Methods to Assess Co-Benefits of California Climate Investments

Transportation User Costs

Center for Resource Efficient Communities, UC-Berkeley
Agreement #15TTD002, Project Order #1, Task 2 Literature Review
Primary Author: Mustapha Harb

I. Background

Under California's Cap-and-Trade program, the State's portion of the proceeds from Cap-and-Trade auctions is deposited in the Greenhouse Gas Reduction Fund (GGRF). The Legislature and Governor enact budget appropriations from the GGRF for State agencies to invest in projects that help achieve the State's climate goals. These investments are collectively called California Climate Investments (CCI).

Senate Bill 862 requires the California Air Resources Board (CARB) to develop guidance on reporting and quantification methods for all State agencies that receive appropriations from the GGRF. Guidance includes developing quantification methodologies for greenhouse gas (GHG) emission reductions and other social, economic, and environmental benefits of projects, referred to as "co-benefits."

This document is one of a series that reviews the available methodologies for assessing selected co-benefits for CCI projects at two phases: estimating potential project-level co-benefits prior to project implementation (i.e., forecasting of co-benefits), and measuring actual co-benefits after projects have been implemented (i.e. tracking of co-benefits). The assessment methodology at each of these phases may be either quantitative or qualitative. As with CARB's existing GHG reduction methodologies, these co-benefit assessment methods will be developed to meet the following standards:

- Apply at the project level
- Align with the project types proposed for funding for each program
- Provide uniform methods to be applied statewide, and be accessible by all applicants
- Use existing and proven tools or methods where available
- Use project level data, where available and appropriate
- Reflect empirical literature

CARB, in consultation with the state agencies and departments that administer CCIs, has selected ten co-benefits to undergo methodology assessment and development. This document reviews available empirical literature on the ***transportation user costs*** co-benefit and identifies:

- the direction and magnitude of the co-benefit,
- the limitations of existing empirical literature,
- the existing assessment methods and tools,
- knowledge gaps and other issues to consider in developing co-benefit assessment methods
- a proposed assessment method for further development
- an estimation of the level of effort and delivery schedule for a fully developed method

II. Co-benefit description

Several CCI programs make substantial investments in new or upgraded transportation systems and services, low-emission vehicles (LEVs) and zero-emission vehicles (ZEVs). In addition to the GHG emission reduction benefits that these investments will produce, they will also affect the costs that users of transportation systems incur to travel.

The transportation user cost co-benefit applies to any situation in which a) travelers may be expected to switch travel modes, and therefore experience either cost savings or increased costs for travel, as a result of a CCI, or b) travelers will be using an LEV or ZEV in place of a conventional gas-powered vehicle, and therefore experience either cost savings or increased costs for vehicle operation, as a result of a CCI.

The purchase cost of LEVs or ZEVs, which is higher compared to conventional vehicles, is not included in the scope of this analysis. However, CCI programs (e.g. Low Carbon Transportation) provide a grant or rebate assistance in the purchase of such vehicles to offset part of this cost differential. Grants range from $1.5K to $7K depending on the car model and the income of applicant. These grants are not being considered as cost savings because they only offset part of the cost differential, meaning the applicant could have spent less money purchasing a conventional vehicle instead of an LEV or a ZEV. In addition, this co-benefit does not include the vehicle operation cost savings (or increased costs) that a transit agency or other institutional vehicle operator may experience as a result of a CCI. Those potential savings are considered in the co-benefit covering energy and fuel costs savings to project applicants (as opposed to users of transportation systems).

