

Evaluating Electric Vehicles in Fleet Applications: Car Sharing, Government Fleets, and a Tribal Community

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Summary

The Metropolitan Transportation Commission's Climate Initiatives Program (in the San Francisco Bay Area) was an unprecedented regional effort to reduce transportation greenhouse gas emissions. Three projects were funded which included the deployment of electric vehicles and charging infrastructure in a local car sharing fleet, local government fleets, and for a local tribal community. This paper presents the evaluation of these deployment programs, focusing on tracked performance metrics, including emission reductions, cost effectiveness. We also identified key lessons learned to improve the design and implementation of future projects or programs and support replication of successful projects elsewhere.

Keywords: deployment, car-sharing, EV (electric vehicles), emissions, fleet

1 Introduction

The Metropolitan Transportation Commission (MTC) has taken bold steps to address the threat of global climate change in the San Francisco Bay Area. These steps respond to the desires of Bay Area residents as well as California mandates. Senate Bill 375 (SB 375), enacted in 2008, requires MTC to demonstrate that the region's long range transportation plan will reduce per-capita greenhouse gas (GHG) emissions as part of a Sustainable Community Strategy (SCS). The California Air Resources Board established GHG reduction targets for all the state's metropolitan planning organizations (MPOs). For the Bay Area, these targets are a 7 percent reduction in per capita GHG emissions from cars and light trucks by 2020 (relative to 2005 levels) and a 15 percent reduction by 2035.

In December 2009, MTC programmed \$80 million to implement the Climate Initiatives Program, an unprecedented regional effort to reduce transportation GHG emissions. The majority of Climate Initiatives Program funding was allocated to local governments or used by MTC for innovative pilot projects to test their ability to reduce GHG emissions. The remaining funds went to other regional or local climate initiatives (Spare the Air, SFGO, and projects in Eastern Solano County). MTC committed to further investment in the Climate Initiatives Program with the 2013 adoption of *Plan Bay Area*, which sets aside \$226 million to invest in the expansion of the most successful approaches identified in the Climate Initiatives Program.

In 2010, MTC issued a call for projects and selected 16 projects for grant funding under the Innovative Grant Program and the Safe Routes to School Creative Grant Program. This paper reviews the following three projects funded:

- eFleet: Car Sharing Electrified
- Local Government EV Fleet
- Tribal Community Sustainable Transportation Pilot

The evaluation team developed an evaluation approach customized to each project. The overall goals of the evaluation effort were to:

- Determine the emission reductions, cost effectiveness, and co-benefits of each major project and activity. The term co-benefits refers to societal benefits that occur in addition to primary emission reduction benefits that each project is expected to generate.
- Identify key lessons learned to improve the design and implementation of future projects or programs and support replication of successful projects elsewhere in the San Francisco Bay Area.
- Produce accessible resource documents to ensure that performance evaluation results and lessons are transferred to communities throughout the San Francisco Bay Area.

Data collection to evaluate each project commenced in 2011 and, in most cases, continued through 2013 or 2014, when the project evaluations were completed.

2 Overview of Projects

2.1 eFleet: Car Sharing Electrified

City CarShare (CCS) procured and deployed a total of 16 plug-in electric vehicles (PEVs) in their fleet, including five battery electric vehicles (BEVs) and 11 plug-in hybrid electric vehicles (PHEVs). The CCS eFleet project was designed to help address and mitigate barriers that prevent the adoption of electric vehicles in the Bay Area. Such barriers include a lack of driver familiarity with the technology; “range anxiety” (distance and duration one can travel due to a lack of widely implemented and available charging infrastructure); and the high expense for relatively “standard” appointed vehicles.

By deploying electric vehicles and infrastructure into their carsharing fleet, CCS provides drivers with immediate and convenient access to vehicles, yielding both scale and low-risk exposure to the public. To complement their electric vehicle offering, CCS launched an outreach and awareness campaign to existing and new carshare members and to community at-large. CCS has placed their eFleet vehicles at a variety of locations, primarily in high density mixed used (residential and business) areas in both the East Bay and San Francisco. Electric vehicles were placed with a focus on locations in Priority Development Areas (PDAs), including garages in eastern quadrants of San Francisco (city garages; UC San Francisco) and Berkeley (downtown city garages). CCS was able to integrate these electric vehicles into their fleet using their existing in-car hardware and software, so that members can reserve, access and utilize them in the same fashion as the rest of their fleet. The only exception is all electric vehicle reservations for which members are limited to certain range and time and are also responsible for plugging in vehicles after use (or face a fine).

