rebates for charging infrastructure
2. More utility technical support for behind-the-meter make-ready process
3. More knowledge sharing with other fleet managers electrifying their fleets
4. Greater interest from drivers
5. Greater interest from other organizational stakeholders or decisionmakers
6. Other, please specify: **[WITH WRITE IN OPTION]**

C3. Based on your experience with fleet electrification so far, what would you recommend to other utility customers who may be going through this process or considering it?
1. **[OPEN ENDED]**

D. Costs of Transportation Electrification

The following questions seek to assess how, if at all, electrifying your fleet would have impacted your total cost of ownership.

D1. Did you estimate how electrifying your fleet as a part of the **[PROGRAM NAME]** program would impact the total cost of ownership compared to the current fleet design?

1. Yes **[ASK D2]**
2. No

D2. **[ASK IF D1=YES]** What was the estimated impact to total cost of ownership? Was it expected to:

1. Increase substantially **[ASK D3]**
2. Increase somewhat **[ASK D3]**
3. Remain relatively equal
4. Decrease somewhat **[ASK D3]**
5. Decrease substantially **[ASK D3]**

D3. **[ASK IF D2= 1 2, 4 OR 5]** For what reasons would the total cost of ownership have been different from what you expected as a result of electrifying your fleet through the **[PROGRAM NAME]** program?

1. **[OPEN ENDED RESPONSE]**

E. Market Impacts, Trends, and Market Barriers

E1. Which of the following market barriers to electrification did your fleet face? Select all that apply. **[MULTIPLE RESPONSE; RANDOMIZE 1-5]**

1. The cost is prohibitive
2. It is challenging to find the right types of EVs for our needs
3. Our routes are too long
4. There is insufficient charging equipment on/near our routes
5. Finding qualified drivers for EVs
6. Other, please specify: **[OPEN ENDED]**
7. We do not face any barriers to electrification

End of Survey Message

Those are all the questions we have. Thank you for your responses. To receive a $50 gift card for your participation, please enter your email address below. Alternatively, please check the “donation” option to have the $50 donated to the American Red Cross.

1. Email address: **[OPEN ENDED]**
2. **Please donate the $50 gift card**

Appendix B. Total Cost of Ownership Analysis

SCE CRT Program

Total Cost of Ownership Background

EVs cost significantly more to purchase than their ICE counterparts, especially for MDHD applications. Because of their expense, both taxes and insurance costs are also higher for EVs than for traditional fossil fuel–powered (counterfactual) vehicles. Building out the infrastructure to support the charging of these vehicles adds substantial expense to their upfront costs. However, operations and maintenance costs are predicted to be lower year over year. The Cadmus team examined the total cost of ownership (TCO) of three types of vehicle fleets representing three different market segments: school buses, transit buses, and Class 4 medium-duty package delivery trucks.

To evaluate the impact of CRT on the TCO of these representative fleets, the Cadmus team assessed their costs over a 10-year operating period as outlined in the Methodology section. For the majority of the analysis, we relied on assumptions and secondary data. We incorporated estimates of actual program data where possible given the limited number of completed projects and months of billing data available. In this analysis, we incorporated billing data to estimate electricity costs to fuel the vehicles and estimated project costs based on available data. Table B-1 shows the specific inputs used in the SCE CRT TCO analysis.

Table B-1. Data Inputs for SCE MDHD Fleet TCO

Data Inputs	School Bus	Transit Bus	Package Delivery Truck	Source
Number of Vehicles in Fleet	10	10	10	Average fleet size based on site visits
Life of Vehicle	20	20	20	CARB Advanced Clean Trucks Tool (total life of MDHD vehicle) [a]
New Vehicle Purchase Price	$400,000	$976,846	$190,000	School bus: assumption based on discussions with fleet managers during site visits and discussions with original equipment manufacturers (OEMs) Transit bus: APTA 2020 vehicle database average cost in California for 40-foot bus manufactured between 2019 and 2021 Medium-duty Class 4 package delivery: from OEMs
TCO Period	10 years	10 years	10 years	Assumption
Sales Tax	8.50%	0.00%	8.50%	California weighted average of 8.5% (excise tax only on Class 8 vehicles that are not publicly owned); no state sales tax on public transit buses until 2024 per AB 784
Vehicle Efficiency (kWh/mile)	1.0959	1.7730	1.0579	From counterfactual analysis (see the Methodology section)

