**MEMORANDUM**

**To:** Josh Shaw, CTA

**From:** Frank Gallivan and Eliot Rose, ICF International

**Date:** October 13, 2014

**Re:** Task 1: Identification of Public Transit Projects Eligible for State Cap and Trade Funds

## 1. Background

The California Transit Association has engaged ICF International to develop a recommended GHG-reduction evaluation methodology for the State to use in scoring transit agency applications for Cap & Trade funds. This memo is the first of four memos to detail transit project characteristics and greenhouse gas (GHG) quantification methodologies as applicable to the funding programs outlined under Senate Bills 852 and 862. Quantification of GHG emissions in this memo generally refers to *projection* of reduced emissions, as projects would be evaluated for potential emission reductions before their implementation. Projecting emission reductions involves pre-project analysis, as opposed to post-project analysis. Some examples of post-project analysis are discussed in this memo for reference, as post-project analyses can sometimes inform pre-project analyses.

The purpose of this memo is to provide a catalog of transit projects that reduce GHG emissions and an analysis of quantification methodologies that can be used to analyze the benefits of potential projects. Also in this memo, we analyze the prevalence of transit GHG reducing projects in Sustainable Communities Strategies (SCSs). In a subsequent memo, this information will be compared to the American Public Transportation Association's *Recommended Practice for Quantifying Greenhouse Gas Emissions from Transit* ('the APTA Protocol') to assess its potential to serve as a guiding document for quantification of all transit projects that are eligible for Cap & Trade funds.

## 2. Transit Projects that Reduce GHG Emissions

The number of specific transit projects that can potentially reduce GHG emissions, either by reducing the emissions produced by transit or displacing emissions produced by personal vehicles, is very large. Potential strategies range from initiating new transit service to improving existing service to retrofits to transit fleets and facilities. There are dozens of possible projects that can contribute to each strategy, depending on the specific assets and operational profiles of the transit agency. For example, increasing service frequency for a rail transit system may require constructing additional track and maintenance facilities, acquiring new vehicles, and reconfiguring stations. For a bus service, a project to improve management of the right of way could be most important to increasing service frequency.

ICF classifies transit GHG reducing projects in four broad *strategy categories*:

- Expanding or Improving Transit Capacity
- Transit Rider Outreach and Incentives
- Active Transportation and Land Use
- Improving the Efficiency of Transit Energy Use

Within each strategy category are multiple *project categories*. Within each *project category* there are multiple possible *project types*. For example, transportation demand management programs are a *project category* within Transit Rider Outreach and Incentives. Discounted transit pass programs are an example *project type* within transportation demand management programs.

This classification system groups projects with respect to three key characteristics:

1. The *sources* of GHG emissions reduced - emissions from transit versus displaced emissions
2. The *mechanism* by which GHG emissions are reduced - the key variables affecting physical or behavioral change that lead to reducing emissions
3. The *quantification methods* for GHG emission reductions – the modeling capabilities, research, and analytical methods available to estimate emission reductions

Categorizing projects in this way allows each transit agency to locate its specific projects within the classification system. Transit systems may also design new project types in the future that fit within the classification system. In some cases a specific project may overlap strategy categories. For example, new vehicle purchases can both improve the fuel efficiency of the fleet and improve transit capacity. In this case, quantifying GHG emissions impacts would require conducting analyses described under both categories.

All project types listed either generate new reductions in GHG emissions or support the continuation of GHG emissions by helping to maintain existing transit ridership. Project types were collected from a review of the literature and a survey of California transit agencies. Project types that cannot be confirmed to reduce GHG emissions in all or most cases are not included. For example, park and ride facilities can both increase GHG emissions by inducing new car trips and reduce GHG emissions by increasing transit ridership. Park and ride projects are not included in the list due to this ambiguity with respect to their impacts.

Table 1 summarizes the categories of emissions generally affected by projects in each strategy category. Direct emissions refer to emissions from the tailpipes of vehicles. Upstream emissions refer to emission that occur in producing and delivering energy to the vehicle, such as emissions from electric plants and fuel production facilities.[1] Projects that expand or improve transit capacity generally increase emissions produced by transit vehicles and facilities but reduce emissions through mode shift. Projects that provide transit rider outreach and incentives or focus on active transportation and land use typically have no effect on transit electricity and fuel (unless paired with projects that expand or improve capacity) but reduce emissions through mode shift. Projects that improve the efficiency of transit energy use reduce both direct and upstream emissions from electricity and fuel use. The magnitude of direct emissions reduced relative to upstream emissions reduced depends on the specific project.

