METROPOLITAN TRANSPORTATION COMMISSION
ASSOCIATION OF BAY AREA GOVERNMENTS

MEMORANDUM

PLAN BAY AREA 2050

TO: Lana Wong, California Air Resources Board DATE: November 22, 2021

FR: David Vautin, MTC/ABAG

RE: Technical Methodology to Estimate Greenhouse Gas Emissions for Plan Bay Area 2050 *(2021-2050 San Francisco Bay Area RTP/SCS)*

TABLE OF CONTENTS

INTRODUCTION

Purpose

This memorandum describes the technical methodology to estimate greenhouse gas emissions for the San Francisco Bay Area's regional plan for 2050, known as *Plan Bay Area 2050*. *Plan Bay Area 2050* is the regional plan for transportation, housing, the economy, and the environment, while also serving as the region's RTP/SCS consistent with state and federal requirements. In compliance with Government Code § 65080(b)(2)(J)(i), this memorandum was initially submitted to the California Air Resources Board (CARB) for review in advance of the September 2019 kickoff of *Plan Bay Area 2050*. Based upon feedback received in fall 2019, winter 2020, spring 2020, summer 2020, fall 2020, and summer 2021, MTC/ABAG is resubmitting the technical methodology memorandum for the final round of review by CARB staff.

Introduction

The Metropolitan Transportation Commission (MTC) and the Association of Bay Area Governments (ABAG) have completed two RTP/SCS cycles to date, adopting *Plan Bay Area* in 2013 and *Plan Bay Area 2040* in 2017. CARB accepted MTC/ABAG's determination that both *Plan Bay Area* and *Plan Bay Area 2040*, if implemented, would meet or exceed the applicable targets of a 7 percent reduction for 2020 and a 15 percent reduction for 2035, relative to 2005.

For *Plan Bay Area 2050*, the 2035 per-capita greenhouse gas target has been updated through CARB action in March 2018. For the San Francisco Bay Area (MTC/ABAG), the updated target is now a **19 percent per-capita reduction by 2035**, again relative to a year 2005 baseline. *Plan Bay Area 2050* includes strategies that influence travel decisions and land use patterns between 2021 to 2050, a 30-year time horizon. Table 1 below shows the analysis years used in forecasting greenhouse gas emissions for *Plan Bay Area 2050*. The year 2035 GHG target is at the midpoint between Plan adoption year (2021) and the horizon year of the planning process (2050). Additional interim years have been modeled for the purpose of meeting air quality conformity requirements.

Table 1. Analysis Years for Plan Bay Area 2050

Year	Purpose
2005	Base Year for Senate Bill 375 Target
2015	Base Year for *Plan Bay Area 2050*
2035	Target Year for Senate Bill 375 GHG Emissions Reduction
2050	Horizon Year for *Plan Bay Area 2050*

In addition, CARB also updated the year 2020 target for the region in March 2018, reflecting a goal of 10 percent per-capita reduction by 2020. While this year is not applicable in the context of *Plan Bay Area 2050*, as the Plan strategies could not be implemented until after the Plan's adoption in fall 2021, CARB staff requested that MTC/ABAG staff analyze historical performance using observed data. MTC/ABAG conducted this analysis and included it in this memorandum in **Attachment A**.

Work Prior to Plan Bay Area 2050 Kickoff

Prior to beginning the official *Plan Bay Area 2050* process, MTC/ABAG prepared for the foundation of the *Plan* through a long-range "blue sky" effort known as *Horizon*. *Horizon* explored how the Bay Area can be resilient and equitable in an era of uncertainty. By preparing for external forces beyond the region's control – ranging from economic boom/bust cycles and telecommuting technologies to autonomous vehicles and sea level rise impacts – *Horizon* identified a suite of resilient and equitable strategies and investments. The intent was that these strategies help boost the likelihood of *Plan Bay Area 2050* achieving key regional goals, including greenhouse gas emission reductions. For consistency purposes, *Horizon* addresses the same four topic areas as *Plan Bay Area 2050* – transportation, housing, economic development (new this cycle), and environmental resilience (new this cycle).