Projects within the following CCI programs may be able to document the transportation user costs co-benefit:

***Table 1**: CCI Programs Affected by Co-Benefit*

Program	Project	Likely direction of co-benefit (+ = beneficial change)
Sustainable Communities and Clean Transportation		
HSRA	High Speed Rail	+
CARB	Low Carbon Transportation (LCT)	+
CalSTA	Transit and Intercity Rail Capital Program (TIRCP)	+
Caltrans	Low Carbon Transit Operations (LCTOP)	+
Caltrans	Active Transportation Program (ATP)	+
SGC	Affordable Housing and Sustainable Communities (AHSC)	-
SGC	Transformative Climate Communities (TCC)	+/-
Natural Resources and Waste Diversion		
CNRA	Urban Greening Program	+

III. Directionality of the co-benefit:

Transportation user costs can be affected either positively or negatively by CCIs. For projects stimulating mode substitution, direct user cost comparisons depend upon the length of trips since automobile operating expenses are estimated on a per-mile basis but many transit systems (especially bus systems) operate with flat or coarsely graduated fares that may be relatively cheaper for longer journeys. In general, use of transit is likely to be cheaper (and thus produce a positive user cost co-benefit) in situations where the journeys are relatively long, or where transit use may enable a traveler to avoid the costs of parking and tolls. For the High Speed Rail project, potential mode shifts from air travel are likely to produce positive user cost co-benefits at the HSR’s anticipated ticket prices.

For projects stimulating vehicle substitution, the co-benefit will generally be positive since the operating costs of an LEV or ZEV are generally lower than that of a conventional gas vehicle.

IV. Magnitude of co-benefit:

For transit projects that stimulate mode substitution, the magnitude of this co-benefit depends on the size of the project and the number of users it will attract. For individual transit users, the amount saved (or newly expended) by a user of the new transit option will be the difference between the fare of the transit system and the average cost of making the same trip by car. Given that most standard, single-trip bus fares and light rail fares in California range from $1.50 to $3.50, many trips would need to be at least three to seven miles in length, respectively, to be cheaper than automobiles given typical automobile operating costs (see below). However, many transit users (particularly seniors, children, and students) benefit from various fare discounts or purchase bulk ride passes, driving down the per-trip cost of transit use. In certain large cities, transit use may also help travelers avoid costs of parking and tolls. At the program level, the magnitude of savings (or increased expenses) will therefore depend on the number of users switching from personal cars to the new or upgraded system, as well as the route and the average length of the trip the users make.

The High Speed Rail (HSR) project will likely stimulate mode switching from airline travel to rail travel. A study conducted by Parsons Brinkerhoff, Cambridge Systematics, and Systra concluded that the average fare of the HSR will be 50% of that of airfare for comparable routes[8]. This is consistent with experience in Europe, showing a roughly 2:1 ratio of airfare to HSR fares[4]:

Ratio: Air fare / HSR fare	Business	Non-Business
Paris-Marseille	1.77	2.63
Madrid-Seville	1.29	1.81
Frankfurt-Hamburg	1.43	2.17
Rome-Milan	2.32	2

Table 1. Ratio of airfares to high-speed rail fare on selected European corridors.

For projects that stimulate vehicle substitution, the magnitude of the co-benefit will be depend upon the number of drivers exchanging vehicles and the difference in operating costs between the old conventional vehicle and the new LEV and ZEV vehicles. Not only is electricity in California generally cheaper than gasoline when used as a vehicle fuel, but several studies have also shown that electric vehicles are cheaper to maintain than conventional ones. A study by the University of California Transportation Center estimated that electric vehicles would have 50% to 75% of the average maintenance cost of a conventional vehicle[6] (Delucchi et al, 1989). A more recent study by the Institute of Transportation Studies at UC Davis, as part of a report for CARB, concluded that the maintenance cost of electric vehicles is 75% of that of conventional vehicles[7] (Delucchi et al, 2000). The same study mentions that the US Department of Energy and General Motors use a 50% maintenance reduction when considering electric vehicles maintenance costs[6]. Dixon and Garber estimated 0 to 33% reduction in maintenance cost, while Humphreys and Brown assumed a 40% reduction in EV maintenance cost[7]. No studies to date have compared the maintenance costs of hybrid vehicles to conventional vehicles.