2.2 Local Government EV Fleet

The local government EV fleet project is a collaborative project to deploy electric vehicles (EVs) and level 2 charging stations (referred to as electric vehicle supply equipment, EVSE) to a diverse set of government agencies across the Bay Area. Deploying EVs in a government fleet setting would showcase the advanced technology vehicles and demonstrate the feasibility of using these new vehicles to meet the high-frequency usage of government vehicles while reducing vehicle-related emissions. Local government fleets represent a large portion of fleet vehicles across the country and the successful implementation of this project could serve as a demonstration for a significant segment of fleets. Additionally, EVs in each fleet will be charged at central locations and monitored for usage, which will increase the potential for observing EV impacts in real-world contexts.

Through this project, ten agencies received and matched funding to purchase 90 EVs and 90 EVSE for use in their fleets. The table below lists each of the partner agencies and their planned procurements.

Table 1: Status of EV and EVSE acquisition and deployment

Agency	# of EV/EVSE	EV Acquisition Status	Expected EVSE Installation	EV Deployment Status
Alameda County	26	Acquired Jun 2014	Spring 2015	Limited deployment
Concord	10	Acquired five Aug 2014; five expected Feb 2015	Spring 2015	1 deployed, 2 available for trial
Fremont	2	Acquired Aug 2014	Winter 2015	Limited deployment
Marin Municipal Water District (MMWD)	1	Acquired Oct 2014	Spring 2015	1 deployed
Oakland	3	Not acquired	Spring 2015	EVs not acquired
San Francisco	14	Not acquired	Winter 2015	EVs not acquired
San Jose	3	unknown	Winter 2015	No response from agency
Santa Rosa	4	Acquired	Winter 2015	No deployment
Sonoma County	22	Acquired Sep 2014	Spring 2015	Limited deployment
Sonoma County Water Agency (SCWA)	5	Acquired Jun 2014	Winter 2015	5 deployed

The project involves a wide diversity of agencies and fleets. Some partners use or plan to use their EVs for outreach and education while others will use them for code enforcement. Some agencies operate their vehicles in low-density areas requiring longer trips than other agencies. Fleets range in size and age with fleets of less than ten vehicles over a decade old and other fleets with over one hundred vehicles, including some electric vehicles.

All partners experienced major delays in the procurement of EVs and installation of EVSE due to Buy America provisions, which require the purchase of U.S.-manufactured products or waivers approved by the federal government. At the start of the project cycle, there were no EVs manufactured in the U.S., and the partners failed to receive a waiver. When the project was initially funded, there were no PEVs manufactured in the USA. There were additional delays in getting authorization to proceed from the various city and county boards engaged in the project. The agencies finally began acquiring Nissan Leaf, Ford Focus EVs, and Zenith electric vans in 2014. However, EVSE funded through this program were not installed until late 2015 after this evaluation was completed; EVSE installation is a relatively unique infrastructure project for Caltrans and required additional time for development procurement processes.

2.3 Tribal Community Sustainable Transportation Pilot

The Kashia Band of Pomo Indians of Stewarts Point Rancheria deployed four electric vehicles (EVs) and is in the process of installing six Level 2 chargers on tribal lands. The EVs will ultimately be used for administrative, social service, and cultural and educational trips in lieu of traditional gasoline-powered vehicles; the charging stations will be used to charge the tribal EVs during the evening and will be open to the public during the day. The project also included a community outreach component that consists of two workshops to educate the tribal community about the project and its findings.

The Kashia Tribal Office provides transportation services for its tribal members to meet their essential health and human service needs. To provide these services and reach their locations, the agency required vehicles that could comfortably seat four adults and handle travel over hilly terrain and backroads. Prior to this project, the Tribal Office only owned or leased pickup truck and SUVs. In December 2013, they purchased two all-electric RAV4 EVs and two Ford C-MAX Energi Plug-In Electric Hybrids. Currently, all four vehicles are at the Tribal Office in Santa Rosa, but one or two will eventually be placed at Stewarts Point Rancheria once the EVSE are installed.