Data Inputs	School Bus	Transit Bus	Package Delivery Truck	Source
Annual Vehicle Miles Traveled (per vehicle)	12,000	43,647	12,435	Secondary data from AFDC 2018 [b]
Fuel Costs (kWh)	$0.303	$0.232	$0.352	Primary data from fleet electricity usage divided by fleet electricity billing data (outliers removed from not-yet-activated or very-low-usage fleets)
Fuel Costs (counterfactual)	$3.67	$1.27	$3.67	School bus and delivery truck: based on EIA California 10-year average cost of diesel fuel Transit bus: based on EIA California 10-year average cost of CNG for commercial customers using the price per diesel gallon equivalent
Maintenance and Repair Cost Per Mile Estimate	$0.600	$0.195	$0.165	Used 75% of per-mile diesel maintenance costs as conservative estimate until we get more information in future years [c]
Discount Rate	7.68%	7.68%	7.68%	2021 California Avoided Costs Calculator Electric Model v1b [d]
Insurance Costs for Year 1 (depreciates over time)	$5,714	$13,955	$2,714	Physical Damage insurance is 1/70th the cost of the new vehicle; insurance costs decline at the depreciation rate [c]
Residual Value	$95,320	$232,782	$60,741	Depreciation rates and table from Advanced Clean Fleets TCO Discussion Document and CARB Advanced Clean Trucks Tool [c]
Infrastructure Costs (estimated)	$300,000	$500,000	$300,000	Utility infrastructure costs based on per-vehicle estimates were multiplied by number of vehicles (assumed a 10 vehicle fleet with 1:1 vehicle-to-charger ratio) [e]
EVSE Costs (per charger)	$4,000	$30,000	$4,000	Charger costs for EV fleets (Utility upgrades are not included in this cost) school bus fleets and medium-duty package delivery trucks: based on L2 chargers Transit buses: based on 50 kW DCFC from mid-range value of literature review
EVSE CRT Rebates (per charger)	($1,700)	($20,000)	0	-Estimated SCE per charger rebates for school bus and transit bus projects.
EVSE Networking and Maintenance Costs (annual)	$528	$1,786	$528	Based on quotes from EVSP for networking, maintenance contract, and estimated repairs
Utility-Owned Infrastructure (TTM/BTM)	($300,000)	($500,000)	($300,000)	Estimates of Utility incentives based on Utility infrastructure cost data and CRT fleet incentive descriptions

Data Inputs	School Bus	Transit Bus	Package Delivery Truck	Source
LCFS Credits (per vehicle)	($3,945)	$0	($3,946)	Calculated credits using CARB tool based on annual kilowatt-hours used per vehicle, used credit price of $181 as midpoint value between 2021 highest value ($218) and 2021 lowest value ($143); no LCFS credit value was included in the transit bus TCO analysis, as transit buses did not accrue LCFS credits (we assumed that transit buses use RNG, and that the LCFS credit value from their use of RNG was used to offset the additional cost of RNG over CNG)

[a] Arneja, Paul. 2019. From CARB Advanced Clean Trucks Workshop. TCO Calculator: https://ww2.arb.ca.gov/sites/default/files/2019-05/190508tcocalc_2.xlsx

[b] U.S. Department of Energy, Energy Efficiency and Renewable Energy. February 2020. "Average Annual Vehicle Miles Traveled by Major Vehicle Category." https://afdc.energy.gov/data/widgets/10309

[c] California Air Resources Board. September 9, 2021. *Draft Advanced Clean Fleets Total Cost of Ownership Discussion Document.* https://ww2.arb.ca.gov/sites/default/files/2021-08/210909costdoc_ADA.pdf

[d] Energy and Environmental Economics. June 28, 2021. "CPUC Approves 2021 Avoided Costs for Valuing Distributed Energy Resources." *News: Distributed Energy Resources.* https://www.ethree.com/cpuc-approves-2021-avoided-costs-for-valuing-distributed-energy-resources/

[e] The EY2021 infrastructure costs are not based on utility data due to a limited number of closed-out sites. These estimates are placeholders and are not indicative of future costs. As more projects are complete and more cost data become available, the estimated infrastructure costs will be updated accordingly.

