California Air Resources Board

Co-benefit Assessment Methodology
Travel Cost Savings

California Climate Investments
Greenhouse Gas Reduction Fund

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Section A. Introduction

The goal of California Climate Investments is to reduce greenhouse gas (GHG) emissions and further the objectives of the California Global Warming Solutions Act of 2006, Assembly Bill (AB) 32. The California Air Resources Board (CARB) is responsible for providing guidance on reporting and quantification methods for all State agencies that receive appropriations from the Greenhouse Gas Reduction Fund (GGRF). Guidance includes developing methodologies for estimating GHG emission reductions and other economic, environmental, and public health benefits of projects, referred to as "co-benefits."

The Center for Resource Efficient Communities at the University of California, Berkeley (UC Berkeley), in consultation with CARB staff, developed this Co-benefit Assessment Methodology to estimate travel cost savings for relevant California Climate Investments programs.

Co-benefit Assessment Methodologies are intended for use by administering agencies, project applicants, and/or funding recipients to estimate the outcomes of California Climate Investments. Co-benefit estimates can be used to inform project selection and track results of funded projects. In addition to this methodology, general guidance on assessing California Climate Investment co-benefits is available in CARB's Funding Guidelines for Agencies Administering California Climate Investments (Funding Guidelines) available at www.arb.ca.gov/cci-fundingguidelines.

Travel Cost Savings Co-benefit Description

Travel cost savings refers to a change in the overall cost of travel for users of the transportation system who switch travel modes (e.g., switch from driving a car to riding mass transit, biking, or walking) as a result of a California Climate Investments project. This may occur because a California Climate Investments create new transit, biking, or walking infrastructure, or new housing or land use strategies that enable residents to make better use of existing transit, biking, and walking opportunities. This methodology uses the most up-to-date travel price data available at the time of publication; CARB may modify default price values as the original source material is updated.

California Climate Investments can cause positive or negative travel cost savings co-benefits. These co-benefits may accrue directly (as a central objective of the project) or indirectly (as a consequence of project activities).

A ***positive*** travel cost savings co-benefit results when a California Climate Investments project decreases the travel costs for users by switching their travel from a more expensive to a less expensive mode.

A ***negative*** travel cost savings co-benefit results when a California Climate Investments project increases the travel costs for users by switching their travel from a less expensive to a more expensive mode. This may include some situations where travel costs increase because the ability to travel also increases (e.g., a project provides car

sharing or vanpool access to people who previously had no transit or vehicle access, adding mobility options but also costs).

Travel Cost Savings Co-benefit Projects

This Co-benefit Assessment Methodology may apply to California Climate Investments[1] projects that involve:

- Transit service expansion, infrastructure, or vouchers;
- Affordable housing; and
- Active transportation infrastructure.

California Climate Investments that result in travel cost savings co-benefit do so as a result of transportation mode-switching. Transit projects can result in mode-shift by enabling people to ride a bus or train instead of driving or flying by creating, expanding, connecting, or modernizing public transit service or by providing vouchers for public transit. Location efficiency and active transportation projects can result in mode-shift by stimulating the use of mass transit or active transportation by improving accessibility and building sidewalks, bike paths, protected lanes or urban trails.

This methodology focuses on cost savings from mode shift only. Cost savings for drivers of more fuel-efficient vehicles and cost savings for transit agencies and operators are estimated using the Energy and Fuel Cost Savings Co-benefit Assessment Methodology[2] and are not included here to avoid double-counting of co-benefits.

Methodology Development

UC Berkeley developed this Co-benefit Assessment Methodology, consistent with the guiding principles of California Climate Investments. The methodology is developed to:

- Support calculating the applicable co-benefits for individual projects;
- Apply to the project types proposed for funding;
- Provide uniform methods that can be applied statewide and are accessible by all applicants and funding recipients;
- Use existing and proven tools or methods, where available;
- Include the expected period of time for when co-benefits will be achieved; and
- Identify the appropriate data needed to calculate co-benefits.