### Table 1: Types of GHG Emissions Affected

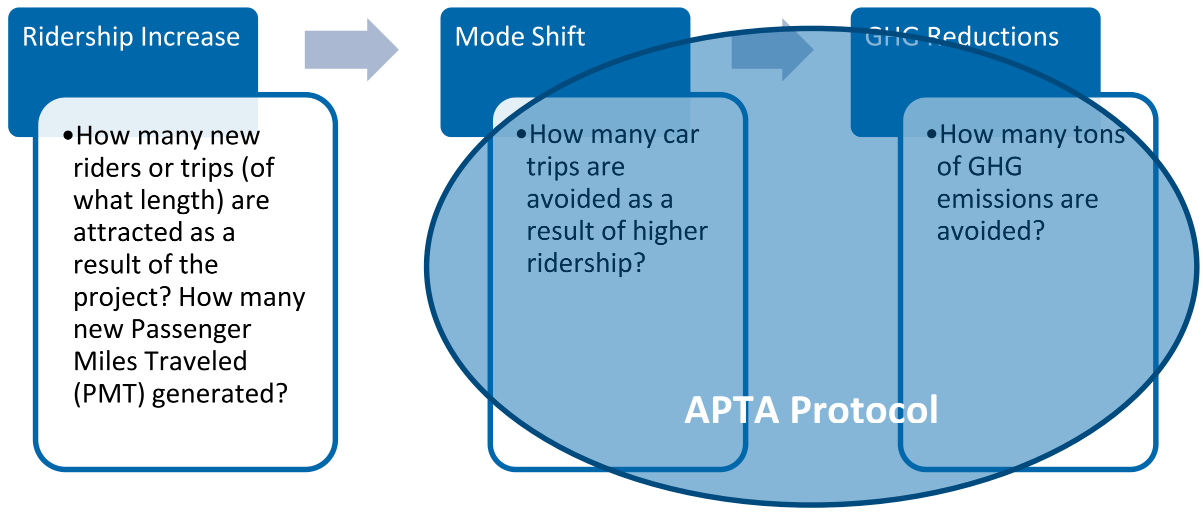
| | GHG Emissions Impact* | | |
|---|---|---|---|
| **Strategy Category** | **Electricity and Fuel (Direct Emissions)** | **Electricity and Fuel (Upstream Emissions)** | **Displaced Emissions (Mode Shift)** |
| Expanding or Improving Transit Capacity | + | + | - |
| Transit Rider Outreach and Incentives | 0 | 0 | - |
| Active Transportation and Land Use | 0 | 0 | - |
| Improving the Efficiency of Transit Energy Use | - | - | 0 |

* A plus (+) indicates increased emissions. A minus (-) indicates decreased emissions. A zero (0) indicates no effect. For example, a plus in 'electricity and fuel' means projects generally increase the use of electricity and fuel. A minus in 'displaced emissions' means projects generally displace (reduce) emissions.

Many of the projects discussed in this memo reduce emissions through mode shift. Figure 1 below shows the three steps in estimating these emission reductions, beginning with estimating ridership increase. The APTA Protocol provides guidance about how to quantify mode shift and GHG emissions once changes in passenger miles traveled (PMT) are known.

[1] The Task 2 memo will provide greater detail on treatment of lifecycle emissions (direct versus upstream emissions) with respect to the APTA Protocol.

**Figure 1: Quantifying Emissions Displaced through Mode Shift**




The following sections discuss each of the four strategy categories in detail.

## 3. Expanding or Improving Transit Capacity

### 3.1. Project Types

Table 2 below lists project categories and example project types that expand or improve transit capacity. The principal role of these projects is to accommodate and attract new ridership to transit. Expanded ridership reduces GHG emissions through mode shift, as explained in the APTA Protocol. Many of these projects require significant capital and operating funds. Project categories include:

- Increase capacity of existing service
- Increase service frequency
- Enhance travel speeds and reliability
- Extend operating hours
- Route expansion

Example project types in each category can be found in Table 2.

### 3.2. Quantification of GHG Emission Reductions

Quantifying GHG emission reductions from projects that expand or improve transit capacity requires forecasting increases in passenger miles traveled (PMT). GHG emission reductions are quantifiable for all project types. Table 2 provides an overview of quantification methods, including both travel demand modeling and off-model approaches. In some cases, such as for projects that provide speed and frequency enhancements, a third party could reasonably estimate increased PMT using published research. In others, such as increasing vehicle capacities, agency-specific ridership forecasting methods must be applied to estimate rider response to specific improvements.

For most projects, the transit agency itself is in the best position to forecast increased ridership and PMT from a proposed project. Ridership forecasting methods differ from agency to agency. Transit agencies may rely on the use of a regional travel demand model, in collaboration with the local Metropolitan Planning Organization (MPO), to forecast changes in ridership, depending on the level of sensitivity of the mode choice component of that model.

A complete accounting of GHG emissions from projects that expand or improve transit capacity should also account for additional emissions generated from new transit service. The APTA Protocol provides a straightforward method of accounting for emissions from additional energy use and vehicle miles traveled.

Some examples of quantified strategies include:

- **Higher capacity buses** – LA Metro analyzed the GHG impacts of using 45 foot buses in place of 40 foot buses, assuming that the additional ridership capacity would result in overall increased ridership during the AM and PM peak periods. Increased ridership translates to an increase in displaced GHG emissions. Because of their lighter weight, the fuel consumed by the 45 foot bus is equivalent to the fuel consumed by the 40 foot bus. Therefore no increase in emissions from longer buses was forecast. (1)
- **Increase service frequency of BART** – In 2008, BART reduced off-peak wait times from 20 to 15 minutes by shortening time between trains. Using their ridership forecasting model, BART projected that change would result in 700 additional daily boardings. Increased boardings translate to higher displaced emissions. (2)
- **Bus rapid transit expansion in Tucson, Arizona** – The Pima Association of Governments (PAG) in Tucson, Arizona explored providing Bus Rapid Transit (BRT) on two major corridors that carry traffic into and out of downtown. Sun Tran, the public transit provider, predicted that BRT would reduce travel times and wait times between transit vehicles by 20% on the two corridors. The TRIMMS model was used to apply elasticities of rider demand with respect to wait and travel times. (3)
- **Extending operating hours**[2] – Whatcom Transportation Authority in Washington State extended service into evening hours on one route between Western Washington University and other trip generators. This "Nightline Service" resulted in significant system wide ridership increases. (4)
- **Expand Rail and Bus Rapid Transit Systems** – LA Metro analyzed the GHG impacts of expanding rail and BRT systems in 21 new transit projects outlined in their Long Range Transportation Plan using ridership forecasts produces as part of the plan. LA Metro estimates that the average expansion project will reduce GHG emissions by 2,700 $MTCO2_e$ annually per mile. Some projects have the potential to reduce emissions by 14,700 $MTCO2_e$ per mile. (1)

[2] This example is a post-project analysis. See Background section for more information.

