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Methods to Assess Co-Benefits of California Climate Investments

Vehicle Miles Traveled

California Air Resources Board

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[1] 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 method at each of these phases may be either quantitative or qualitative. As with CARB's existing GHG emission 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 administering agencies, has selected ten co-benefits to undergo methodology assessment and development under a contract with University of

[1] SB 862, Chapter 36, Statutes of 2014, Health and Safety Code Section 39715.

California, Berkeley. CARB is also evaluating two additional co-benefits, air pollutant emissions and vehicle miles traveled (VMT). This document reviews available empirical literature on the ***VMT*** co-benefit and identifies:

- the direction and magnitude of the co-benefit,
- the limitations of existing empirical literature and data,
- the existing assessment methods and tools,
- other issues to consider in developing co-benefit assessment methods, and
- a proposed assessment method for further development.

II. Co-Benefit Description

VMT is a metric of the total miles travel by vehicles in a defined area over a defined period of time and is often used to estimate the environmental impacts of driving, such as GHG and air pollutant emissions. Reduced VMT also results in additional co-benefits (e.g., reduced congestion), but these additional benefits are outside the scope of this document.

CCI projects that effect VMT include projects that promote a mode shift from personal auto vehicle to transit, biking, walking, or vanpool, and projects that restrict urban sprawl and promote infill development. Both project types have the ability to reduce personal auto VMT. The focus of this document will be on VMT associated with passenger travel and not the movement of goods.

Transportation and land use projects funded through CCI often reduce VMT as a pathway to reduce GHG emissions. Factors that influence VMT include travel mode[2], number of trips, and distance traveled. The estimated VMT reduction associated with a transportation or infill project is the difference between VMT before the project is implemented and VMT after the project is implemented. Actual VMT reduction can also be tracked post project, however a survey of users would be required to determine the effect of the project on mode shift from auto vehicles to transit, biking, or walking. For land conservation projects, avoided VMT is estimated from a conservative projection of development that could have occurred at the proposed project site, based on the number of development rights to be extinguished based on the zoning density and the number of acres of agricultural land at risk of conversion.

As part of CARB GHG quantification methods, many transportation-related projects currently estimate GHG emission reductions by first estimating reductions in VMT. Table 1 includes a list CCI programs that may reduce VMT.

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[2] Travel mode refers to means by which people make a trip, which includes personal vehicles, transit, biking, walking, etc.

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

Administering Agency	Program	Likely direction of co-benefit (+ = beneficial change)
Sustainable Communities and Clean Transportation		
CARB	*Low Carbon Transportation Program*	+
Caltrans	*Active Transportation Program*	+
	Low Carbon Transit Operations Program	+
HSRA	*High Speed Rail*	+
CalSTA	*Transit and Intercity Rail Capital Program*	+
SGC	*Affordable Housing and Sustainable Communities Program*	+
	Sustainable Agricultural Lands Conservation Program	+
	Transformative Climate Communities	+
Natural Resources and Waste Diversion		
CNRA	*Urban Greening Program*	+

III. Directionality of the Co-Benefit

CCI projects are expected to have a positive impact by reducing or avoiding VMT

IV. Magnitude of the Co-Benefit

Reductions in VMT are achieved by CCI projects through either a mode shift from personal auto vehicles to transit, biking, walking, or vanpool. VMT is avoided by land use decisions that limit opportunities for expansive, vehicle-dependent forms of development.

Transportation Projects

Generally, a transit project has a greater impact on reducing VMT if it attracts riders who would otherwise drive versus walk, bike, or use another type of transit (Handy, Lovejoy, Boarnet, and Spears 2013). Similarly, biking, walking, and vanpool trips will have an impact on VMT only if they replace travel by car. In most cases, walking or biking for utilitarian purposes will have an impact on VMT, but walking or biking for recreational purposes will not. Projects that facilitate a mode shift to biking or walking may further reduce VMT by enhancing access to transit (Handy, Tal, and Boarnet 2014, Handy, Sciara, and Boarnet 2014).