[1] This list is based off of project types funded by the Greenhouse Gas Reduction Fund as of April 2018 and may be modified as California Climate Investments evolve or expand.
[2] www.arb.ca.gov/cci-cobenefits

UC Berkeley assessed peer-reviewed literature and consulted with experts, as needed, to identify:

- The direction and magnitude of the co-benefit;
- Project types to which the co-benefit is relevant;
- The limitations of existing empirical literature;
- Existing assessment methods and tools; and
- Knowledge gaps and other issues to consider in developing co-benefit assessment methods.

This work is summarized in a literature review on this co-benefit, which can be found at: www.arb.ca.gov/cci-cobenefits. UC Berkeley also considered ease of use, specifically the availability of project-level inputs from users for the applicable California Climate Investments programs.

CARB released the Draft Travel Cost Savings Co-benefit Assessment Methodology for public comment in April 2018. This Final Travel Cost Savings Co-benefit Assessment Methodology has been updated to address public comments, where appropriate. CARB staff periodically review each methodology to evaluate its effectiveness and update methodologies to make them more robust, user-friendly, and appropriate to the projects being quantified.

Administering agencies, project applicants, and/or funding recipients estimate GHG emission reductions using CARB GHG Quantification Methodologies and Calculator Tools. Some of the data used for estimating GHG emission reductions may also be used to estimate travel cost savings co-benefits. CARB anticipates incorporating methods used to estimate the travel cost savings co-benefit into CARB Calculator Tools.

Program Assistance

For assistance with this Co-benefit Assessment Methodology, send questions to: GGRFProgram@arb.ca.gov. For more information on CARB's efforts to support implementation of California Climate Investments, see: www.arb.ca.gov/auctionproceeds.

Section B. Co-benefit Assessment Methods

This section describes how users estimate travel cost savings co-benefits. Overall, the methods for assessing the travel cost savings are quantitative, amounting to estimating the level of mode shift and the associated costs to travelers during the project quantification period[3] compared to a no-project scenario.

Additional information about the specific data inputs (e.g., default values and data sources) is provided in Section C and Appendix A. Examples of how to apply the methods and data inputs needed for a transit project and an active transportation project are provided in Appendices B and C, respectively.

Travel Cost Savings is estimated using the equations below. Not all equations will apply to every project; users only need to determine inputs that are relevant to the project. If a project results in travelers switching from vehicle travel to both transit and active transportation, users need to estimate the approximate proportion of avoided vehicle miles traveled (VMT) that is attributable to each measure.

In general, travel cost savings is calculated using the following approach:

$$Travel\ Cost\ Savings/Increase\ = (Travel\ Cost\ of\ Baseline\ Mode - Travel\ Cost\ of\ New\ Mode) \times Quantification\ Period \quad \text{(Eq. 1)}$$

Travel cost savings during the project quantification period ($) should be reported as a positive (+) dollar value and cost increases should be reported as a negative (-) dollar value.

The Travel Cost of Baseline Mode is the cost associated with the mode of travel a user switches from. California Climate Investments projects typically have a baseline travel mode of personal auto vehicles or air planes. Travel Cost of Baseline Mode is calculated using the following approach:

$$Travel\ Cost\ of\ Baseline\ Mode = Operation\ Cost_{Base} + Parking\ Cost_{Base} + Toll\ Costs_{Base} \quad \text{(Eq. 2)}$$

Operation Costs, Parking Costs, and Toll Costs are calculated using Equations 3 through 5, respectively.

$$Operation\ Cost_{Base} = Cost\ Per\ Mile_{Base} \times Miles_{Base} \quad \text{(Eq. 3)}$$

Where:

- Operation $Cost_{Base}$ = The cost of airfare or the cost to operate the vehicle for the length of the trip(s) ($)
- Cost Per $Mile_{Base}$ = The cost per mile of airfare or to operate the vehicle ($ per mile)
- $Miles_{Base}$ = The total air or vehicle mileage for the trip(s) (miles)

[3] The project quantification period varies for the different programs and is defined in each of CARB's GHG Quantification Methodologies and Calculator Tools.

$$Parking\ Cost_{Base} = Avoided\ Parking_{Wd} \times Parking\ Cost_{Wd} + Avoided\ Parking_{We} \times Parking\ Cost_{We}$$ (Eq. 4)