Vehicle Costs

School bus fleets were the largest market segment participating in CRT in 2021. Electrification in this market was fueled largely by a combination of vehicle grants through the California Energy Commission and local air quality management districts and infrastructure support provided by SCE. Based on site visit conversations and MSRP data, the upfront cost of the electric school buses was almost four times the upfront cost of their diesel counterfactual vehicles. In addition, increased insurance and sales taxes were associated with the higher value of the vehicle. However, based on fleet manager information collected from 10 site visits (of the 13 completed school bus sites), the vehicles were completely paid for by grants. For schools districts with tight budgets, fleet managers indicated during site visits that these incentives made vehicle electrification possible.

As of December 31, 2021, SCE electrified two transit fleets through CRT. Similar to school buses, fleet owners and operators rely heavily on grants to pay for the EVs. Feedback from site visits indicate that through a combination of federal, state, and AQMD grants, the public transit fleets participating in SRP programs had no out-of-pocket expenses for the actual vehicles. CARB's Innovative Clean Transit Regulation requires public fleets to transition to clean buses. As such, the counterfactual vehicle for the transit fleet TCO is a CNG bus.

Transit buses travel an average of over 43,000 miles per year. They are among the more expensive fleet vehicles, costing almost $1 million for a single EV transit bus and over $600,000 for a CNG bus. Both vehicles require extensive infrastructure for fueling. For this TCO analysis, the Cadmus team only assessed the infrastructure for the EV, using the assumption that the fueling infrastructure is already in place for a counterfactual vehicle. Similar to school bus fleets, transit bus fleets rely heavily on grants for vehicle purchase. Combinations of grants are often stacked to procure EV transit buses. Under most circumstances HVIP funding cannot be stacked with state incentives. The exception to this rule is public transit buses: in addition to being eligible for federal funding through the Federal Transit Administration, state grants such as the VW Mitigation Trust and the Carl Moyer program can be combined with HVIP and AQMD grants to make these vehicles feasible for public transit agencies. The passage of AB 784 exempts public transit buses from paying state sales tax until 2024, which saved the example fleet over $800,000 in upfront costs.

Because of California's Innovative Clean Transit Regulation, public transit agencies are not adding new diesel transit buses to their fleets. As a result, the Cadmus team used a CNG bus as a counterfactual vehicle for the analyses in this report. Transit buses running on CNG have very low fuel costs since the average CNG cost over the last 10 years was about $1.27 per diesel gallon equivalent. Based on the billing data for SCE transit projects, the fuel costs for a fleet of counterfactual CNG buses were actually lower than the energy costs for buses running on electricity. During site visits, transit agencies provided anecdotal feedback that CNG transit fleets in California often run on renewable natural gas (RNG). This feedback was confirmed in a recent report by NGV America and RNG Coalition that 64% of all on-road fuel used in natural gas vehicles in the U.S. during calendar year 2021 was RNG.[145] RNG suppliers use the value of LCFS credits to buy down the cost of the RNG, which puts it at price parity with CNG. As a result, we did not include LCFS credit values in the TCO analysis for transit fleets, as we assumed the RNG suppliers already applied the value of those credits toward the cost of fuel.

The other market segment we examined in this analysis was medium-duty (Class 4) package delivery vehicles. An electric medium-duty package delivery vehicle costs almost four times that of a diesel-powered counterfactual vehicle. Because these vehicles are typically not part of public fleets like school and transit buses, they have fewer resources available in terms of vehicle incentives. For the purposes of this TCO, we assumed that the package delivery fleet would use HVIP funding to help offset the higher purchase price of the package delivery trucks. HVIP offers $60,000 grants per vehicle.

Infrastructure Costs

TTM or Utility-side infrastructure and BTM or customer-side of the meter infrastructure associated with building out EV chargers added significant upfront costs to the TCO of EVs. For this TCO analysis, we assumed that all the infrastructure was SCE-owned since, in 2021, the majority of the completed MDHD vehicle infrastructure projects included Utility-owned customer-side infrastructure.