The measured outcome from transit-service strategies is a change in ridership, typically expressed as total ridership or as ridership per capita. Research on the effect of transit-service strategies on VMT indicate that:

- a one percent increase in service frequency will lead to a ridership increase of approximately 0.5 percent;
- a one percent increase in service hours or miles could lead to an increase of approximately 0.7 percent; and
- a one percent decrease in fares will lead to approximately a 0.4 percent increase in transit ridership.

In general, ridership is likely to increase the most where existing service is infrequent, for riders who are not dependent on transit, and for discretionary trips (Handy, Lovejoy, Boarnet, and Spears 2013).

In urban and suburban settings, improvements in transit access may encourage a mode shift from personal auto vehicles to transit. A key indicator of transit access is a community's distance to a bus stop or rail station. Reduced distance to transit may reduce VMT both by encouraging a mode shift from personal auto vehicles and by encouraging transit riders to bike or walk to the stop or station in place of driving. Research on the effect of the distance to transit on VMT indicate that VMT decreases between 1.3 and 5.8 percent per mile within approximately 2 miles of a rail station or 0.75 miles of a bus stop (Tal, Handy, and Boarnet 2013). The distance from a transit stop to a rider's workplace may have more impact on VMT than the distance from the rider's home to the transit stop as workers do not typically have access to a car or bike to get from the transit station to the workplace. Transit riders typically will not walk further than 0.25 mile or 0.5 to 0.75 miles to access bus stops or rail stations, respectively (Tal, Handy, and Boarnet 2013).

The average length of an auto trip that is typically replaced by biking and walking is 1.8 miles and 1 mile, respectively, as indicated by the National Household Transportation Survey. Research on the effect of bike infrastructure on VMT indicate that:

- a one percent increase in the streets with bike lanes in a city is associated with a 0.35 to 0.36 percent increase in worker commuting by bicycle and a 0.004 to 0.010 percent decrease in workers commuting by car (Handy, Tal, and Boarnet 2014); and
- a one percent increase in the streets with sidewalks in a city is associated with a 0.05 percent decrease in VMT (Handy, Sciara, and Boarnet 2014).

A reduction in driving in an area can induce travel on a roadway from other areas or by travelers that wouldn't have otherwise made a trip. This increase in VMT due to induced travel has the potential to offset reductions associated with the factors discussed in Section IV.

Land Use Projects

Land use decisions that restrict sprawl development and encourage infill development have the ability to impact VMT. Protecting agricultural land at risk of conversion through conservation easements or the implementation of local and regional planning policies that protect agricultural lands from development result in the extinguishment of development rights, thereby avoiding increases in VMT by limiting opportunities for expansive, vehicle-dependent forms of development. Although little research is available on the direct effect of land conservation on VMT, protecting agricultural land at risk of conversion helps to set boundaries to contain sprawl development and promotes infill and transit-oriented development (TOD) in existing urban or suburban areas.

Infill and TOD projects can impact VMT through a variety of ways including improving accessibility to transit, promoting mixed-use development, and increasing residential and employment densities. VMT is strongly related to the distance to destinations, such as jobs, shopping, or other attractions, which tend to be highest in central locations (Ewing and Cervero, 2010). Mixed-use development has a strong correlation with low non-work related VMT, likely due to closer proximity to retail options, and higher rates of non-auto modes for commuting (Chatman, 2016). The impact of employment density on VMT likely depends on the existing density and job-house balance in an area. Generally, increases in employment and residential densities are associated with decreased VMT. In low density areas, a doubling of employment density is associated with up to a 3 percent decrease in VMT, but in some cases is associated with an increase in VMT (Cicella, Handy, and Boartnet 2014). Similarly, a doubling of residential density is associated with a 4 percent to 19 percent decrease in VMT (Boarnet and Handy 2014).

V. Limitations of Current Studies

Transportation Projects

The effect of the distance to transit on mode shift from personal auto vehicle to transit is dependent on transit level of service, travel times by car, local land use patterns, and location within the region. Although the distance to workplace from transit may be an important factor for mode shift, no studies that directly quantify this effect are available (Tal, Handy, and Boarnet 2013).