Where:

- Parking $Cost_{Base}$ = The cost of parking associated with baseline trip(s) ($)
- Avoided $Parking_{Wd}$ = The expected avoided parking on weekdays associated with the increase in transit ridership, bike trips, or pedestrian trips (roundtrips)
- $Cost_{Wd}$ = The weekday cost for parking ($ per trip)
- Avoided $Parking_{We}$ = The expected avoided parking on weekends associated with the increase in transit ridership, bike trips, or pedestrian trips (roundtrips)
- $Cost_{We}$ = The weekend cost for parking ($ per trip)

$$Toll\ Cost_{Base} = Avoided\ Tolls \times Toll\ Rate$$ (Eq. 5)

Where:

- Toll $Cost_{Base}$ = The cost of tolls associated with baseline trip(s) ($)
- Avoided Tolls = The expected avoided tolls associated with the increase in transit ridership, bike trips, or pedestrian trips (trips)
- Toll Rate = The cost of tolls avoided ($ per trip)

The Travel Cost of New Mode is the cost associated with the mode of travel a user switches to. California Climate Investments projects typically have a new travel mode of public transit, bicycling, or walking. Travel Cost of New Mode is calculated using the following approach:

$$Travel\ Cost\ of\ New\ Mode = Transit\ Costs_{New} + Parking\ Costs_{New} - Transit\ Voucher\ Costs_{New} + Active\ Transportation\ Costs_{New}$$ (Eq. 6)

Not all inputs to the equation above are applicable for all project types. Transit Costs, Parking Costs, Transit Voucher Costs, and Active Transportation Costs[4] can be calculated using Equations 7 through 10, respectively.

$$Tranist\ Cost_{New} = User\ Increase \times Average\ Fare$$ (Eq. 7)

Where:

- Transit $Cost_{New}$ = The cost of transit fares associated with the increase in ridership ($)
- User Increase = The expected increase in transit ridership (trips)
- Average Fare = The average transit system one-way fare ($ per trip)

[4] Active transportation costs are the costs associated with bicycles, walking trips are assumed to be free of cost.

$$Parking\ Cost_{New} = Avoided\ Parking_{Wd} \times Cost_{Wd} + Avoided\ Parking_{We} \times Cost_{We} \quad \text{(Eq. 8)}$$

Where:

- Parking $Cost_{New}$ = The cost of parking associated with new mode trip(s) ($)
- Avoided $Parking_{Wd}$ = The expected parking on weekdays associated with the increase in transit ridership (roundtrips)
- $Cost_{Wd}$ = The weekday cost for parking ($ per trip)
- Avoided $Parking_{We}$ = The expected parking on weekends associated with the increase in transit ridership (roundtrips)
- $Cost_{We}$ = The weekend cost for parking ($ per trip)

$$Transit\ Voucher\ Cost_{New} = Voucher\ Value \times Voucher\ Quantity \quad \text{(Eq. 9)}$$

Where:

- Transit Voucher $Cost_{New}$ = The value associated with all of the vouchers provided by the project ($)
- Voucher Value = The value associated with each individual voucher provided by the project ($ per voucher)
- Voucher Quantity = The number of vouchers provided by the project (vouchers)

$$Active\ Transportation\ Cost_{New} = Cost\ Per\ Mile_{Bicycle} \times Miles_{Bicycle} \quad \text{(Eq. 10)}$$

Where:

- Active Transportation $Costs_{New}$ = The cost to operate the bicycle for the length of the trip(s) ($)
- Cost Per $Mile_{Bicycle}$ = The cost per mile to operate the bicycle ($ per mile)
- $Miles_{Bicycle}$ = The total bicycle mileage for the trip(s) (miles)

Section C. Data Requirements and Tools

This section describes the data requirements and tools required for the Travel Cost Savings Co-benefit Assessment Methodology. The data that a user will need to provide will vary by project category and may include the following:

- **Cost Per Mile:** The cost per mile rate for driving and biking is the cost per California Department of Transportation Mileage Reimbursement Rates. As of January 1, 2018, the State of California mileage reimbursement rate for personal vehicles and bicycles is 54.5 cents per mile and 4 cents per mile, respectively.[5] The cost per mile rate for flying is estimated using the default values from Table 1 in Appendix A.[6] For projects that enhance walking conditions, the per-mile cost of walking is assumed to be zero.
- **Miles:** The miles traveled for the baseline mode is the number of miles that would have been traveled by driving a personal vehicle (avoided VMT), or by flying, that will instead be traveled by transit or active transportation. The miles traveled by bicycle for projects that include active transportation is the distance traveled by bicycle resulting from the project, if known. If the distance traveled by bicycle due to the project is unknown, avoided VMT should be used.
- **Avoided Parking:** Avoided parking costs may be relevant for some projects, particularly those likely to reduce driving in urban downtowns or commercial districts. Avoided parking is the projected change in ridership to the downtown on weekdays and weekends. Ridership is counted in one-way trips, so for use in estimating avoided parking, ridership should be cut in half since only one parking event is included for two one-way trips (one round trip).
- **Parking Cost:** The cost of parking is the statewide averages of $11.13 per day for baseline scenario weekday trips, $1.50 per hour for baseline scenario weekend trips, and $3 per day for project scenario if there is paid parking at the transit facilities where the trip originates.[7] For parking costs associated with weekend travel, multiply the per-hour parking cost by two hours per day.
- **Toll Cost:** The toll costs may be relevant for some projects, particularly those likely to reduce driving on key bridges. If the route of the alternative transportation enables riders to avoid crossing a bridge (e.g., taking BART and avoiding the Bay Bridge), estimate avoided toll costs using the average bridge toll cost for passenger vehicles of $5 per trip[8] (i.e., Toll Rate) and multiply by the projected change in ridership on that portion of the route (i.e., Avoided Tolls).

[5] http://www.dot.ca.gov/hq/asc/travel/ch11/9priv_car.htm

[6] Table 1 refers to commercial passenger air travel. For private aircraft, the State of California mileage reimbursement rate can be found at http://www.dot.ca.gov/hq/asc/travel/ch11/9priv_car.htm

[7] http://journals.sagepub.com/doi/pdf/10.1177/1087724X13514380

[8] https://mtc.ca.gov/about-mtc/what-mtc/bay-area-toll-authority-bata

- **User increase:** The user increase (i.e., the number of travelers switching from personal vehicle or plane to transit) is estimated by the applicant in order to quantify avoided VMT and GHG emission reductions using a CARB Quantification Methodology and Calculator Tools and is typically the increase in ridership multiplied by an adjustment factor.
- **Average Fare:** The average fare is specific to each transit agency and can be estimated using the system-wide average fare in the absence of more detailed information on passenger demographics and route choices. If the system-wide average is unknown, a non-discounted adult fare can be used.
- **Voucher value:** The Voucher Value is the dollar value of an individual voucher provided by the project. If a project provides travel vouchers, the value of the vouchers contributes to the overall cost savings and are factored into the change in travel costs by multiplying the value of the individual vouchers (i.e., Voucher Value) by the number of travel vouchers distributed (i.e., Voucher Quantity).

When inputs required to estimate the travel cost savings are inputs to, or outputs from, a CARB GHG Quantification Methodology or Calculator Tool (e.g., avoided vehicle miles traveled), the values used in estimation of GHGs and co-benefits must be identical.

Appendix A. Reference Table for Cost of Flying

Average cost per mile for commercial air travel between cities/metropolitan areas in California are presented below in Table 1.

Table 1. Average Cost Per Mile for Commercial Air Travel

Northern California Origins/Destinations	Southern California Origins/Destinations		
	Los Angeles Metro Area	Palm Springs	San Diego
San Francisco Metro Area	$0.73	$0.88	$0.67
Fresno	--	--	$0.87
Sacramento	$0.78	--	$0.62
Salinas/Monterey	$0.97	--	--
Santa Rosa	$0.74	--	--

These per-mile costs used in this methodology and displayed in Table 1 are based on the average city-pair commercial airfare and distance as tracked by the U.S. Department of Transportation.[9] For each pair of cities or metropolitan areas, the average one-way airfare is doubled for an average round-trip airfare, displayed in Table 2 below. This is divided by the number of miles between cities, also displayed in Table 2.