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145 The Coalition for Renewable Natural Gas and NGV America. n.d. "Decarbonize Transportation with Renewable Natural Gas." https://static1.squarespace.com/static/53a09c47e4b050b5ad5bf4f5/t/62713267744fca5791fef73d/1651585640069/NGV%2BRNG%2BDecarbonize%2B2022%2B5%2B02%2B22.pdf

The actual cost of a L2 charger for each of these school buses was estimated to only be about $4,000. The bulk of the EVSE cost was the infrastructure and construction necessary to support the charging stations. Construction including design and engineering, permitting, trenching, excavation, and infrastructure (such as meters, transformer upgrades, panels, and switchgear) were estimated to cost about $30,000 per vehicle. CRT provided incentives to cover the costs of this infrastructure, and the Utility continues to own and maintain the infrastructure going forward. We did not conduct a TCO using customer-owned BTM infrastructure because the majority of SCE projects relied on the Utility-owned offering in 2021. Without the combination of infrastructure and vehicle grants, these electrified fleets would cost almost three times that of the counterfactual fleets and would not be financially feasible.

Since transit buses have a much lower dwell time than school buses and drive longer distances each day, transit fleets required the installation of L3 DCFC to maintain fleet operability. Based on available infrastructure cost data,[146] infrastructure necessary to support a 50 kW to 60 kW DCFC and all of the costs associated with design, engineering, trenching, and installing the chargers averaged about $50,000 per vehicle. Building out the necessary TTM and BTM infrastructure for a 10-vehicle fleet cost approximately $500,000. Charger costs are the responsibility of the site hosts but are eligible for CRT incentives for transit projects. DCFCs cost about $45,000 each. Assuming a one-to-one ratio of vehicles and chargers, EVSE costs are in the range of $450,000 for the fleet.

CRT's incentives for Utility-owned infrastructure and charging equipment for transit buses offset the cost of the BTM and TTM for Utility-owned infrastructure and procurement of charging stations. These infrastructure and charging equipment incentives dovetail with robust funding for transit buses at all levels of government. CARB's Innovative Clean Transit Regulation states that the rule is exempt "when incremental capital or electricity costs for depot-charging battery electric buses cannot be offset after applying for all available incentive and funding programs."[147] By offsetting the infrastructure costs, SCE is supporting market transformation by supporting fleets subject to this regulation.

Medium-duty (Class 4) package delivery vehicles typically travel 12,435 miles per year.[148] For this analysis, we paired them with L2 chargers for overnight charging based on site visit evidence. The estimated BTM/TTM infrastructure costs were similar to those for electric school buses, with BTM/TTM upgrade costs to support the chargers totaling about $30,000 per charger. The chargers themselves cost about $4,000 and were paid for by site hosts. The Cadmus team assumed a one-to-one ratio of vehicles to chargers for this market segment.

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146 TTM/BTM estimates for CRT projects was based on literature review findings combined with average cost data from other Utility projects. This value is a placeholder until CRT cost data is available in future evaluation years.

147 California Air Resources Board. April 2019. "Innovative Clean Transit (ICT) Regulation." https://ww2.arb.ca.gov/sites/default/files/2019-07/ICTreg_factsheet.pdf

148 U.S. Department of Energy, Energy Efficiency and Renewable Energy. February 2020. "Average Annual Vehicle Miles Traveled by Major Vehicle Category." https://afdc.energy.gov/data/widgets/10309

Fuel Costs

At the time of the writing of this report, diesel costs in California were higher than normal, with prices topping $6.00 per gallon in many parts of California. For this analysis the Cadmus team used a 10-year average price of diesel, which came to $3.64 as a conservative estimate. While impossible to predict, one can reasonably expect fuel costs for the counterfactual fleet to be higher than modeled in the near future. To determine the electricity cost used to fuel the EVs, we simply relied on 2021 billing data and divided the billing data for projects by the kilowatt-hour usage for those projects. We removed outliers such as months where the project's chargers were activated, but usage was low because the vehicles were not operational. In these cases, costs were spread out over very few kilowatt-hours, resulting in inflated energy costs per kilowatt-hour.