In most communities, bicycling and walking represent a small share of all daily travel, so even large percentage increases in bicycling may lead to small percentage decreases in VMT. Some new bicycling trips may replace trips by transit or walking rather than driving. Studies related to the impact of a mode shift from personal auto vehicles to biking or walking focus on metropolitan regions as a whole, the urban core, or suburban areas. In rural areas, the effect size of projects that encourage a mode shift from personal auto vehicles to walking or biking are likely to be smaller due to larger distances between destinations (Handy, Tal, and Boarnet 2014, Handy, Sciara, and Boarnet 2014). Additionally, as biking for transportation has grown in popularity in recent years, effect sizes may have increased since the time of the studies, or may have decreased if people that are most likely to bike have already changed their behavior (Handy, Tal, and Boarnet 2014, Handy, Sciara, and Boarnet 2014).

Land Use Projects

People that want to drive less may self-select to live in higher density neighborhoods and if higher density neighborhoods are in sufficient supply to meet this demand, building more high density neighborhoods is not likely to reduce VMT (Boarnet and Handy 2014). Land use policies are typically implemented with other policies aimed at reducing VMT, making it difficult to separate out the impact of each policy individually (Cicella, Handy, and Boartnet 2014). Additionally, little research has been done on the variation in impact of land use policies at the neighborhood level, studies have typically looked at variations at the regional level. Studies of the impact of land use policies at the regional level may not be applicable at the project level (Boarnet and Handy 2014).

More research is needed to determine the direct impact of each land use policy on VMT. Land use policies are typically packaged together in order to reduce VMT, and it is difficult to separate out the impact of each policy individually. Grouping multiple policies together may create a synergistic effect and result in a larger reduction in VMT than if the policies were undertake individually. Studies on the effect of land use policies on VMT are usually done on a regional scale; more work is needed to determine the effect of these policies on VMT at the project level.

VI. Existing Quantification Methods and Tools

Transportation Projects

Reductions in VMT associated with transportation projects are typically estimated using the "Methods to Find the Cost-Effectiveness of Funding Air Quality Projects for Evaluating Motor Vehicle Registration Fee Projects and Congestion Mitigation and Air Quality Improvement Projects" (CMAQ Methods). The CMAQ Methods were developed by CARB and the California Department of Transportation and are used statewide by transportation agencies to evaluate criteria pollutant emission reductions from transportation projects competing for state motor vehicle fee and federal CMAQ funding. The methods estimate the change in VMT based on the transit and connectivity features of a project.

Land Use Projects

Multiple methods exist for estimating VMT reductions associated with land use projects. Regional travel models tend to be more resource intensive, while sketch models are easier to use and require fewer user inputs. A recent report by UC Davis for the Strategic Growth Council evaluated sketch-level VMT quantification tools to determine the applicability and usability of the tools. In total, six tools were evaluated under a range of case study projects that included various land use projects and context areas (urban to exurban areas). Table 2 shows the applicability of each tool evaluated in the report.

Table 2: Applicability of Evaluated VMT Quantification Tools

Tool	Applicability
California Emissions Estimator Model (CalEEMod) 2013 & 2016	• Commercial (subset), educational, industrial, recreational, residential, retail (subset) • Any context area
California Smart Growth Trip Generation Adjustment Tool	• Mid- to high-density residential, office, restaurant, coffee shop, retail • "Smart growth" project location
GreenTrip Connect	• Residential • Any context area
Mixed-Use Development Model (MXD)	• Residential, retail, office, industrial (subset), commercial (subset), educational, other • Any context area
Sketch 7	• Mixed use, residential office, retail, industrial, public, civic, medical, educational, military, airport • Any context area

In addition to evaluating each tool's ability to quantify VMT from the various case studies, the report includes an analysis of CalEEMod 2016, GreenTrip Connect, and Sketch 7 to determine their sensitivity to a range of land use context areas ranging from the urban core to exurb. Results from this sensitivity analysis indicate that:

- **CalEEMOD**'s outputs appear to be highly dependent on land use setting and project setting and best follow the expected upward trend of VMT along the urban-to-exurban spectrum. There was no variation in VMT for the project located in a low-density suburban area with versus without high-quality transit, which indicates very little, if any, sensitivity to the availability of transit for this project setting.
- **GreenTrip**'s outputs mostly follow a linear increase from urban core to the exurban locations with the exception of outer suburb without transit, which resulted in decreased VMT. This result is counter to expectations.
- **Sketch7**'s outputs had little variation, which is a result of land use type being a major factor in modeling VMT and location in the urban to exurban context areas having little effect on result.