Table 2. Calculations Used to Derive Average Cost Per Mile

Northern California Origins/Destinations	Southern California Origins/Destinations		
	Los Angeles Metro Area	Palm Springs	San Diego
San Francisco Metro Area	$272.78 / 372 miles	$369.84 / 421 miles	$300.98 / 447 miles
Fresno	--	--	$274.60 / 314 miles
Sacramento	$314.64 / 404 miles	--	$296.00 / 480 miles
Salinas/Monterey	$294.36 / 302 miles	--	--
Santa Rosa	$296.06 / 400 miles	--	--

[9] Consumer Airfare Report, Table 1: Top 1,000 Contiguous State City-Pair Markets. This data is from the 2nd quarter of 2017. https://data.transportation.gov/Aviation/Consumer-Airfare-Report-Table-1-Top-1-000-Contiguo/4f3n-jbg2

Appendix B. Example Methods and Data Inputs for Transit Projects

The following is a hypothetical project[10] to demonstrate how the Travel Cost Savings Co-benefit Assessment Methodology would be used to estimate the benefits of a Transit and Intercity Rail Capital Program project. This example does not include the supporting documentation that may be required of actual project applicants.

Overview of the Proposed Project

The applicant is proposing the following project components:

- Expand capacity of the regional (commuter) transit orange and purple line by purchasing ten railcars and extending the existing daily light rail service for one year.

The proposed project has the following relevant project features:

- The proposed project is located in Sacramento County;
- Daily ridership will increase by 350 unlinked trips;
- Daily light rail service will be extended by 35.5 miles;
- Length of the average unlinked trip will be 5.66 miles;
- Total avoided VMT is 357,700 miles, per the CARB GHG Quantification Methodology and Calculator Tool;
- According to agency estimates, the average per-person one-way fare is $1.30;
- According to agency estimates, 20% of the new ridership will avoid parking downtown for work on weekdays and 15% will avoid parking downtown for shopping and errands on weekends;
- There is no paid parking at the transit facility where the service line originates; and
- The project quantification period is one year, per the CARB GHG Quantification Methodology and Calculator Tool.

Methods to Apply

In this example, there is no avoided air travel, tolls, transit vouchers or active transportation costs so the relevant equation components use are:

$$Travel\ Cost\ Savings/Increase\ = (Travel\ Cost\ of\ Baseline\ Mode - Travel\ Cost\ of\ New\ Mode) \times Quantification\ Period \quad \text{(Eq. 1)}$$

[10] The hypothetical project has not undergone verification of any program requirements; all assumptions about location type and features are for demonstration purposes only.

Where:

$$Travel\ Cost\ of\ Baseline\ Mode = Operation\ Cost_{Base} + Parking\ Cost_{Base} \quad \text{(Eq. 2)}$$

and,

$$Travel\ Cost\ of\ New\ Mode = Transit\ Cost_{New} \quad \text{(Eq. 6)}$$

Step 1: Calculate the Travel Cost of Baseline Mode

$$Operation\ Cost_{Base} = Cost\ Per\ Mile_{Base} \times Miles_{Base} \quad \text{(Eq. 3)}$$

$$Operation\ Cost_{Base} = 0.545\frac{Dollars}{Mile} \times 357{,}700\frac{Miles}{Year} = \$194{,}947\ per\ year$$

$$Parking\ Cost_{Base} = Avoided\ Parking_{Wd} \times Parking\ Cost_{Wd} + Avoided\ Parking_{We} \times Parking\ Cost_{We} \quad \text{(Eq. 4)}$$

$$Parking\ Cost_{Base} = \left(20\% \times \frac{350\frac{Trip}{Day}}{2} \times 5\frac{Days}{Week} \times 52\frac{Weeks}{Year}\right) \times \left(11.13\frac{Dollars}{Trip}\right) + \left(15\% \times \frac{350\frac{Trip}{Day}}{2} \times 2\frac{Days}{Week} \times 52\frac{Weeks}{Year}\right) \times \left(1.50\frac{Dollars}{Hour} \times 2\frac{Hours}{Trip}\right)$$

$$= 9{,}100\ \frac{Trips}{Year} \times 11.13\frac{Dollars}{Trip} + 2{,}730\frac{Trips}{Year} \times 3\frac{Dollars}{Trip}$$

$$= \$109{,}473\ per\ year$$

$$Travel\ Cost\ of\ Baseline\ Mode = \$194{,}947\ per\ year + \$109{,}473\ per\ year = \$304{,}420\ per\ year$$