Maintenance Costs

The design of EVs results in lower maintenance costs than their ICE counterparts.[149] They never need oil changes, fluid replacements, flushes, or hoses. Electric motors have few moving parts. Due to regenerative braking, EVs experience much slower brake wear. These savings contribute to lower maintenance costs over time. However, since we are conducting a 10-year TCO, we did not factor battery replacement into the cost of the EVs nor did we factor an engine rebuild into the cost of ICE vehicles. If we choose to assess TCO over a longer time period in future reports, we will factor in these costs.

Taxes, Registration, Residual Value, and Insurance

Since sales taxes and vehicle physical damage insurance are directly linked to vehicle value, they are also much more expensive for the EV fleet with the exception of EV transit buses, which are exempt from sales tax until 2024 as a result of AB 784. Residual value is higher after 10 years for the EV fleet based on the use of a standard depreciation schedule since the vehicle costs more initially. This has generally been true for light-duty vehicles, but due to the nascency of the MDHD EV market, it remains to be seen whether residual value will remain high for MDHD EVs. We have used this assumption for 2021 fleets and will refine this data point as more information on the residual values of MDHD EVs becomes available.

Federal excise taxes are levied on Class 8 vehicles and therefore did not apply to the school buses, which we assumed are Class 7 Type D school buses. Excise taxes also are not levied on public fleets, so therefore did not apply to our transit bus fleets. Our package delivery truck fleet was made up of Class 4 vehicles and was also not subject to excise taxes. In the analysis, the Cadmus team considered taxes as an upfront cost, while we spread physical damage insurance and registration fees out over the life of the

149 California Air Resources Board. September 9, 2021. *Draft Advanced Clean Fleets Total Cost of Ownership Discussion Document*. p. 24. https://ww2.arb.ca.gov/sites/default/files/2021-08/210909costdoc_ADA.pdf

vehicle following proration schedules identified in the CARB Advanced Clean Trucks Tool and the CARB Draft Advanced Clean Fleets Total Cost of Ownership Discussion.[150]

PG&E EV Fleet

Total Cost of Ownership Background

EVs cost significantly more to purchase than their ICE counterparts, especially for MDHD applications. Because of their expense, both taxes and insurance costs are also higher for EVs than for traditional fossil fuel-powered (counterfactual) vehicles. Building out the infrastructure to support the charging of these vehicles adds substantial expense to their upfront costs. However, operations and maintenance costs are predicted to be lower year over year. For this analysis, the Cadmus team examined the TCO of three types of vehicle fleets representing three different market segments: school buses, transit buses, and Class 4 medium-duty package delivery trucks.

To evaluate the impact of PG&E's EV Fleet program on the TCO of these representative fleets, the Cadmus team assessed their costs over a 10-year operating period, as outlined in the Methodology section. For the majority of the analysis, we relied on assumptions and secondary data. We incorporated estimates of actual program data where possible given the limited number of completed projects and months of billing data available. In this analysis, we incorporated billing data to estimate electricity costs to fuel the vehicles and estimated project costs based on available data. Table B-2 shows the specific inputs used in the PG&E TCO analysis.

Table B-2. Data Inputs for PG&E MDHD Fleet TCO

Data Inputs	School Bus	Transit Bus	Package Delivery Truck	Source
Number of Vehicles in Fleet	10	10	10	Average fleet size based on site visits
Life of Vehicle	20	20	20	CARB Advanced Clean Trucks Tool (total life of MDHD vehicle) [a]
New Vehicle Purchase Price	$400,000	$976,846	$190,000	School bus: assumption based on discussions with fleet managers during site visits and discussions with OEMs Transit bus: APTA 2020 vehicle database average cost in California for 40-foot bus manufactured between 2019 and 2021 Medium-duty Class 4 package delivery: from OEMs
TCO Period	10 years	10 years	10 years	Assumption
Sales Tax	8.50%	0.00%	8.50%	California weighted average of 8.5% (excise tax only on Class 8 vehicles that are not publicly owned); no state sales tax on public transit buses until 2024 per AB 784

[150] California Air Resources Board. September 9, 2021. *Draft Advanced Clean Fleets Total Cost of Ownership Discussion Document*. https://ww2.arb.ca.gov/sites/default/files/2021-08/210909costdoc_ADA.pdf