In each case, the per-mile costs to operate conventional gas automobiles is a key input. The California Department of Human Resources annually updates the reimbursement rates for personal car use[5] (CDHR, 2017). For 2017, the rate is \$0.535 per mile. This rate includes gas, maintenance, insurance, registration, and depreciation. The American Automobile Association (AAA) also releases a yearly national estimate of the per mile costs associated with driving[1] (AAA, 2016). This rate also includes gas, maintenance, insurance, registration, depreciation, as well as the costs of licenses, tires, and vehicle financing. For a small sedan, the AAA national per-mile cost of driving sums up to \$0.599, \$0.464, or \$0.394 when assuming 10K, 15K, and 20K miles driven per year respectively. In Table 3 we corrected for the cost of fuel used by AAA by replacing the national average cost of fuel with that of California.

To estimate the per-mile cost of driving electrically powered vehicles in Table 3 (attached at the end of this document), we used the following formula:

$$\text{Electricity} = \frac{60\ \text{KWh} * \frac{0.1887\$}{\text{KWh}}}{238\ \text{miles}} = \frac{0.0476\$}{mile} \qquad Equation\ (1)$$

The formula incorporates the following assumptions:

- Battery used in calculation is that of a Chevy Bolt EV (60 KWh)
- On average, the battery driving range is 238 miles
- The California cost of electricity is 0.1887\$/KWh

Given the study findings summarized above, we conservatively estimated the maintenance costs of electric vehicles as:

$$\text{Maintenance} = 0.75 * \text{Maintenance of conventional car} = \frac{0.0361\$}{\text{mile}} \qquad Equation\ (2)$$

where maintenance cost of a conventional vehicle is the per mile cost calculated by AAA.

Some alternative fuel vehicles are powered by fuels other than electricity, including biodiesel and natural gas. According to the US Department of Energy, the only difference in operating cost from a conventional vehicle is the cost of fuel, since the two vehicles have the same components and will require similar maintenance[3]. The most recent available west coast and national averages for prices of alternative fuels are presented in Table 2.

Fuel	West Coast Region Cost per Unit	West Coast Region Cost per GGE	National Average Cost per Unit	National Average Cost per Unit
Biodiesel (B20)	$2.55/gallon	$2.32/GGE	$2.49/gallon	$2.27/GGE
Biodiesel (B99–B100)	$3.14/gallon	$3.11/GGE	$3.09/gallon	$3.06/GGE
Ethanol (E85)	$2.49/gallon	$3.51/GGE	$2.11/gallon	$2.98/GGE
Natural Gas (CNG)	$2.46/GGE	$2.46/GGE	$2.15/GGE	$2.15/GGE
Propane	$3.02/gallon	$4.17/GGE	$2.83/gallon	$3.91/GGE
Gasoline	$2.84/gallon	$2.84/GGE	$2.38/gallon	$2.38/GGE
Diesel	$2.89/gallon	$2.60/GGE	$2.55/gallon	$2.30/GGE

Table 2. National average retail fuel prices, as of April 2017 (USDOE 2017).

V. Limitations of current studies:

The California and AAA per-mile estimates of the cost of driving rely on average values of components and several simplifying assumptions are made to facilitate the quantification. AAA uses national averages for every component of the per-mile cost of driving. California generally has higher fuel costs than the national average[2], also the tax rates and labor cost (which affects the maintenance cost), may be different from the national average, so the AAA values and estimates for these components of the overall driving cost may not be precisely accurate when applied to California.

VI. Existing quantification methods and tools

Transportation user cost co-benefits for various types of CCIs can be directly calculated using simple equations that rely upon readily available inputs.

<u>*Transit and High Speed Rail projects*</u>

For transit and High Speed Rail projects, the total user cost co-benefit may be calculated as:

Total user cost co-benefit = total user cost of driving (or flying) – total user cost of transit system use – avoided parking costs (if any) – avoided tolls (if any)

Equation (3)

Where:
*Total user cost of driving = cost per mile * avoided vehicle miles traveled (VMT)*

Equation (4)

*Total user cost of transit system use = number of new users switching from car to transit * average fare of using the transit system*

Equation (5)

The cost per mile of driving can vary depending upon the type of vehicles being driven (i.e. small sedan, medium sedan, and large sedan), as shown in Table 3 (attached to the end of this document). Avoided parking and toll costs may be relevant factors for certain transit projects, particularly for those that are anticipated to reduce driving in urban downtowns or commercial districts, or on key bridges.