Until the charging infrastructure is in place, the vehicles cannot be used as fully planned. Although many trips are very local, the Tribal Office requires transportation for distant meetings and site visits, including frequent trips to the Rancheria. Notably, while the Tribal Office is located in Santa Rosa and handles administrative and business affairs for the tribe, the reservation sits nearly 60 miles away at Stewarts Point

Rancheria. Because the RAV4 EVs have a range of approximately 100 miles and the hilly terrain to the Rancheria reduces vehicle efficiency, the RAV4s cannot be used to reach the reservation. Once charging stations are installed there, the EVs can charge there for a return trip; additionally, one or two of the vehicles will be stationed at the Rancheria. The placement of intermediate EVSE at the various planned sites can also allow the vehicles to travel further on electricity only.

In addition to the range restrictions, the lack of EVSE at the Tribal Office where the vehicles have been parked makes charging the vehicle inconvenient and logistically challenging. Without the opportunity to charge, the RAV4s are not used as often and the Ford C-MAX Energi plug-in hybrids are used more as conventional hybrid vehicles rather than taking advantage of their all-electric driving capabilities. However, even with the limited deployment, the Tribal Office has reported using the trucks and SUVs in their fleet significantly less and some departments are now using the new vehicles nearly exclusively.

The project originally planned for installing photovoltaic panels to offset the increased electricity used for EV charging to a renewable energy source. However, it became apparent very early in the project implementation that materials and installation of the solar panels were cost-prohibitive.

As a pilot project to model advanced vehicle technology in a new context, the project includes outreach opportunities to interact with other tribal communities. As part of this task, the EV Coordinator from the Kashia Tribal Office presented on the EV/PHEV project at the EPA Region 9 Tribal Conference in October 2014. Additionally, the Office offers outreach and meetings with other local tribal members.

3 Methodology

The evaluation assesses the GHG and criteria pollutant emission impacts of displacing conventional vehicles in fleets with battery electric and plug-in hybrid electric vehicles. The analysis includes an evaluation of the following elements:

This evaluation assesses the GHG and criteria pollutant emission impacts of displacing conventional vehicles in fleets with battery electric and plug-in hybrid electric vehicles. The analysis includes an evaluation of the following elements:

- A quantitative analysis of GHG emission reductions due to the deployment of electric and plug-in hybrid electric vehicles in place of conventional vehicles.
- A quantitative analysis of criteria pollutant emissions due to the deployment of electric and plug-in hybrid electric vehicles in place of conventional vehicles.
- A quantitative analysis of project costs using data provided by the grantees and data drawn from government publications.
- Where appropriate, a summary of “lessons learned” from the deployment project.

The evaluation assessed the GHG emission impacts of the EV miles travelled relative to baseline emissions from driving conventional vehicles that use an internal combustion engine, powered exclusively by gasoline. The emissions are assessed on a lifecycle basis, which includes emissions related to processes upstream of the point of use in the vehicle, in addition to the direct emissions that result from fuel combustion in the vehicle. Therefore, for vehicles using grid-supplied electricity, emissions associated with the generation and transmission of the electricity supplied to the vehicles are included. For vehicles using gasoline, this accounting includes the production and delivery of the fuel and the combustion of the gasoline in the vehicle. GHG emissions related to conventional vehicles, EVs, or EVSE production, installation, and maintenance are not included in this assessment. The carbon intensity emission factors used in our analysis were 98.95 g/MJ for gasoline and 104.71 g/MJ for electricity.

Criteria pollutants are emitted from internal combustion processes. The criteria pollutants considered in this evaluation are non-methane organic gases (NMOG), nitrogen oxides (NOx), and particulate matter (PM). Fully electric vehicles and plug-in hybrids when driving in all-electric mode have no direct tailpipe emissions, thus providing significant criteria pollutant benefits. And unlike the GHG assessment, criteria pollutant emissions are only estimated from the tailpipe rather than on a lifecycle basis because uncertainties related to upstream criteria pollutant emissions are unacceptably high. We estimated emission reductions based on comparison to baseline vehicles are assumed to meet the California Low Emission Vehicle II (LEV II) regulation, which requires all new vehicles sold in the state to be certified as Low Emission Vehicle (LEV), Ultra Low Emission Vehicle (ULEV), or Super Ultra Low Emission Vehicle (SULEV). Each certification

level has a maximum emissions limit (in g/mile). These emission standards, for the purposes of this evaluation, were assumed to be the emission factors for the baseline vehicles.