Horizon consisted of four core elements, all of which wrapped up by the end of 2019 in advance of developing the Draft Blueprint for *Plan Bay Area 2050*:

- **Futures**[1]. Developed collaboratively with stakeholders beginning in spring 2018, this exploration of "what if…?" scenarios looked at three very different scenarios for how the world and nation could change over the next three decades. Defined by external forces beyond the control of the region, the analysis modeled regional impacts as a result of unexpected shifts. The futures analysis for *Horizon* considered issues such as a significant expansion or reduction in national in-migration, global success or failure to adhere to the Paris Climate Accord, fast or slow adoption of autonomous vehicles, effects of economic booms or busts, etc.
- **Perspective Papers**[2]**.** *Horizon* promoted the exploration of innovative strategies and solutions for issue areas that have been outside of the scope of past Plan Bay Area processes. To delve into these topics and identify a toolbox of potential strategies for consideration in *Horizon* and *Plan Bay Area 2050*, the following white papers were released:
    - Autonomous Vehicles
    - Toward a Shared Future
    - Regional Growth Strategies
    - The Future of Jobs
    - Bay Crossings
- **Project Performance**[3]**.** Similar to past *Plan Bay Area* cycles, all of the region's major capacity-increasing transportation projects were evaluated individually through a project-level performance assessment. Relying on benefit-cost analyses, equity analysis, and other qualitative assessments, project performance looked at a wide-ranging suite of benefits and disbenefits, including greenhouse gas reduction. For *Horizon*, projects were evaluated against each of the three futures, with their unique external forces resulting in different land use patterns and different exogenous factors in the travel model. The ultimate project scores were used to prioritize transportation investments in *Plan Bay Area 2050*.
- **Public Engagement.** A critical component of both *Horizon* and *Plan Bay Area 2050*, public engagement has been targeted at a wide range of audiences – from general public events like pop-up outreach to targeted public engagement campaigns in disadvantaged communities to online outreach to seek input from underrepresented demographics. The first round of *Plan Bay Area 2050* engagement in October 2019 bridged the two long-range planning efforts, highlighting

[1] More information available here, including the Futures Final Report: https://mtc.ca.gov/our-work/plans-projects/horizon/futures-planning
[2] More information available here, including all five Perspective Papers: https://mtc.ca.gov/our-work/plans-projects/horizon/perspective-papers
[3] More information available here, including the Final Project Performance Findings: https://mtc.ca.gov/our-work/plans-projects/horizon/project-performance-assessment

key findings from *Horizon* and seeking input from the public and stakeholders on which should be advanced into the Blueprint development process.

To prepare for *Plan Bay Area 2050*, technical work for Plan Bay Area 2050 occurred during 2019 and into the first half of 2020:

- **Request for Transportation Projects.** Project data for most major transportation investments had already been collected via *Horizon*, which not only updated major projects from *Plan Bay Area 2040* but allowed agencies, organizations, and the public at large to submit new projects with costs exceeding $1 billion. The remaining regionally significant capacity-increasing projects were submitted to MTC/ABAG by county transportation agencies in summer 2019, and they were responsible for conducting local public engagement efforts on such submissions.
- **Revenue & Needs Assessments.** In order to create a more comprehensive regional plan, staff have estimated revenues and needs for transportation, housing, and resilience, expanding beyond traditional transportation silos for *Plan Bay Area 2050*. Needs and revenue estimates were released in draft form in fall 2019 and have been finalized in summer 2020, with updates made to reflect impacts of COVID-19 and the 2020 recession.
- **Regional Growth Forecast.** Building upon forecasts of population, jobs, and housing (referred to as "control totals" in past Plan cycles) developed for the three Futures in the predecessor *Horizon* process, MTC/ABAG developed the technical methodology for the Regional Growth Forecast and received approval from the ABAG Board in fall 2019; since then, staff developed the Forecast in consultation with subject area experts. The Draft Forecast was released in early 2020, with updates made in spring/summer 2020 to account for near-term impacts from the 2020 COVID-19 recession; the Final Regional Growth Forecast was adopted by MTC and ABAG in September 2020. Additional information is available in the Population and Employment Forecasts section below.
- **Growth Framework Update.** The Regional Growth Framework was updated in 2019 to address climate, affordability, and equity challenges associated with the original Priority Development Area (PDA) program. Adopted revisions were based in part on the findings of *Horizon* Perspective Paper #3, which identified that the integration of additional transit-rich and high-resource areas were critical to achieve the goals of *Plan Bay Area 2050*.
- **Equity & Performance Analysis Methodology.** Before conducting the Equity Analysis for Plan Bay Area 2050, MTC/ABAG identified a process to update data associated with Communities of Concern, locations with higher concentrations of low-income persons or persons of color. Staff also worked to identify a suite of performance measures in consultation with stakeholders sitting on the Regional Equity Working Group and the Regional Advisory Working Group.