### 3.3. 'State of Good Repair' Projects

'State of Good Repair' projects can be considered to expand or improve transit service in one or more of the project categories listed, and thereby reduce GHG emissions, if they prevent the loss of service or rider capacity. Such projects include replacing aging vehicles, tracks, and communications equipment, and other facilities that would reduce the amount or quality of service, and thereby contribute to a loss of ridership, if not replaced. Quantifying GHG emission reductions from such projects involves identifying a baseline scenario in which unfunded repairs and replacements contribute to deteriorating transit service and loss of ridership.

For example, a 2012 study prepared by Prof. Elizabeth Deakin of UC Berkeley on BART's 'State of Good Repair' needs examined operating and ridership scenarios in which the region funded only a fraction of BART's maintenance backlog. Estimates of ridership impact were created using elasticities derived from the regional travel demand model, results from the literature, and riders surveys. The study team projected ridership losses based on lost vehicle capacity and decreases in speed and reliability. (5) Lost ridership means fewer displaced GHG emissions. If one of the underfunded scenarios is accepted as the most adopted baseline, then increasing funding for 'State of Good Repair' projects will reduce GHG emissions. It should be noted that as a baseline, the Bay Area's SB375-guided *Plan Bay Area* funds only two-thirds of BART and San Francisco Municipal Transportation Agency's (SFMTA) identified needs through 2040.

### 3.4. Maintaining Existing and New Transit Service in Operation

Reducing GHG emissions through expanding or improving transit capacity depends on shifting passengers from higher emitting modes (typically private automobile) to transit. Per the APTA Protocol, mode shift is a significant source of emission reductions from transit. Ongoing emission reductions from either existing or new transit depend on maintaining that transit service in operation consistently. Service reductions due to insufficient operational funds result in mode shift away from transit, which in turn results in higher GHG emissions. Operational funding for transit service is therefore a GHG reduction strategy. Like 'State of Good Repair' projects discussed above, quantifying the impact of continuing transit service depends on the establishment of a baseline scenario in which service is reduced.

**Table 2: Expanding or Improving Transit Capacity: project types**

| Project Category | Example Project Types | GHG emissions quantifiable | Off-model quantification approaches (meaning not using a travel demand model) | Model-based quantification approaches (assuming model has a mode choice component) | Quantification Examples (Source Document Number) |
|---|---|---|---|---|---|
| Increase capacity of existing service | ■ Purchase higher capacity/longer vehicles<br>■ Expand vehicle fleet and maintenance facilities<br>■ Expand vertical circulation elements at stations/station expansion to increase passenger throughput capacity<br>■ 2nd or 3rd track | For all project types | Agency-specific ridership forecasting methods must be applied to estimate rider response to specific improvements. | If the model used contains a control to limit transit ridership based on rider capacity, these project types can be evaluated in the regional travel demand model | ■ Higher Capacity Buses (6)<br>■ LA Metro's 45-foot composite buses (1) |
| Increase service frequency | ■ Additional buses or trains put into service<br>■ Modernize train control system<br>■ Expand vehicle fleet and maintenance facilities | For all project types | Can be quantified using published elasticities of demand or other agency-specific ridership forecasting methods. | Increased frequency can be translated into reduced wait times and the ridership impact modeled | ■ Increase service frequency of BART (2) |
| Enhance travel speeds and reliability | ■ Upgrades to right of way<br>■ Exclusive bus right of way<br>■ Bus rapid transit (BRT)<br>■ Level boarding for buses<br>■ Bus signal priority system | For all project types | Reduced average wait times or travel times can be quantified using published elasticities of demand or other agency-specific ridership forecasting methods. | Reduced average wait times or travel times can be quantified in the travel demand model | ■ Bus Rapid transit expansion in Tucson, Arizona (3) |

| Project Category | Example Project Types | GHG emissions quantifiable | Off-model quantification approaches (meaning not using a travel demand model) | Model-based quantification approaches (assuming model has a mode choice component) | Quantification Examples (Source Document Number) |
|---|---|---|---|---|---|
| Extend operating hours | ▪ Late night or early morning transit service | For all project types | Agency-specific ridership forecasting methods must be applied to estimate rider response to specific improvements. | Travel demand model will predict higher ridership based on improved accessibility | ▪ Whatcom Transportation Authority in Washington State -- Extending operating hours (4, p.19) |
| Route expansion | ▪ Extend bus or train lines into unserved areas | For all project types | Agency-specific ridership forecasting methods must be applied to estimate rider response to specific improvements. | Travel demand model will predict higher ridership based on improved accessibility | ▪ Expand Rail and BRT Systems (1) |

# 4. Transit Rider Outreach and Incentives

## 4.1. Project Types

Table 3 below lists project categories and example project types that attract additional ridership through transit rider outreach programs and incentives. The principal role of these projects is to achieve higher ridership on existing transit service. Expanded ridership reduces GHG emissions through mode shift, as explained in the APTA Protocol. While some project types require both capital and operating funds, there are many that require only operating funds. Project categories include:

- Transportation demand management programs – including monetary incentives and other techniques to encourage transit use
- Improvements to transit customer experience – including improved transit information and amenities
- Network/fare integration – seamless transfers and universal transit fare cards (e.g. Clipper)

Example project types in each category can be found in Table 3.