Table 2. Criteria pollutant emission standards (g/mile)

Category	Emission Factors (g/mile)		
	NMOG	NOx	PM
Low Emission Vehicle (LEV)	0.090	0.070	0.010
Ultra Low Emissions Vehicle (ULEV)	0.055	0.070	0.010
Super Ultra Low Emissions Vehicle (SULEV)	0.010	0.020	0.010

The emission impacts are assessed over the assumed lifetime of each vehicle, which varies depending on the fleet application. For carsharing, we assumed a 5-year lifetime; we assumed a useful life of ten years for the other applications. Because these vehicles had been deployed for less than two years at the time of the evaluation, there are some cases where the mileage and fuel economy of the EVs are extrapolated and annualized based on a smaller subset of data.

4 Project Findings

This section reviews the costs, emissions impacts (focused on GHG emissions), and co-benefits (focused on criteria air pollutant emissions) of each project evaluated.

4.1 Review of Project Costs

For this evaluation, cost-effectiveness is measured as the cost to reduce one ton of GHG emissions (\$/ton CO₂e). To assess accurately the cost-effectiveness of GHG reductions, the total costs of each project were included in the evaluation. Costs considered in this assessment include:

- **Capital costs:** EVSE materials and installation; Electric vehicles; Conventional gas vehicles
- **Operations and maintenance costs:** EVSE maintenance; Vehicle maintenance; EV electricity; Vehicle fuel

Costs were estimated for the expected useful life of the vehicles, (ranging from 5-10 years). Additionally, because EV emissions were calculated relative to new vehicle purchases displaced by the EVs, cost-effectiveness was calculated in terms of incremental costs (i.e., total cost of EV ownership beyond the costs of conventional vehicle ownership).

4.1.1 eFleet: Car Sharing Electrified

CCS reported that the total cost of installing 20 chargeports was \$62,836.72. Assuming that each chargeport has the same installation cost (\$3,141.84), the total EVSE cost for 16 PEVs is estimated to be \$50,269. CCS pays a \$30/month flat fee to ChargePoint for charging their PEV vehicles. The total cost for 16 PEVs is therefore estimated to be \$28,800 over the assumed five year vehicle fleet lifetime. CCS was not able to determine the gasoline cost data for the 11 PHEVs, therefore ICF estimated these costs using monthly average gasoline price data for California Reformulated Gasoline (CaRFG) in 2012-2014 from the California Energy Almanac.

The total marketing and outreach funded by MTC for 40 vehicles over 36 months was \$22,843, or about \$571 per PEV. The total administration and evaluation program costs funded by MTC for 40 vehicles over 36 months was \$41,475 or about \$1,037 per PEV. The total eFleet operational costs covering 40 vehicles over 36 months was \$424,221. ICF assumed that a) CCS will decrease their operational expenses by 60% in the 4th and 5th years of the program; and b) these costs are the same for each vehicle. Therefore, the total operating costs for each PEV over 5 year is estimated to be \$13,434.

4.1.2 Local Government EV Fleet

The incremental EV costs are estimated at \$1.9 million, EVSE costs are estimated at \$990,000, and the incremental lifetime operations and maintenance savings were estimated at \$640,000.

Ultimately, the local government investments in vehicle and infrastructure costs may be reduced by securing grants from other incentive programs, such as the California Clean Vehicle Rebate Program (CVRP) and the Bay Area Air Quality Management District's Public Agency PEV Rebate Program. Such incentives can allow MTC funds obligated for vehicle costs to be shifted to covering EVSE costs, thus reducing the local government agencies' funding burden. The partners are currently applying or considering applying for these incentives. Because the final amount of incentives secured is not final, these grant amounts were excluded from this cost evaluation.

4.1.3 Tribal Community Sustainable Transportation Pilot

The planned projects costs, including equipment, capital, construction, administration, and evaluation, were included in the budget and expenditure sheets provided by the grantee, the Tribal Office. Because a number of budgeted tasks remained at the time of evaluation, the final allocation of funds had not been determined. A number of the capital costs were higher than budgeted, requiring reallocation of money.