Data Inputs	School Bus	Transit Bus	Package Delivery Truck	Source
Vehicle Efficiency (kWh/mile)	1.0959	1.7730	1.0579	From counterfactual analysis (see the Methodology section)
Annual Vehicle Miles Traveled (per vehicle)	12,000	43,647	12,435	Secondary data from AFDC 2018 [b]
Fuel Costs (kWh)	$0.303	$0.232	$0.352	Primary data from fleet electricity usage divided by fleet electricity billing data (outliers removed from not-yet-activated or very-low-usage fleets)
Fuel Costs (Counterfactual)	$3.67	$1.27	$3.67	School bus and delivery truck: based on EIA California 10-year average cost of diesel fuel Transit bus: based on EIA California 10-year average cost of CNG for commercial customers price per diesel gallon equivalent
Maintenance and Repair Cost Per Mile Estimate	$0.600	$0.195	$0.165	Used 75% of per-mile diesel maintenance costs as conservative estimate until we get more information in future years. [c]
Discount Rate	7.81%	7.81%	7.81%	From 2021 California Avoided Costs Calculator Electric Model v1b [d]
Insurance Costs for Year 1 (depreciates over time)	$5,714	$13,955	$2,714	Physical damage insurance is 1/70th the cost of the new vehicle, so insurance costs decline at the depreciation rate. [c]
Residual Value	$95,320	$232,782	$60,741	Depreciation rates and table from Advanced Clean Fleets TCO Discussion Document and CARB Advanced Clean Trucks Tool [c]
Infrastructure Costs (estimated)	$300,000	$500,000	$300,000	Utility infrastructure costs based on per-charger estimates from Utility cost data and multiplied by number of vehicles (assumed a 10-vehicle fleet with 1:1 vehicle-to-charger ratio)
EVSE Costs (per charger)	$4,000	$30,000	$4,000	Charger costs for EV fleets (Utility upgrades are not included in this cost) School bus fleets and medium-duty package delivery trucks: based on L2 chargers Transit buses: based on 50 kW DCFC from mid-range value of literature review
EVSE Networking and Maintenance costs (annual)	$528	$1,786	$528	Based on quotes from EVSP for networking, maintenance contract, and estimated repairs
IOU Infrastructure Incentives	$162,000	$162,000	$162,000	TTM infrastructure costs paid by Utility to understand the cost impact of IOU support to make these fleets economically viable to customers
IOU Charger Incentives	$40,000	$90,000	$40,000	School bus and medium-duty delivery: $4,000 per vehicle or 80% of customer infrastructure costs (80% of (68% of $125,000 = $85,000) = $68,000), so $40,000 value is lower of two values Transit bus: lower of $90,000 or 80% of BTM (0.68 * $175,000 = $119,000) =$95,200

Data Inputs	School Bus	Transit Bus	Package Delivery Truck	Source
LCFS Credits (per vehicle)	($3,945)	$0	($3,946)	Calculated credits using CARB tool based on annual kilowatt-hour used per vehicle, used credit price of $181 as midpoint value between 2021 highest value ($218) and 2021 lowest value ($143); no LCFS credit value was included in the transit bus TCO analysis. as transit buses did not accrue CARB credits (we assumed that transit buses use RNG, and that the LCFS credit value from their use of RNG was used to offset the additional cost of RNG over CNG)

[a] Arneja, Paul. Last updated May 8, 2019. "Advanced Clean Trucks Draft Total Cost of Ownership Calculator." From CARB Advanced Clean Trucks Workshop. https://ww2.arb.ca.gov/sites/default/files/2019-05/190508tcocalc_2.xlsx

[b] U.S. Department of Energy, Energy Efficiency and Renewable Energy. February 2020. "Average Annual Vehicle Miles Traveled by Major Vehicle Category." https://afdc.energy.gov/data/widgets/10309

[c] California Air Resources Board. September 9, 2021. *Draft Advanced Clean Fleets Total Cost of Ownership Discussion Document.* https://ww2.arb.ca.gov/sites/default/files/2021-08/210909costdoc_ADA.pdf

[d] Energy and Environmental Economics. June 28, 2021. "CPUC Approves 2021 Avoided Costs for Valuing Distributed Energy Resources." *News: Distributed Energy Resources.* https://www.ethree.com/cpuc-approves-2021-avoided-costs-for-valuing-distributed-energy-resources/

Vehicle Costs

School bus fleets were the largest market segment participating in PG&E's EV Fleet program in 2021. Electrification in this market was fueled largely by a combination of vehicle grants through the California Energy Commission and local air quality management districts and infrastructure grants by PG&E. Based on site visit conversations and MSRP data, the upfront cost of the electric school buses was almost four times the upfront cost of the diesel counterfactual vehicles, but for each school bus fleet that had site visits through the evaluation, the vehicles were completely paid for by grants. For schools districts with tight budgets, fleet managers indicated during site visits that these incentives made vehicle electrification possible.