## 4.2. Quantification of GHG Emission Reductions

Quantifying GHG emission reductions for projects that provide outreach and incentives to riders also requires forecasting increases in passenger miles traveled (PMT). Forecasting techniques vary widely depending on the project type, and not all project types can be reasonably quantified. Those that can be are typically quantified outside of a travel demand model.

Transportation demand management (TDM) programs that involve discounted transit fares or free transit passes are the most straightforward to quantify, using elasticities of rider demand. Non-monetary TDM programs and many types of improvements to the transit customer experience (real time arrival information, more comfortable vehicles, etc.) can only be quantified by applying results from post-project studies of similar programs. If there are no post-project evaluation studies for a particular project type, such as network/fare integration, estimating GHG reductions will be difficult or impossible.

Some examples of quantified strategies include:

- **Transit Pass Programs for LA Employers**[3] – LA Metro provides special transit passes for employees and students and commute reduction services to 2,400 business locations in LA County. LA Metro analyzed GHG benefits from these programs by comparing mode before and after percentages of employees in Metro's program driving alone to work. LA Metro found that their programs reduced vehicle trips by 1.7%, resulting in an annual GHG emissions decrease of 17,100 metric tons. (1)

[3] This example is a post-project analysis. See Background section for more information.

- **Chicago Transit Authority (CTA) Bus Tracker**[4] – CTA began using the Bus Tracker system in August 2006 that tracks arrival times of city buses. The Bus Tracker system brought in an average of 126 more weekday riders a month and increased ridership between 1.8 and 2.2 percent. (7)

Some project types expect only marginal GHG reductions, making it challenging to quantify benefits within an acceptable range of certainty. For example, although the CTA Bus Tracker was estimated to increase ridership by approximately 2%, other studies of real time arrival information have found inconclusive impacts on ridership. (7) In addition, many examples of quantified projects are post-project rather than pre-project analyses. For these reasons, many project types in Transit Rider Outreach and Incentives, with the exception of monetary TDM programs, are not good candidates for quantification.

More information on quantification techniques can be found in Table 3.

[4] This example is a post-project analysis. See Background section for more information.

**Table 3: Transit Rider Outreach and Incentives: project types**

| Project Category | Example Project Types | GHG emissions quantifiable | Off-model quantification approaches (meaning not using a travel demand model) | Model-based quantification approaches (assuming model has a mode choice component) | Quantification Examples (Source Document Number) |
|---|---|---|---|---|---|
| Transportation demand management programs | ■ Discounted transit passes<br>■ Transit vouchers<br>■ Bike to transit incentives<br>■ Vanpool subsidies<br>■ Transit encouragement programs | For most project types | Programs that provide free or discounted transit passes or other monetary incentives can be quantified using published elasticities of demand. The impact of non-monetary incentives and encouragement programs must be quantified using anecdotal information and survey data. | Generally quantified off-model | ■ LA Metro transit pass programs for LA employers (1)<br>■ MyGo Pasadena Bike to Transit Incentive (8)<br>■ BART Kids Ride Free Fare transit example (2) |
| Improvements to transit customer experience | ■ Traveler information system/real time arrival information<br>■ New/upgraded bus shelters | For some project types | Limited studies of the impact of real time arrival information are available, but there is not strong evidence to support quantification. Little to no evidence to support quantification of other project types. | Quantified off-model if at all | ■ Chicago Transit Authority Bus Tracker (7)<br>■ Improved bus waiting areas in Kansas City, Missouri (4, p.20) |
| Network/fare integration | ■ Integrated ticketing across systems | No | No known studies of impact | Quantified off-model if at all | ■ No known quantification examples. |

# 5. Active Transportation and Land Use

## 5.1. Project Types

Table 4 below lists project categories and example project types that promote active transportation, first / last mile connections to trunk route transit, and land uses oriented to transit. These project types are unique in that they extend beyond the traditional purview of transit agencies—that is, operating transit vehicles—into the built environment and other modes of transportation. While some of these projects encourage higher transit ridership, many have broader GHG reducing benefits by enabling walking and bicycling trips as well. These types of land use measures have a strong nexus with SB375-guided Sustainable Communities Strategies (SCS). There is also evidence that people who live near high frequency transit service are more likely to take transit to work outside of the most congested peak periods.[5] Projects may require relatively small amounts of capital funding. Project categories include:

- Transit oriented development (TOD)
- Bicycle and pedestrian connections to transit

Example project types in each category can be found in Table 4.