The evaluation also determined the usability benefits and drawbacks to each of the six tools evaluated. The report did not aim to recommend the use of any one tool over another, but to highlight that each tool has both benefits and drawbacks and selection should be based on project type and inputs available. Table 3 shows the benefits and drawbacks of each tool as identified in the report.

Table 3: Benefits and Drawbacks of Evaluated Tools

Tool	Benefits	Drawbacks
CalEEMod 2013 & 2016	• Many, customizable inputs • Program interface reduces back-end error	• Many, customizable inputs • Defaults and land use categories may misrepresent project and/or context area
California Smart Growth Tool	• Few, intuitive inputs with direction of where to find them	• Calculates trips one land use at a time, and in limited context areas • Calculates trips, not VMT
GreenTrip Connect	• Simple user interface • Straightforward outputs	• Measures only residential travel, even in mixed-use projects
MXD	• Simple inputs categories Straightforward outputs	• Important input data may be difficult to find
Sketch7	• Straightforward inputs & interface • System-level outputs Outputs include walk, bike, and transit trips	• Spreadsheet interface can become “buggy”, break • Regional TAZ data used to calibrate tool may be difficult to obtain

VII. Knowledge Gaps and other Issues to Consider in Developing Co-Benefit Quantification Methods

In the sketch-level VMT reduction tools, uncertainty may arise for inputs for the classification of the land-use (e.g., low-rise apartments, medium-rise apartments) and pricing strategy (e.g., parking pricing, transit pass subsidy) (Fang and Handy 2017). Uncertainty in model outputs may arise when using the input defaults in these models instead of project specific inputs, as the defaults provided are typically state wide averages. Additionally default data in tools, such as CalEEMOD, are based on surveys of existing land uses and features, and these defaults may not be applicable for use in evaluating projects with uses or features that are substantially different (Fang and Handy 2017).

The accuracy of the sketch-level VMT reduction tools is unknown without before and after studies for individual projects; the tools should be further validated for accuracy using household- or person-level surveys and household VMT outputs from regional travel models that have been calibrated with regional travel surveys. Although the accuracy of the tools needs to be further validated, the internal consistency of these tools make them useful for comparing the transportation implication of a range of land use scenarios (Fang and Handy 2017).

VIII. Proposed Method/Tool for Use of Further Development

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

Methods for estimation prior to award of CCI funds:

CARB currently uses methodologies based on CMAQ and CalEEMOD to estimate GHG emission reductions based on reductions in VMT and should utilize these methodologies for reporting changes in VMT associated with projects receiving CCI funds. By utilizing these methodologies, CARB will ensure consistency between estimated VMT reductions and the GHG emission reductions associated with those VMT reductions and ultimately decrease the burden to estimate co-benefits on applicants. Additionally, CMAQ Methods and CalEEMOD are established and accepted methods that are currently utilized for transportation and land use projects across the state of California.

Methods for measurement after award of CCI funds:

The same methods recommended for estimation prior to award should be used for estimates after award. Although the same methods should be used, the inputs for the methodologies should be obtained through travel surveys after the project has been completed for all programs besides the Sustainable and Agricultural Lands Conservation program, which will use surveys to assess land use outcomes instead. Utilizing travel data from surveys will indicate if the project resulted in the VMT reductions expected.

Schedule:

The proposed methods are already utilized for calculating GHG reductions using existing GHG quantification methodologies and should only take a few weeks to incorporate onto a co-benefits summary tab in the existing tools.

Data needs

By utilizing the existing GHG quantification methodologies to estimate VMT reductions, no additional data will be needed from applicants. CARB does not currently provide guidance on calculating inputs for the methodologies to estimate GHG and VMT reductions. CARB may find it beneficial to develop guidance on calculating inputs as it would result in applications with more accurate estimates of GHG emission reductions and VMT reductions and provide CARB with a way to better verify inputs provided by applicants.

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