Step 2: Calculate the Travel Cost of New Mode

$$Transit\ Cost_{New} = User\ Increase \times Average\ Fare \quad \text{(Eq. 7)}$$

$$Transit\ Cost_{New} = \left(350\ \frac{Trips}{Day} \times 365\frac{Days}{Year} \times 0.5\ Adj\ Factor\right) \times 1.30\frac{Dollars}{Trip}$$

$$= 63{,}875\frac{Trips}{Year} \times 1.30\frac{Dollars}{Trip} = \$83{,}038\ per\ year$$

$$Travel\ Cost\ of\ New\ Mode = \$83{,}038\ per\ year$$

Step 3: Calculate the Travel Cost Savings/Increase

$$Travel\ Cost\ Savings/Increase = (\$304{,}420\ per\ year - \$83{,}038\ per\ year) \times 1\ year = \$222{,}382$$

In this example, it is estimated that the project would result in travel cost savings for transit riders of $222,382 during the one-year project quantification period.

Appendix C. Example Methods and Data Inputs for Active Transportation Projects

The following is a hypothetical project[11] to demonstrate how the Travel Cost Savings Co-benefit Assessment Methodology would be used to estimate the benefits of an Active Transportation Program project. This example does not include the supporting documentation that may be required of actual project applicants.

Overview of the Proposed Project

The applicant is proposing the following project components:

- New construction of 1 mile of Class II bike lane.

The proposed project has the following relevant project features:

- Total avoided VMT is 15,120 miles per year, per the CARB GHG Quantification Methodology and Calculator Tool; and
- The project quantification period is 15 years, per the CARB GHG Quantification Methodology and Calculator Tool.

Methods to Apply

In this example, there is no avoided air travel, parking costs, or tolls, no increased transit system ridership, and no transit vouchers so the relevant equations to use are:

$$Travel\ Cost\ Savings/Increase\ = (Travel\ Cost\ of\ Baseline\ Mode - Travel\ Cost\ of\ New\ Mode) \times Quantification\ Period \quad \text{(Eq. 1)}$$

Where:

$$Travel\ Cost\ of\ Baseline\ Mode = Operation\ Cost_{Base} + Parking\ Cost_{Base} \quad \text{(Eq. 2)}$$

and,

$$Travel\ Cost\ of\ New\ Mode = Transit\ Cost_{New} \quad \text{(Eq. 6)}$$

Step 1: Calculate the Travel Cost of Baseline Mode

$$Operation\ Cost_{Base} = Cost\ Per\ Mile_{Base} \times Miles_{Base} \quad \text{(Eq. 3)}$$

$$= 0.545 \frac{Dollars}{Mile} \times 15{,}120\ \frac{Miles}{Year} = \$8{,}240.40\ per\ year$$

Step 2: Calculate the Travel Cost of New Mode

$$Active\ Transportation\ Cost_{New} = Cost\ Per\ Mile_{Bicycle} \times Miles_{Bicycle} \quad \text{(Eq. 10)}$$

$$= 0.04 \frac{Dollars}{Mile} \times 15{,}120\ \frac{Miles}{Year} = \$604.80\ per\ year$$

[11] The hypothetical project has not undergone verification of any program requirements; all assumptions about location type and features are for demonstration purposes only.

Step 3: Calculate the Travel Cost Savings/Increase

$$Travel\ Cost\ Savings/Increase = (\$8{,}240.40\ per\ year - \$604.80\ per\ year) \times 15\ years$$
$$= \$114{,}534$$

In this example, it is estimated that the project would result in travel cost savings for active transportation users of $114,534 during the 15-year project quantification period.

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