## 5.2. Quantification of GHG Emission Reductions

Quantifying GHG emission reductions for transit oriented development projects requires accounting for both higher transit ridership due to increased transit accessibility as well as changes in other travel patterns due to land use changes. There are a variety of methods available to account for both aspects, including travel demand modeling (where models account for fine-grain land use patterns), application of case study results, or application of 5D elasticities—factors from the literature that relate VMT to urban density, land use diversity, urban design, access to destinations, and distance to transit. (9)

Quantifying GHG emission reductions for bicycle and pedestrian connections to transit is more challenging. While bicycle and pedestrian improvements certainly support GHG reductions, and there are studies available to demonstrate reductions, the information available to predict traveler reactions to specific improvements is relatively sparse.

Some examples of quantified strategies include:

- **BART Transit Oriented Development** – BART is reducing GHG emissions by dedicating land around transit stations to transit oriented development. This involves building housing, retail, and office space around transit stops. A study conducted by the Metropolitan Transportation Commission shows that mixed used development decreases GHG emissions because people who live within a half mile of transit stations tend to drive 16 fewer miles per day than the average resident of the region. (2)

[5] Travel Characteristics of Transit-Oriented Development in California, p. 50, Lund, Willson, Cervero, January 2004, http://www.bart.gov/sites/default/files/docs/Travel_of_TOD.pdf

- **Orange Line Bike Path**[6] – LA Metro's orange line is a 14 mile BRT busway. A bicycle path was built alongside the orange line to encourage alternative transportation. In 2010, Metro studied the impacts of this bicycle lane on GHG emissions using a user survey and found that the bicycle lane and corresponding facilities reduced between 314 and 507 MtCO2e per year. (1)

<u>TOD projects are generally quantifiable, but many bicycle and pedestrian projects are not good candidates for pre-project quantification.</u>

More information on quantification techniques can be found in Table 4.

[6] This example is a post-project analysis. See Background section for more information.

## Table 4: Active Transportation and Land Use: project types

| Project Category | Example Project Types | GHG emissions quantifiable | Off-model quantification approaches (meaning not using a travel demand model) | Model-based quantification approaches (assuming model has a mode choice component) | Quantification Examples (Source Document Number) |
|---|---|---|---|---|---|
| Transit oriented development | ▪ Joint development project on transit-agency owned property | For all project types | Agency-specific ridership forecasting methods can be used to predict transit ridership response. Apply 5D elasticities or anecdotal examples from research studies in order to predict broader impact on travel patterns due to land use changes. | Can be modeled if the model has sensitivity to parcel level 5D factors (density, diversity, design, destinations, distance to transit) | ▪ Fruitvale Transit Village, Oakland, CA and other case studies(10)<br>▪ BART Transit-oriented development (2)<br>▪ LA Metro Transit-oriented development (1) |
| Bicycle and pedestrian connections to transit | ▪ Bike/ped paths<br>▪ Bike share at transit stations<br>▪ Bicycle parking at transit stations<br>▪ Bike racks on buses/trains | For some project types | Limited studies of the impact of bike/ped paths and bike share are available, but there is not strong evidence to support quantification. Little to no evidence to support quantification of other project types. | Quantified off-model if at all | ▪ LA Metro Orange Line Bike Path (1)<br>▪ Bikeshare connections to rail stations (11)<br>▪ Bicycle improvements and parking at facility (2) |
| Carshare at transit stations | ▪ Provide carshare parking at transit stations or other incentives | For some project types | Can be quantified only with user surveys. No known studies available. | Quantified off-model if at all | ▪ No known quantification examples |

# 6. Improving the Efficiency of Transit Energy Use

## 6.1. Project Types

Table 5 below lists project categories and example project types that improve the efficiency of transit energy use. Unlike previous strategy categories which displace GHG emission by shifting travel to lower emitting modes, this category of projects reduces the GHG emissions produced by transit assets. Projects may require large or small amounts of capital funding. Project categories include:

- Bus and railcar retrofits to improve fuel efficiency
- Rail electrification
- Non-transit vehicle improvements
- Deploy hybrid, alternative fuel, or more efficient transit vehicles
- Renewable energy projects
- Facility energy efficiency improvements

Example project types in each category can be found in Table 5.

## 6.2. Quantification of GHG Emission Reductions

Methods to quantify GHG emissions vary by project category. For improvements to vehicles, quantification relies on comparison of pre-project emissions per mile to post-project emissions per mile. For new vehicle purchases emissions can generally be estimated using a combination of manufacturer specifications and outputs from models such as CA-GREET and EMFAC. Estimating emissions for new rail vehicles generally requires more complex modeling by rail engineers.

Projecting GHG emission reductions from vehicle retrofits typically requires application of empirical study results and occasionally modeling by vehicle specialists. There is more evidence to support quantification of some types of improvements than others. For example, tire pressure monitoring systems have been demonstrated to improve fuel economy in heavy duty fleets, but their effectiveness depends on the existing maintenance procedures employed by the transit agency. On the other hand, using LED lighting directly reduces the load on the vehicle engine and thereby reduces fuel consumption, making quantification more straightforward.

Methods to quantify GHG emission reductions from renewable energy and facility energy efficiency projects again vary by project type. For renewable energy projects, generation capacity must be estimated, which may require expert input. For facility energy efficiency improvements, energy savings are estimated using manufacturers' specifications and/or empirical study results, where available.