MTC grant funding included \$376,000, and the grantee received a match of \$33,676 with an in-kind match of \$21,000. We estimate incremental lifetime operational and maintenance costs of \$239,108.

4.2 Emissions Impacts and Co-Benefits

4.2.1 eFleet: Car Sharing Electrified

CCS provided our team with activity data for a sample of their hybrids, BEVs, and PHEVs that covered a total of six months (March 2014 to August 2014). The following data were supplied for each vehicle month:

- Number of reservations made by drivers (trips)
- Total miles driven during reservations (VMT)
- Total gasoline consumed (gallons)
- Total kWh consumed (ChargePoint)

In addition, we requested three months of more granular reservation and charging data to cross check and perform QAQC on the analysis. We scaled emissions reductions (from a six month time frame to a vehicle fleet lifetime) using data provided by CCS from 2012 to September 2014. We analyzed six months of activity data from CCS for BEVs and PHEVs to determine the average energy consumption per mile of each eFleet vehicle funded by MTC. We subsequently quantified PEV emissions and the emissions that would have been emitted if those miles were driven in a baseline vehicle (i.e., a Toyota Prius) using energy conversions and lifecycle carbon intensity emissions factors. Emission reductions were scaled to cover the entire lifetime of the vehicle based on median monthly VMT. Future VMT was projected using the median VMT by vehicle model. ICF chose to use the median for the scaling calculations (as opposed to the mean) in order to minimize outlier skew.

The total GHG reduction over the carshare vehicle lifetimes are dependent on how frequently they are reserved and driven by CCS members. In general, the BEVs deployed have not been highly utilized by CCS members compared to the average Prius Hybrid.

The GHG emissions reductions of the 5 BEVs and 11 PHEVs (MTC-funded vehicles) over the carshare vehicle lifetime (of five years) are estimated to be 4.4 short tons of CO₂e. ICF found that Ford Focus Electric emits, on average, 140.6 g CO₂e for every mile driven. This represents a 44% reduction from hybrid baseline of 252.4 g CO₂e/mile. These results are consistent with the expectation that BEVs emit half the emissions of a standard hybrid. Although CCS users made more reservations and drive more miles with PHEVs than BEVs, the overall emissions reductions were much lower than expected. ICF found that the Ford C-Max had a higher average emissions rate on a per mile basis (273.1 g CO₂e/mile) than the baseline hybrid (252.4 g CO₂e/mile).

Table 3 presents the estimated project costs and costs per ton of GHG emissions reduced. These estimates cover the 16 PEVs funded by MTC over an assumed five year fleet vehicle lifetime. They are also broken out by funding source to show the GHG abatement costs by funding source.

Table 3. Program Costs and Cost per Ton of GHG Emissions Reduced

	Program Costs			\$/ton GHG		
	MTC	CCS	Total	MTC	CCS	Total
5 BEVs	\$193,406	\$79,009	\$272,415			
11 PHEVs	\$375,386	\$199,289	\$574,675	\$37,990	\$62,755	\$100,745
TOTAL	\$568,792	\$278,298	\$847,090			

Similar to the results of the GHG analysis, PHEV criteria pollutant emissions reductions were lower than expected due to a lower percentage of miles driven in electric mode. When compared to a hybrid (SULEV) baseline, the total reduction for 300,347 PHEV miles driven is estimated to be 1.9 lbs of NMOG, 3.9 lbs of NOx, and 1.9 lbs of PM. Since BEVs have zero tail-pipe emissions, each vehicle has the same amount of emissions reductions per mile. The total emissions reduction (lbs/vehicle lifetime), however, varies according to how utilized the vehicle is by CCS members. When compared to a hybrid (SULEV) baseline, the total reduction for 86,800 BEV miles driven is estimated to 1.9 lbs of NMOG, 3.8 lbs of NOx, and 1.9 lbs of PM.

4.2.2 Local Government EV Fleet

When the 90 vehicles are fully deployed with complementary charging infrastructure, we estimate GHG emission reductions of 2,033 tons. These GHG reduction calculations may represent the high end of the range of estimates. We assumed that all of the miles traveled by the baseline vehicles will be converted into electric vehicle miles. However, this may not actually be the case; some trips taken by the baseline vehicles may be beyond the range of the electric vehicles (approximately 76 miles and 84 miles for the Ford Focus and Nissan Leaf, respectively); this issue could be exacerbated early in their deployment by potential drivers avoiding the EVs because of range anxiety. Furthermore, there may be daily mileage restrictions because of the charging times required. However, even if the EVs only displaced half of the conventional vehicle miles, they would still reduce GHG emissions by over 1,000 tons.