Low-emission vehicles

For programs that replace conventional vehicles with low-emitting ones, the total user cost co-benefit may be calculated as:

Total user cost co-benefit = cost of driving conventional vehicle – cost of driving low-emitting vehicle

Equation (6)

Where:

*Cost of driving conventional vehicle = cost per mile of conventional vehicle * total vehicle miles traveled (VMT)*

Equation (7)

*Cost of driving low-emitting vehicle = cost per mile of low-emitting vehicle * total vehicle miles traveled (VMT)*

Equation (8)

Active transportation (walking and bicycling), AHSC (location efficiency), and Urban Greening

For programs that stimulate walking and bicycling, or reduce automobile travel through location efficiency, the total user cost co-benefit may be calculated as:

*Total user cost co-benefit = (average cost of driving conventional car * avoided vehicle miles traveled) – (bicycle miles traveled, if relevant * average per-mile cost of bicycling)*

For active transportation projects that build bicycle infrastructure, per-mile reimbursement rates for bicycle travel used by the State of California may be multiplied by estimates of bicycle miles traveled (if known) due to the project.

VII. Knowledge gaps and other issues to consider in developing co-benefit quantification methods

The accuracy of estimating the user cost co-benefits for transit projects will depend on the accuracy of the estimates of VMT reduction calculated by CCI applicants as part of the existing GHG quantification. Many of these estimates may not be based on robust demand modeling, which require input data generated from travel surveys that may be beyond the financial and technical resources of many transit districts. In addition, as noted in Section V above, existing estimates of the per-mile cost of driving rely on statewide or nationwide averages and incorporate simplifying assumptions.

The significance of the transportation user cost co-benefit will vary by CCI program. The High-Speed Rail project is likely to produce significant transportation user cost benefits at the anticipated ticket prices, since those prices are lower than both driving costs and plane fares for journeys of comparable length. For other transit projects funded by the TIRCP and LCTOP programs, the potential significance of user cost co-benefits at both the project and program levels will depend heavily on the average length of anticipated transit journeys by users. The longer the journeys, the more likely the user cost co-benefit is to be positive.

For projects that fund the replacement of conventional gas-fueled vehicles with electric vehicles under the Low Carbon Transportation program, user cost co-benefits are likely to be significant at both the project and program levels, given the lower operating and maintenance costs of electric vehicles. Projects funded by the Low Carbon Transportation program that involve other alternative vehicle fuels may or may not create positive user cost co-benefits, depending upon specifically which fuels are proposed for use (see Table 2).

Projects that result in the net replacement of driving by non-motorized travel, such as those funded by the Affordable Housing and Sustainable Communities program, the Active Transportation program, or the Urban Greening program (for trails projects) will produce significant positive user cost co-benefits at the project and program scales.

Overall, the net effect of all CCIs is likely to be a significantly positive transportation user cost co-benefit. However, given the size of the High Speed Rail project, any significant adjustment in anticipated ticket prices could alter this overall conclusion.

VIII. Proposed method/tool for use or further development, schedule, and applicant data needs

Given these findings, we offer the following recommendations for methods to assess transportation user cost co-benefits, schedule for development of guidance documents, and applicant data needs

Methods for estimation prior to award of CCI funds

- Calculation of user cost co-benefits from the TIRCP, LCTOP, AHSC, Active Transportation, Low Carbon Transportation, and Urban Greening programs using the equations in Section V

- Calculation of user cost co-benefits from the High-Speed Rail program using the equation for transit projects in Section V plus an estimation of the avoided costs of plane travel based on the number of avoided plane trips generated as part of the HSR's GHG quantification estimation

Methods for measurement after award of CCI funds

- Application of the same equations as above using data, when available from existing GHG quantification methods, on (a) actual avoided conventional automobile VMT, or (b) new transit system ridership and average length of automobile trips avoided, as appropriate to the CCI program in questions

Schedule

Because these methods are based directly on existing GHG quantification guidance, we anticipate that we could develop draft co-benefit assessment methodology guidance within three months of CARB’s instruction to proceed.