PG&E has electrified two transit bus fleets through the EV Fleet program. Similar to school buses, fleet owners and operators relied heavily on grants to pay for the EVs. Feedback from site visits indicated that through a combination of federal, state, and AQMD grants, public transit fleets participating in SRP programs typically had no out-of-pocket expenses for the vehicles themselves. CARB's Innovative Clean Transit Regulation requires public fleets to transition to clean buses. As such, the counterfactual vehicle for the transit fleet TCO is a CNG bus. A new electric transit bus costs almost $1 million, while a CNG transit bus costs about $600,000. Anecdotal feedback from transit agency site visits indicated that CNG transit fleets in California often run on RNG. This feedback was confirmed in a recent report by NGV America and RNG Coalition that noted that 64% of all on-road fuel used in natural gas vehicles in the U.S. during calendar year 2021 was RNG.[151] RNG suppliers use the value of LCFS credits to buy down the

[151] The Coalition for Renewable Natural Gas and NGV America. n.d. "Decarbonize Transportation with Renewable Natural Gas." https://static1.squarespace.com/static/53a09c47e4b050b5ad5bf4f5/t/62713267744fca5791fef73d/1651585640069/NGV%2BRNG%2BDecarbonize%2B2022%2B5%2B02%2B22.pdf

cost of the RNG, which puts it at price parity with CNG. As a result, we did not include LCFS credit values in the TCO analysis for transit fleets, as we assumed the RNG suppliers already applied the value of those credits toward the cost of the RNG.

The other market segment we examined in this analysis is medium-duty (Class 4) package delivery vehicles. An electric medium-duty package delivery vehicle costs almost four times that of a diesel-powered counterfactual vehicle. Because these vehicles are typically not part of public fleets like school and transit buses, they have fewer resources available in terms of vehicle incentives. For the purposes of this TCO, we assumed that the package delivery fleet would use HVIP funding to help offset the higher purchase price of the package delivery trucks. HVIP offers $60,000 grants per vehicle.

Infrastructure Costs

TTM or Utility-side infrastructure and BTM or customer-facing infrastructure associated with building out EV chargers added significant upfront costs to the TCO of EVs. For this TCO analysis, we assumed that all the infrastructure was customer-owned since in 2021 and that all the completed PG&E MDHD vehicle infrastructure projects included customer-owned customer-side infrastructure.

The actual cost of a L2 charger for each of these school buses was estimated to only be about $4,000. The bulk of the EVSE cost was the infrastructure and construction necessary to support the charging stations. Construction including design and engineering, permitting, trenching, excavation, and infrastructure (such as meters, transformer upgrades, panels, and switchgear) was estimated to cost about $30,000 per charger. PG&E's EV Fleet program provided incentives to cover the TTM costs of this infrastructure. The customer paid the cost of the BTM infrastructure, but PG&E offered incentives based on the number of vehicles procured. Without the combination of infrastructure and vehicle grants, these electrified fleets would cost almost three times that of the counterfactual fleets and would not be financially feasible.

Since transit buses have a much lower dwell time than school buses and drive longer distances each day, transit fleets required the installation of L3 DCFCs to maintain fleet operability. Based on available infrastructure cost data, infrastructure necessary to support a 50 kW to 60 kW DCFC and all the costs associated with design, engineering, trenching, and installing the chargers averaged about $50,000 per charger. Building out the necessary TTM and BTM infrastructure for a 10-vehicle fleet cost approximately $500,000. Chargers also cost about $45,000 each. Assuming a one-to-one ratio of vehicles and chargers, EVSE costs are in the range of $450,000 for the fleet.