ICF estimates a GHG cost-effectiveness of around \$1,100 per ton for this project.

Table 4: Cost-effectiveness of GHG emission reductions (\$/ton CO₂e)

MTC	Local Govt Partners	Total
\$1,203	\$(96)	\$1,106

We estimate criteria pollutant emission reductions of 209-1,729 lbs of NMOG, 476-1,427 lbs of NOx, and 201 lbs of PM via the deployment of the project EVs into the government fleets over the next ten years. The increasing stringency of the LEV standards are reflected in the range of NMOG and NOx emissions. Gasoline vehicles already have very low PM emissions, so benefits to switching to EVs are more limited for this pollutant. However, these are significant and positive benefits especially because criteria pollutants have localized impacts and direct impacts on human health.

4.2.3 Tribal Community Sustainable Transportation Pilot

The total reduced GHG emissions from the deployment of the four EVs ranges from less than one ton to over 33 tons, depending on the assumed baseline vehicle. Because the tribal community has such a small fleet, the displaced vehicle is more difficult to determine than for other fleets. In the low end of the range for GHG

¹ Includes full vehicle purchase price

² Includes only the incremental vehicle purchase price above a baseline Prius Hybrid of the same model year

emissions reductions, we assume the EVs are displacing a new hybrid sedan; in the high end of the range, we assumed the EVs displace a sport utility vehicle (SUV).

The table below reports the cost-effectiveness of the GHG emissions reductions.

Table 5: Cost-effectiveness of GHG emission reductions (\$/ton CO₂e)

MTC	Kashia Tribal Office	In Kind Match	Total
\$11,265	\$(6,155)	\$629	\$5,740

The cost per ton of GHG emissions reduced are high, largely because the GHG reductions are lower than expected; as noted elsewhere, the all-electric driving opportunities have not been fully realized because of the lack of charging infrastructure. However, even with the partial deployment of the vehicles, the projected operating and maintenance savings are significant over the lifetime of the EVs.

For criteria pollutant emission reductions, we report a range of 0.3-16.6 lbs of NMOG, 0.7-18.8 lbs of NO_x, and 0.3 lbs of PM. The emissions of the project vehicles were not much lower than the scenario with hybrid sedan emissions; because the PHEVs were charged very infrequently during the reporting period, they drove as gasoline hybrids more than battery electric vehicles. Also, the difference between the SULEV and ULEV results highlights the effect that the LEV standards can have on long-term emission levels.

5 Discussion and Review of Findings

5.1 eFleet: Car Sharing Electrified

ICF's evaluation demonstrates that the use of PEVs in City CarShare's fleet requires more careful consideration to maximize the GHG emission reduction potential of the technology and reduce program costs. Our evaluation revealed that the MTC-funded vehicles are not achieving their maximum reduction potential for several reasons, including driver behavior and limited reservations for BEVs (i.e., consumer/member choice). The program also needs to find ways to achieve cost reductions. ICF notes that the cost-effectiveness calculation over-simplifies some of the nuances of this program, including the following:

- **Vehicle lifetime.** The carshare fleet lifetime is limited to five years; most vehicles have a useful life of around 10 years. Using a longer lifetime would lead to additional GHG reductions and limited additional cost, thereby changing (likely reducing) the cost-effectiveness.
- **Vehicle re-sale and residual battery life.** The cost-effectiveness calculation does not account for the re-sale value of the PEV after its carshare vehicle lifetime, nor does it account for the value of the battery after it is no longer useful in an automotive application. Again, these cost elements
- **Infrastructure costs.** The cost-effectiveness includes the full cost of the infrastructure deployed as part of this project, even though the EVSE have a useful life that is greater than the vehicle lifetime. This makes a small difference in cost-effectiveness, but when amortized over an assumed lifetime of 20 years, the cost-effectiveness is reduced slightly.