Data needs

The High-Speed Rail project and applicants to the TIRCP, LCTOP, AHSC, Active Transportation and Urban Greening programs are required to use CARB-developed GHG quantification methodology that generates an estimate of annual average automobile VMT displaced or reduced. The High-Speed Rail GHG quantification estimation also generates an estimate of the number of plane trips avoided by use of the HSR. The Low Carbon Transportation program may be required to provide estimates of the annual VMT for each low-emission vehicle type funded by its projects as part of its GHG quantification guidance. Tables 3 and 4 (attached at the end of this document) contain data on operating costs of various vehicle types, modified for California, that can be provided to CCI project applicants in the guidance document.

The additional input data required of applicants to various programs, for both pre-award and post-award quantification, are shown below. In pre-award quantification, many of these values would be estimates; in post-award quantification, awardees would be asked to use actual observed data, when available.

High Speed Rail:

- Number of users switching from automobile to the HSR
- Average fare paid by HSR riders
- Average plane fare for avoided plane trips (or default value could be established in guidance)

TIRCP and LCTOP:

- Number of users switching from automobile to transit system
- Average fare for the new service improvement, when known, or of transit system as a whole
- Estimated avoided parking (if relevant and known)
- Estimated avoided tolls (if relevant and known)

Active Transportation, AHSC, and Urban Greening:

- For bicycle projects, bicycle miles traveled (if known)

Low Carbon Transportation:

- Vehicle type (e.g. hybrid, battery electric vehicle, etc).

IX. Bibliography:

1. *AAA Association Communication. YOUR DRIVING COSTS How much are you really paying to drive? Heathrow, FL, 2016.*

2. *AAA Association Communication.* http://gasprices.aaa.com/

3. Alternative Fuels Data Center. U.S Department of Energy. Maintenance and Safety of Hybrid and Plug-In Electric Vehicles: http://www.afdc.energy.gov/vehicles/electric_maintenance.html

4. Barron, Ignacio, Javier Campos, Philippe Gagnepain, Chris Nash, and Andreu Ulied. *Economic Analysis of High Speed Rail in Europe*. Spain: Foundation BBVA, 2009.

5. California Department of Human Resources. Personal Vehicle Mileage Reimbursement: http://www.calhr.ca.gov/employees/Pages/travel-personal-vehicle.aspx

6. Delucchi, Mark, Quanlu, Wang, and Daniel, Sperlin. "electric vehicles: performance, life-cycle costs, emissions, and recharging requirements." *Transportation Research Part A* 23A (February 1989): 255-78.

7. Delucchi, Mark, Tim Lipman, Andy Burke, and Marshall Miller. "Electric and Gasoline Vehicle Lifecycle Cost and Energy-Use Model." *Institute of Transportation Studies. UC Davis: Institute of Transportation Studies (UCD)* (April 1, 2000). http://escholarship.org/uc/item/1np1h2zp

8. Parsons Brinckerhoff, Cambridge systematics, Systra. *California High-Speed Train Project, Ridership and Revenue Forecasts, 2010*