Some examples of quantified strategies include:

- **Caltrain Electrification** – The expected GHG reduction for the conversion of Caltrain operations from diesel to electric was estimated for the project’s Environmental Impact Report. The current system of all diesel locomotives will eventually be replaced with up to 150 electric units by 2040. The Peninsula Corridor Joint Powers Board, the operators of Caltrain, provided forecasted diesel gallon and electricity consumption for the train operations. Diesel consumption is projected to drop from 4,452,984 gal/year to 146,615 gal/year in 2040, while electricity for operations rise from 3,945,021 kWh/year to 104,855,697 kWh/year. Using emission factors from the Climate Registry, PG&E, and published research, the change in energy use is estimated to reduce Caltrain operational $CO_2e$ emissions from 46,684 metric tons/year to 15,628 metric tons/year. Additionally, emission changes from the removal of trees and the change in VMT from mode shift were estimated for the EIR. (12)

- **Gasoline electric hybrid buses**[7] – LA Metro analyzed the GHG emission effects of replacing conventional CNG buses with gasoline hybrid electric (GHE) buses, a more fuel-efficient option. Based on a pilot test of GHE buses in their fleet, LA Metro found that GHE buses achieved close to 30% higher fuel economy than CNG buses. However, because gasoline has a higher carbon intensity natural gas, GHG emissions from GHE buses are only 5.4% lower than CNG buses. Furthermore, if accounting for upstream well-to-tank emissions associated with the production and distribution of each fuel, GHE buses result in higher lifecycle GHG emissions than CNG buses. (1)
- **Solar Panels** – LA Metro analyzed the GHG emission effects of installing solar panels on the Metro's buildings and transportation facilities and along the I-405 freeway soundwalls. The electricity produced would be used by the Metro's buildings and facilities. Based on an existing 1 MW solar panel project on an LA Metro building, they estimated that putting solar panels on the freeway would produce 269 MWh annually. Using carbon intensity factors from the Climate Registry for electricity produced by the local utilities (929 lbs CO2e/MWh), the GHG benefits were calculated from the estimated solar energy production. (1)
- **Facility Lighting Upgrades** – LA Metro also analyzed the GHG emission effects of replacing lighting fixtures in Metro facilities with more energy efficient lighting. Based on an inventory of light fixtures and the wattage difference between older T12 lamps and more efficient T8/T5 lamps, LA Metro projected that these lighting retrofits could save up to 30% of energy use in facilities. Using an emission factor of 1,228 lbs $CO_2$/MWh for electricity from the local utility, emissions reductions could be up to 326 MtCO2e annually. (1, 8)

<u>Most project types can be quantified, but the scale of emission reductions for smaller retrofits and improvements to vehicles and facilities may not merit the burden of quantifying them.</u>

More information on quantification techniques can be found in Table 5.

[7] This example is a post-project analysis. See Background section for more information.

## Table 5: Improving the Efficiency of Transit Energy Use: project types

| Project Category | Example Project Types | GHG emissions quantifiable | Quantification Approaches | Quantification Examples (Source Document Number) |
|---|---|---|---|---|
| Bus and railcar retrofits to improve fuel efficiency | ■ LED lighting on buses and trains<br>■ Anti-idling systems for diesel trains<br>■ Regenerative braking for trains | For most project types | Quantification approaches differ widely by improvement type but generally rely on application of empirical study results and occasionally modeling by vehicle specialists. | ■ Interior LED lighting (6)<br>■ Tire pressure monitoring system (6)<br>■ Reduce train weight (8)<br>■ On-board energy storage (8) |
| Rail electrification | ■ convert diesel trains to electricity | For all project types | Compare per mile GHG emissions between vehicle types. Emission factors for diesel units available from the literature. Emission factors for electricity available from utilities or EPA's eGRID. Requires electricity demand projections modeled by vehicle specialists. | ■ Caltrain Electrification (12) |
| Non-transit vehicle improvements | ■ charging stations for EVs at transit stations<br>■ hybrid support vehicles | For most project types | Compare per mile GHG emissions between vehicle types (estimates available from CA-GREET model and/or EMFAC). Requires estimate of miles traveled per vehicle type, which may be difficult to estimate for vehicles not owned by the transit agency. | ■ Gasoline-electric hybrid buses (1)<br>■ Hybrid vehicles for non-revenue fleets (1) |
| Deploy hybrid, alternative fuel, or more efficient transit vehicles | ■ conversion of on demand shuttles to electric vehicles<br>■ conversion of fixed route fleet to CNG<br>■ CNG refueling station<br>■ Hybrid buses<br>■ Electric buses | For all project types | Compare per mile GHG emissions between vehicle types (estimates available from CA-GREET model and/or EMFAC). Requires estimate of miles traveled per vehicle type. | ■ Alternative fuel buses-compressed natural gas and diesel-electric hybrid (6)<br>■ Gasoline-electric hybrid buses (1)<br>■ Battery electric buses (1)<br>■ Hydrogen/CNG Blend in Buses (1) |

| Project Category | Example Project Types | GHG emissions quantifiable | Quantification Approaches | Quantification Examples (Source Document Number) |
|---|---|---|---|---|
| Renewable energy projects | ■ Solar power generating plants at operating and maintenance (O&M) facilities and transit stops and stations<br>■ Wind power in transit right of way | For most project types | Estimating GHG reductions requires electricity generation capacity and utility-specific emission factors (available from utilities) or region-specific factors available from EPA's eGRID. Predicting electricity generation capacity may require a significant effort for innovative projects such as wind energy generation in a transit right of way. | ■ LA Metro Solar Panels (1)<br>■ LA Metro Wind Energy in Subway Tunnel (unquantified) (1)<br>■ BART Power Supply (2) |
| Facility energy efficiency improvements | ■ More efficient lighting<br>■ More efficient HVAC<br>■ lights on timers<br>■ reduce energy use from computers and other electronics<br>■ Certify facility under LEED standard | For most project types | Energy savings in kWh are estimated using manufacturers' specifications and/or empirical study results. Estimating GHG reductions then requires utility-specific emission factors (available from utilities) or region-specific factors available from EPA's eGRID. | ■ Facility lighting upgrades (8) |