CCS eFleet BEVs performed according to expectations on a per mile basis (44% reduction in GHG from baseline hybrid), but the total emissions reductions over the carsharing vehicle lifetime (of five years) is quite low due to their low reservation rate. In the case of PHEVs, ICF found that emissions actually increased compared to a baseline Toyota Prius hybrid because the vehicles are not being properly charged at the end of member reservations. When this happens, the battery is being drained and not being recharged between member reservations. Subsequently, the PHEVs are effectively driving like a hybrid vehicle, but not one that is as efficient as the Prius Hybrid.

Despite the cost-effectiveness—around \$100,000/ton—ICF believes there are reasons to believe this cost can come down significantly as CCS and its member become more familiar with electric vehicles. Modest improvements in PHEV charging, a re-focused effort on PHEV over BEV deployment, and reduced program operation costs can improve the cost effectiveness of the program by five- to seven-fold.

Results of a survey of members showed that significantly more members are now aware that PEVs are offered by CCS. The comparison of the July 2012 and December 2014 survey indicate that members have: ncreased their familiarity and experiences with PEVs; continue to have strong support for PEVs as a transportation option, with slightly more support for PHEVs than BEVs; continue to have more knowledge of BEV ranges

than PHEVs, but have not significantly increased their knowledge of either over the course of two years; continue to agree that they would feel comfortable driving a PEV and that they are safe to operate; increased their awareness of PEV benefits, such as carpool lane access; and continue to report that environmental concerns and curiosity or affinity for technology are top reasons for their interest in PEVs

This evaluation suggests that enhanced driver outreach, education, and incentives are needed to ensure the proper use and in turn highest efficiency of the PEV vehicles. More specifically, for city carsharing organizations:

- **Increase driver education and awareness on vehicle charging:** it has been inferred that many of the vehicle charging failures are due to drivers not following EVSE instructions properly, rather than forgetting to plug-in the vehicle. Although CCS has provided ample instructions on how to use PEVs and EVSE on their website, it may not be read or used as often as they should be. The following ideas may help to alleviate this problem: a) Update the user interface design of the reservation portal so that drivers must watch a short (30-90 second) instructional video on EVSE equipment prior to finalizing their first PEV reservation and b) Keep laminated copies of the EVSE charging instructions in the in the door side pocket of the vehicle
- **Implement fees for drivers who do not plug-in PHEVs after their reservation has ended:** ICF found that the CCS PHEVs were often not properly charged, even several months into the program when the education and outreach campaign had been launched.
- **Focus on PHEV deployment.** Given the low reservation rate of BEVs compared to other vehicles, including PHEVs, it seems that CCS should focus its efforts on PHEV deployment. These low reservation rates make it very difficult to recoup the upfront investment made in BEVs, which are generally more expensive than PHEVs. If CCS's efforts to improve the charging of PHEVs (as described in the first two bullets) are successful, it will only justify further a focus on PHEVs.

And for granting agencies, ICF recommends that they tie funding to performance of existing vehicles. ICF recommends phasing in funds towards fleets to ensure that they are maximizing their existing PEVs before providing additional funding. As it stands, CCS derived little GHG benefit from PEV deployment; however, there is little incentive to ensure that these vehicles are achieving their maximum GHG reduction potential. Although the improved charging will to more to improve the cost-effectiveness of this strategy (by increasing the denominator in the cost-effectiveness metric), it is also important to find cost reductions. The focus on PHEV deployment, for instance, will help on the vehicle cost side; however, there is not much else that CCS can do to reduce this cost element. However, ICF also found that the program operations costs accounted for as much as 35-40% of the overall cost. The other costs—fuel and charging equipment, marketing and outreach, and administration and evaluation—collectively accounted for less than program operations. ICF anticipates that CCS will be able to demonstrate operational cost reductions if future funding is tied to performance of existing vehicle deployments – as measured by cost, GHG reductions, and cost-effectiveness.

5.2 Local Government EV Fleet

The introduction of electric vehicles into government fleets is expected to reduce substantially GHG and criteria pollutant emissions. Although the deployment of EVs and the installation of EVSE are only in their initial stages, there are a number of recommendations that could help improve the implementation of similar projects and maximize the benefits.