AUG 18, 2017

	small Sedan (ICEV)	*small Sedan (BEV)*	**medium sedan (ICEV)**	*medium sedan (BEV)*	**large sedan (ICEV)**	*large sedan (BEV)*	**SUV (ICEV)**	*SUV (BEV)*	**Minivan (IEV)**	*Minivan (BEV)*
operating cost	**per mile**	***per mile***	**per mile**	***per mile***	**per mile**	***per mile***	**per mile**	***per mile***	**per mile**	***per mile***
gas/ electricity	**$0.0940**	$0.0476	**$0.1101**	$0.0476	**$0.1420**	$0.0476	**$0.1488**	$0.0476	**$0.1371**	$0.0476
maintenance	**$0.0481**	$0.0361	**$0.0539**	$0.0404	**$0.0563**	$0.0422	**$0.0592**	$0.0444	**$0.0532**	$0.0399
tires	**$0.0070**	$0.0070	**$0.0125**	$0.0125	**$0.0104**	$0.0104	**$0.0130**	$0.0130	**$0.0088**	$0.0088
total cost per mile	**$0.1491**	$0.0907	**$0.1765**	$0.1005	**$0.2087**	$0.1002	**$0.2210**	$0.1050	**$0.1991**	$0.0963
ownership cost	**per year**	***per year***	**per year**	***per year***	**per year**	***per year***	**per year**	***per year***	**per year**	***per year***
insurance	**$1,169**	*$1,169*	**$1,208**	*$1,208*	**$1,288**	*$1,288*	**$1,212**	*$1,212*	**$1,128**	*$1,128*
License + registration	**$502**	*$502*	**$701**	*$701*	**$857**	*$857*	**$838**	*$83*	**$732**	*$732*
License + registration (SB1) *	**$502.0000**	$602.0000	**$701.0000**	$801.0000	**$857.0000**	$957.0000	**$838.0000**	$938.0000	**$732.0000**	$832.0000
depreciation	**$2,568.**	*$2,568*	**$3,729**	*$3,729*	**$4,917**	*$4,917*	**$4,639**	*$4,639*	**$4,235**	*$4,235*
finance charge	**$481**	*$481*	**$698**	*$698*	**$869**	*$869*	**$848**	*$848*	**$731**	*$731*
cost per year	**$4,720**	*$4,720*	**$6,336**	*$6,336.*	**$7,931**	*$7,931*	**$7,537**	*$7,537*	**$6,826**	*$6,826.*
cost per year*	**$4,720.0000**	$4,820.0000	**$6,336.0000**	$6,436.0000	**$7,931.0000**	$8,031.0000	**$7,537.0000**	$7,637.0000	**$6,826.0000**	$6,926.0000
cost per day	**$12.93**	*$12.93*	**$17.35**	*$17.35*	**$21.72**	*$21.72*	**$20.64**	*$20.64*	**$18.70**	*$18.70*

Table 3. Disaggregated operating and ownership costs for various vehicle types from AAA, partially adjusted for California fuel prices

	Total cost per mile	small Sedan (ICEV)	*small Sedan (BEV)*	medium sedan (ICEV)	*medium sedan (BEV)*	large sedan (ICEV)	*large sedan (BEV)*	SUV (ICEV)	*SUV (BEV)*	Minivan (ICEV)	*Minivan (BEV)*
10,000 miles per year	cost/mile * miles	**$1,490.5**	$906.8	**$1,764.7**	$1,005.3	**$2,087.2**	$1,002.3	**$2,210.5**	$1,050.0	**$1,991.1**	$963.0
	cost per year	**$4,720.0**	$4,720.0	**$6,336.0**	$6,336.0	**$7,931.0**	$7,931.0	**$7,537.0**	$7,537.0	**$6,826.0**	$6,826.0
	cost per year*	**$4,720.0**	$4,820.0	**$6,336.0**	$6,436.0	**$7,931.0**	$8,031.0	**$7,537.0**	$7,637.0	**$6,826.0**	$6,926.0
	decrease depreciation*	**-$220.0**	-$220.0	**-$290.0**	-$290.0	**-$324.0**	-$324.0	**-$303.0**	-$303.0	**-$236.0**	-$236.0
	total cost per year	**$5,990.5**	$5,406.8	**$7,810.7**	$7,051.3	**$9,694.2**	$8,609.3	**$9,444.5**	$8,284.0	**$8,581.1**	$7,553.0
	total cost per year*	**$5,990.5**	$5,506.8	**$7,810.7**	$7,151.3	**$9,694.2**	$8,709.3	**$9,444.5**	$8,384.0	**$8,581.1**	$7,653.0
	cost per mile	**$0.599**	$0.541	**$0.781**	$0.705	**$0.969**	$0.861	**$0.944**	$0.828	**$0.858**	$0.755
	cost per mile*	**$0.599**	$0.551	**$0.781**	$0.715	**$0.969**	$0.871	**$0.944**	$0.838	**$0.858**	$0.765
15,000 miles per year	cost/mile * miles	**$2,235.8**	$1,360.1	**$2,647.0**	$1,507.9	**$3,130.8**	$1,503.4	**$3,315.7**	$1,575.0	**$2,986.6**	$1,444.5
	cost per year	**$4,720.0**	$4,720.0	**$6,336.0**	$6,336.0	**$7,931.0**	$7,931.0	**$7,537.0**	$7,537.0	**$6,826.0**	$6,826.0
	cost per year*	**$4,720.0**	$4,820.0	**$6,336.0**	$6,436.0	**$7,931.0**	$8,031.0	**$7,537.0**	$7,637.0	**$6,826.0**	$6,926.0
	decrease depreciation*	**$0.0**	$0.0	**$0.0**	$0.0	**$0.0**	$0.0	**$0.0**	$0.0	**$0.0**	$0.0
	total cost per year	**$6,955.8**	$6,080.1	**$8,983.0**	$7,843.9	**$11,061.8**	$9,434.4	**$10,852.7**	$9,112.0	**$9,812.6**	$8,270.5
	total cost per year*	**$6,955.8**	$6,180.1	**$8,983.0**	$7,943.9	**$11,061.8**	$9,534.4	**$10,852.7**	$9,212.0	**$9,812.6**	$8,370.5
	cost per mile	**$0.464**	$0.405	**$0.599**	$0.523	**$0.737**	$0.629	**$0.724**	$0.607	**$0.654**	$0.551
	cost per mile*	**$0.464**	$0.412	**$0.599**	$0.530	**$0.737**	$0.636	**$0.724**	$0.614	**$0.654**	$0.558