## 7. Transit Projects in Sustainable Communities Strategies

The guidelines for the Affordable Housing and Sustainable Communities (AHSC) grant program state that projects must be consistent with activities or strategies identified in the regional SCS. ICF examined what types of transit GHG reduction strategies would be likely to support RTP/SCS implementation by reviewing the transit-related strategies contained in RTP/SCSs from the following six MPOs:

- Southern California Association of Governments (SCAG)
- Bay Area Metropolitan Transportation Commission (MTC)
- San Diego Association of Governments (SANDAG)
- Sacramento Area Council of Governments (SACOG)
- Fresno Council of Governments (Fresno COG)
- Kern Council of Governments (Kern COG)

These six MPOs were selected because they represent metropolitan regions with diverse transit services, from high-capacity rail lines to rural buses and demand-response service, and because they have relatively sophisticated travel models that are able to capture a variety of strategies. ICF reviewed both strategies listed in the policy elements of these plans and the descriptions of transit strategies in the body of the RTP.

Table 6 summarizes the strategies included in each RTP/SCS, and includes examples of the language describing each strategy. The examples illustrate the degree to which different transit GHG reduction strategies are likely to be included in RTP/SCSs in general.

Within the SCSs examined, there are examples within every project category in Expanding or Improving Transit Capacity, Transit Rider Outreach and Incentives, and Active Transportation and Land Use. Not all project categories within Improving the Efficiency of Transit Energy Use are represented.

## Table 6: Summary of transit GHG reduction strategies contained in SCSs

| Strategy category | SCAG | MTC | SANDAG | SACOG | Fresno COG | Kern COG | Example |
|---|---|---|---|---|---|---|---|
| *Expanding or Improving Transit Capacity* | | | | | | | |
| Increase capacity of existing service | X | X | X | X | X | X | SANDAG: “Develop a system of high-speed Rapid Bus services in key arterial corridors to supplement local bus services.” |
| Increase service frequency | X | X | X | X | X | X | SACOG: “The plan calls for 53 percent of all transit services to operate 15-minute or better service by 2035, up from 24 percent today.” |
| Enhance travel speeds and reliability | X | X | X | | X | | Kern COG: "Introduce Express bus service along SR 178/24th Street/Rosedale Highway and SR 99." |
| Extend operating hours | | | | | X | | Fresno COG: "Implement ‘Owl Service’ on 6-8 routes, extending service hours until midnight." |
| Route expansion | X | X | X | X | | X | MTC: "[Implement] rail extensions that support and rely on high levels of future housing and employment growth.” |
| *Transit Rider Outreach and Incentives* | | | | | | | |
| Transportation demand management programs | X | X | X | X | | | SCAG: "Encourage transit fare discounts and local vendor product and service discounts for residents and employees of TOD/HQTAs" |
| Improvements to transit customer experience | X | X | X | X | | | SACOG: "Increase public perception of the value, benefits, and use of transit, vanpool and rideshare services, via activities such as an enhanced 511 website, image and product-specific advertising, and promotion of new and restructured services.” |
| Network/fare integration | X | X | | X | | | SACOG: "Support more seamless trips through coordination between operators for transfers and implementation of the Connect Card, a universal fare card." |
| *Active Transportation and Land Use* | | | | | | | |

Task 1: Identification of Public Transit Projects Eligible for State Cap and Trade Funds

| Strategy category | SCAG | MTC | SANDAG | SACOG | Fresno COG | Kern COG | Example |
|---|---|---|---|---|---|---|---|
| Transit oriented development | X | X | X | X | | | SACOG: "Identify appropriate best practices for successful transit-oriented development in different settings through case studies from this MTP/SCS, and continue to assist local governments with environmental review to capitalize on SB 375 CEQA benefits for residential and residential mixed-use Transit Priority Projects." |
| Bicycle and pedestrian connections to transit | X | X | X | X | X | | SANDAG: "Potential strategies to facilitate Safe Routes to Transit include first-mile/last-mile solutions such as enhanced pedestrian crosswalks near transit stations, bicycle lanes that connect to transit and bike parking at transit stations, feeder-distributor bus/shuttle routes, car sharing/station cars, and ridesharing. |
| *Improving the Efficiency of Transit Energy Use* | | | | | | | |
| Bus and railcar retrofits to improve fuel efficiency | | X | | | | | MTC RTP/SCS funds Caltrain Electrification. |
| Rail electrification | | X | | | | | MTC RTP/SCS includes a Regional Electric Vehicle Charger Network with chargers sited at locations such as transit stations. |
| Non-transit vehicle improvements | | | | | | | No examples found. |
| Deploy hybrid, alternative fuel, or more efficient transit vehicles | | | | | | | No examples found. |
| Renewable energy projects | | | | | | | No examples found. |
| Facility energy efficiency improvements | | | | | | | No examples found. |

## 8. The Affordable Housing and Sustainable Communities (ASHC) Program

Of the three funding programs available to transit agencies, draft guidelines are currently available only for the Affordable Housing and Sustainable Communities (AHSC) Program. ICF analyzed these guidelines as they apply to the project types listed in this document.