- **Manage EV deployment to maximize use:** Make sure EVs are placed in the locations or fleet applications that maximize their use and draw drivers away from gasoline vehicles. EVs are not appropriate or the best choice for all applications. For example, they have limited range and may not meet the needs of the users who must take longer trips. Or, an EV assigned to a single user who does not regularly use the vehicle may be better utilized in a shared pool setting with multiple users driving the vehicle more frequently.
- **Collect detailed trip, fueling, and charging data for all fleet vehicles:** Analyzing vehicle usage patterns is essential to ensuring that EVs are being utilized fully and appropriately. Tracking miles traveled for both gasoline and electric vehicles by trip can help identify if there are additional opportunities to shift trips being taken in gas vehicles to trips taken in EVs. Also, monitoring mileage and fueling/charging can help keep track of vehicle efficiency; high kWh or gasoline gallons per mile can indicate vehicle problems or even inefficient driving behaviors.
- **Educate drivers on proper EV use and charging:** Drivers unfamiliar with electric vehicles may use the vehicles or charging equipment incorrectly or may avoid using the vehicles altogether; many aspects of

driving an EV (e.g., starting the car or plugging it in after a trip) are significantly different from their typical driving experience. Introducing potential users to EVs through ride and drive events and other outreach efforts can help reduce their hesitation. Also providing clear step-by-step instructions in the vehicle can prevent misuse. Encouraging new drivers into EVs can also have the added co-benefit of increasing interest and use of EVs outside of the government fleet setting.

5.3 Tribal Community Sustainable Transportation Pilot

The GHG emission reduction results suggest that driving standard hybrid vehicles could result in emission reduction benefits on par with more advanced and expensive electric vehicles. This is perhaps not unexpected given the driving and charging behaviour experienced by the EVs during the reporting period. Because of the lack of conveniently accessible charging infrastructure, the EVs were not being charged regularly. Thus, the all-electric RAV4 EVs were not being driven often and the C-MAX PHEVs were being driven as standard gasoline hybrids. **Error! Reference source not found.** shows the frequency of total miles per trip day (i.e., sum of miles on any given day) driven in the C-MAX PHEVs. About half of the days a C-MAX was driven, the vehicle was driven 90 or less miles. This distance is comfortably within the 100-mile range of the RAV4 EVs. If these shorter trips were shifted from the C-MAX, which only drives its first 20 miles or so in all-electric mode, to the RAV4 EVs, the emission reduction benefits could increase.

Although this project is still being implemented, with some significant tasks such as EVSE installation still to be completed, there are a number of lessons learned ever before full deployment of the project. Specific recommendations and lessons learned are provided below.

- **Select vehicles based on typical driving patterns:** The Kashia Tribal Office purchased two all-electric vehicles and two plug-in hybrid electric vehicles. Although both types of EVs take advantage of on-board batteries to drive emission-free miles, the selection of electric-only versus hybrid can have broad implications on benefits and costs. The battery electric vehicles have longer electric ranges than the PHEVs, but the range is less than a hybrid's combined electric and gasoline range. If a vehicle is needed for a mix of short and long trips (current BEVs have ranges of 80-100 miles), a hybrid is probably advised. But, if the vehicle is only going to be used for long trips, it may be more cost-effective to acquire a standard hybrid vehicle; when driving beyond the first 20 miles, the plug-in hybrids have the same fuel economy as a standard hybrid.
- **Plan for convenient access to charging stations:** Before acquiring a plug-in vehicle, make sure there is or will be easy and convenient access to charging equipment at locations where the vehicle is typically parked. Although this may seem an obvious recommendation, it is easy to overlook the need for convenient charging opportunities when focused on acquiring an EV. As seen in this evaluation of EVs deployed before charging stations were available, EV benefits cannot be fully realized without accessible EVSE; although it should be noted that the agency was able to acquire valuable discounts by moving quickly to purchase EVs, improving their value proposition.
- **Educate drivers and monitor use to identify potential improvements:** The deployment electric vehicles to users unfamiliar with the driving and fueling characteristics of EVs will benefit from education of all potential drivers. A typical concern from new drivers is the shorter range and more restrictive fueling requirements. However, a review of the trip data may show that such range anxiety is unnecessary. For example, the trip logs from this project show that 50% of the trips taken by the PHEV could have been taken in the underutilized all-electric vehicle instead. Shifting these trips to the BEV would reduce emissions and reduce fueling costs.

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