20,000 miles per year	cost/mile * miles	**$2,981.1**	$1,813.5	**$3,529.3**	$2,010.5	**$4,174.4**	$2,004.5	**$4,421.0**	$2,100.0	**$3,982.1**	$1,926.0
	cost per year	**$4,720.0**	$4,720.0	**$6,336.0**	$6,336.0	**$7,931.0**	$7,931.0	**$7,537.0**	$7,537.0	**$6,826.0**	$6,826.0
	cost per year*	**$4,720.0**	4,820.0	**$6,336.0**	6,436.0	**$7,931.0**	8,031.0	**$7,537.0**	7,637.0	**$6,826.0**	6,926.0
	increase depreciation*	**$175.0**	$175.0	**$225.0**	$225.0	**$256.0**	$256.0	**$290.0**	$290.0	**$225.0**	$225.0
	total cost per year	**$7,876.1**	$6,708.5	**$10,090.3**	$8,571.5	**$12,361.4**	$10,191.5	**$12,248.0**	$9,927.0	**$11,033.1**	$8,977.0
	total cost per year*	**$7,876.1**	$6,808.5	**$10,090.3**	$8,671.5	**$12,361.4**	$10,291.5	**$12,248.0**	$10,027.0	**$11,033.1**	$9,077.0
	cost per mile	**$0.394**	$0.335	**$0.505**	$0.429	**$0.618**	$0.510	**$0.612**	$0.496	**$0.552**	$0.449
	cost per mile*	**$0.394**	$0.340	**$0.505**	$0.434	**$0.618**	$0.515	**$0.612**	$0.501	**$0.552**	$0.454

Table 4. Overall per-mile cost of driving for various vehicle types, at three annual mileage levels

* depreciation caused by driving more/less than the average miles per year (15,000)
* cost increase due to SB1 requirements that will be effective staring 2020

Summary of assumptions and adjustments in Tables 3 and 4:

- Operating costs of conventional vehicles are from AAA's annual report on operating cost of different vehicle types
- Fuel cost was adjusted to California cost (AAA national average fuel cost is $2.139/gallon; California's is $2.92/gallon)
- Cost of electricity was assumed to be the average electricity cost in California of $0.1887/KWh
- Maintenance cost of electric vehicles was assumed to be 75% of that of a conventional vehicle (see section IV).