The AHSC provides funding for projects in the following categories:

- Expanding / improving capacity
- Transit rider outreach and incentives
- Land use and active transportation

However, not all projects listed above under these categories are eligible for funding; the AHSC includes specific lists of the types of projects that will be funded. Furthermore, the other requirements in the AHSC guidelines affect the likelihood that projects will receive funding. In addition to requiring that projects be consistent with an SCS, the guidelines further the emphasis on the location of projects, requiring that eligible projects "demonstrate mode shift from SOV use to transit use, generating new or significant increase in transit ridership to Key Destinations."[8]

Below we list the specific project types that are eligible for funding in each category, and discuss how the requirements discussed above affect which projects are likely to receive funding.

**Expanding or improving capacity** – the AHSC guidelines mention the following project types:

- Right-of-way acquisition
- Development of special or dedicated bus lanes
- Development and/or improvement of stations
- Relocation of transportation-related infrastructure
- Capital purchases of transit-related equipment
- Transit Signal Priority
- At-grade boarding

These strategies are likely to be included in SCSs, but agencies will need to show that projects serve high-growth areas identified in the SCS to demonstrate consistency. This should be relatively easy to demonstrate for most of the projects listed above since SB375 generally requires MPOs to demonstrate that transit improvements are targeted toward supporting the land use pattern in the SCS, so these plans often identify high-priority transit corridors. It may require additional work to show that transit

[8] Draft AHSC Guidelines, 8. The AHSC includes two types of eligible project types, transit-oriented development (TOD) Project Areas and Integrated Connectivity Projects (ICPs). TOD Projects are required to include an affordable housing development, so we focus on ICPs, which include transit-only projects most relevant to transit agencies. However, TOD projects have a similar requirement to "achieve mode shift within a Metropolitan Area by integrating Qualifying High Quality Transit systems and Key Destinations." (p. 8)

signal priority or at-grade boarding increase frequency or speeds, both because these are very granular strategies that may not be called out within detail in the SCS and in order to demonstrate mode shift.

**Transit outreach and incentives** – the AHSC guidelines mention the following project types:

- Real time arrival/departure info
- Development and improvement of shelters/waiting areas
- Ticket machines
- Amenities such as WiFi access
- Education and marketing of transit subsidy programs
- Transportation Demand Management (TDM) programs

These strategies are generally likely to be included in SCSs, but it may require some nuance or collaboration with the MPO to demonstrate consistency since SCSs often characterize these strategies very broadly rather than calling out specific project types. Demonstrating that some of projects serve high-growth areas identified in the SCS and other key destinations may be challenging for improvements that agencies are likely to deploy system-wide, such as real-time arrival info and amenities like WiFi, and the evidence relating these strategies to mode shift and increased ridership is limited. Therefore, these projects are most likely to receive AHSC funding if they are specifically targeted toward high-growth areas or are implemented in conjunction with capacity-increasing projects that serve these areas.

**Active transportation and Land Use – the AHSC guidelines mention the following project types:**

- Streetscape improvement, intersection safety, and traffic calming projects serving transit stations
- Bicycle lanes and paths serving transit stations
- Secure bicycle storage or parking
- Bicycle carrying structures on public transit
- Parking replacement in the case of a new TOD located on transit station
- Joint-development projects to develop station areas in high-growth areas identified within an SCS.

The emphasis in both SCSs and the AHSC guidelines on linking new development to high-quality transit means that joint development projects and bicycle and pedestrian facilities that connect transit stations to new development in high-growth areas are good candidates for AHSC funding. Though TOD on agency-owned sites may require replacement of parking, agencies may need to demonstrate that replacement parking doesn't conflict with bicycle, pedestrian, and transit access, given the high priority in SCSs and the AHSC guidelines in increasing non-vehicle access to stations.

The AHSC guidelines also include some transit infrastructure investments, such as signage and noise mitigation, that do not fit into the categories that we use in this memo, and are not likely to be included in SCSs. These activities are not likely to receive AHSC funding unless they are part of a larger project that includes some of the elements discussed above.

## 9. Conclusions and Next Steps

Transit agencies have a broad range of GHG reducing projects available to them. Methods to quantify GHG emission reductions depend on both the specific project and the modeling resources available to the agency. In general:

- For *Expanding or Improving Transit Capacity*, the transit agency itself is in the best position to forecast increased ridership and PMT from a proposed project, possibly in collaboration with modeling staff at the local MPO.
- For *Transit Rider Outreach and Incentives*, most projects are not good candidates for quantification due to limited empirical information. The exceptions are projects that provide monetary incentives, including changes to transit fares or discounted transit passes.
- For *Active Transportation and Land Use*, TOD projects are generally quantifiable using one of several methods, but most bicycle and pedestrian projects are not good candidates for quantification due to limited empirical information.
- For *Improving the Efficiency of Transit Energy Use*, most project types can be quantified, but the scale of emission reductions for smaller retrofits and improvements to vehicles and facilities may not merit the burden of quantifying them.

A subsequent memo will compare quantification methods to the APTA Protocol to assess that document's potential to serve as a guiding document for quantification of all transit projects that are eligible for Cap & Trade funds.

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