PG&E's incentives for Utility-owned infrastructure offset a substantial amount of the cost of the EVSE installation including BTM and TTM for Utility-owned infrastructure. These infrastructure incentives dovetail with robust funding for transit buses at all levels of government. CARB's Innovative Clean Transit Regulation states that the rule is exempt "when incremental capital or electricity costs for depot-charging battery electric buses cannot be offset after applying for all available incentive and funding programs."[152] By offsetting the infrastructure costs, PG&E is supporting market transformation by supporting fleets subject to this regulation.

Medium-duty (Class 4) package delivery vehicles typically travel 12,435 miles per year.[153] For this analysis, we paired them with L2 chargers for overnight charging. The EVSE costs were similar to those of school buses, with chargers themselves costing about $4,000 and construction costs totaling about $30,000 per charger/vehicle.

Fuel Costs

At the time of the writing of this report, diesel costs in California were higher than normal, with prices topping $6.00 per gallon in many parts of California. For this analysis, the Cadmus team used a 10-year average price of diesel, which came to $3.64 as a conservative estimate. While impossible to predict, one can reasonably expect fuel costs for the counterfactual fleet to be higher than modeled in the near future. To determine the electricity cost used to fuel the EVs, we simply relied on 2021 billing data and divided the billing data for projects by the kilowatt-hour usage for those projects. We removed outliers such as months where the project's chargers were activated, but usage was low because the vehicles were not operational. In these cases, the costs were spread out over very few kilowatt-hours, resulting in inflated energy costs per kilowatt-hour.

Maintenance Costs

The design of EVs results in lower maintenance costs than that of their ICE counterparts.[154] They never need oil changes, fluid replacements, flushes, or hoses. Electric motors have few moving parts. Due to regenerative braking, EVs experience much slower brake wear. These savings contribute to lower maintenance costs over time. However, since we are conducting a 10-year TCO, we did not factor battery replacement into the cost of the EVs, nor did we factor an engine rebuild into the cost of ICE vehicles. If we choose to assess TCO over a longer time period in future reports, we will factor in these costs.

Taxes, Registration, Residual Value, and Insurance

Since sales taxes and vehicle physical damage insurance are directly linked to vehicle value, they are also much more expensive for the EV fleet with the exception of EV transit buses, which are exempt from sales tax until 2024 as a result of AB 784. Residual value is higher after 10 years for the EV fleet based on the use of a standard depreciation schedule since the vehicle costs more initially. This has generally been true with light-duty vehicles, but due to the nascency of the MDHD EV market, it remains to be seen

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[152] California Air Resources Board. April 2019. "Innovative Clean Transit (ICT) Regulation." https://ww2.arb.ca.gov/sites/default/files/2019-07/ICTreg_factsheet.pdf

[153] U.S. Department of Energy, Energy Efficiency and Renewable Energy. February 2020. "Average Annual Vehicle Miles Traveled by Major Vehicle Category." https://afdc.energy.gov/data/widgets/10309

[154] California Air Resources Board. September 9, 2021. *Draft Advanced Clean Fleets Total Cost of Ownership Discussion Document*. p. 24. https://ww2.arb.ca.gov/sites/default/files/2021-08/210909costdoc_ADA.pdf

whether residual value will remain high for MDHD EVs. We have used this assumption for 2021 fleets and will refine this data point as more information on the residual values of MDHD EVs becomes available.

Federal excise taxes are levied on Class 8 vehicles and therefore did not apply to the school buses, which were assumed to be Class 7 Type D school buses. Excise taxes also are not levied on public fleets, so therefore did not apply to our transit bus fleets. Our package delivery truck fleet was made up of Class 4 vehicles and was also not subject to excise taxes. In the analysis, we considered the taxes as an upfront cost, but spread physical damage insurance and registration fees out over the life of the vehicle following proration schedules identified in the CARB Advanced Clean Trucks Tool and the CARB Draft Advanced Clean Fleets Total Cost of Ownership Discussion.[155]

[155] California Air Resources Board. September 9, 2021. *Draft Advanced Clean Fleets Total Cost of Ownership Discussion Document*. https://ww2.arb.ca.gov/sites/default/files/2021-08/210909costdoc_ADA.pdf