<u>Schedule</u>

In order to achieve the envisioned fall 2021 adoption date, *Plan Bay Area 2050* had the following interim milestones; refer to **Attachment B** for additional details. In short, the planning process built upon the two years of prior work on *Horizon*, with calendar year 2020 primarily focused on crafting the Blueprint composed of strategies for transportation, housing, the economy, and the environment. After the Final Blueprint was advanced as the Preferred EIR Alternative, MTC/ABAG then focused both on environmental analysis and on implementation planning throughout much of 2021.

- **Fall 2019.** Staff kicked off *Plan Bay Area 2050* and conducted public and stakeholder engagement on the resilient and equitable strategies that emerged from the predecessor *Horizon* initiative. Staff worked to refine strategies into an initial package for analysis, known as the Draft Blueprint.

- **Winter 2020.** MTC/ABAG boards approved the shortlist of strategies, as well as the corresponding growth geographies, for analysis in the Draft Blueprint.
- **Spring 2020.** Staff conducted modeling and analysis on the Draft Blueprint, as well as preparatory work for the Final Blueprint phase, including a final call for PDAs and county submissions of transportation project lists and commitment letters.
- **Summer 2020.** Staff conducted public engagement on the analysis of the Draft Blueprint, which identified successes and shortcomings associated with the 25 strategies approved for analysis; one of the five "big challenges" was the Draft Blueprint's inability to meet the greenhouse gas target despite a focused growth near transit, 100% focus of transportation monies on transit and bike/ped investments, and all-lane tolling on select corridors.
- **Fall 2020.** MTC/ABAG boards approved the 35 final strategies and growth geographies to integrate into the Final Blueprint, weaving in public and stakeholder feedback, with analysis published in December 2020.
- **Winter 2021.** Following MTC/ABAG boards' adoption of the Final Blueprint as the Preferred EIR Alternative, staff continued development of the parallel short-range Implementation Plan and finished environmental analysis required under CEQA.
- **Spring 2021.** Staff released the Draft Plan, Draft EIR, and Draft Implementation Plan for public comment and kick off a final round of public & stakeholder workshops for *Plan Bay Area 2050*.
- **Summer 2021.** Staff finalized the Plan Document, EIR, and Implementation Plan based upon public, stakeholder, and elected officials' feedback.
- **Fall 2021.** Final *Plan Bay Area 2050* was released and adopted by the Commission and the ABAG Executive Board at a special joint meeting in October 2021 and was submitted to federal and state partner agencies for final review in November 2021.

OVERVIEW OF EXISTING CONDITIONS

Changes in Planning Context

The past decade has been a period of significant change for the San Francisco Bay Area. From the depths of the Great Recession in 2009, the regional economy rebounded more quickly than California or the United States. However, a lack of sufficient housing production at all income levels, combined with aging infrastructure and limited funding for expansion projects, has resulted in rising rents, growing displacement pressures, significant traffic congestion, and overcrowded transit systems. Furthermore, in 2020, the COVID-19 pandemic yielded seismic shifts in economic conditions, with lower-income communities and communities of color taking on a disproportionate share of the impacts associated with the pandemic and the ensuing economic instability.

Since the adoption of *Plan Bay Area 2040* in 2017, several major changes to the regional planning context have occurred:

- **Impacts from COVID-19 pandemic.** Due to physical distancing requirements and closure of non-essential facilities during the pandemic, demand for transit services has collapsed, while telecommuting has boomed in popularity. Due to financial losses, operators had to reduce or eliminate service on some routes[4]. Transportation revenue forecasts were updated as part of the Final Blueprint phase in summer[5] and fall 2020[6] to ensure consistency with federal regulations for Regional Transportation Plans, with minor adjustments between committed and uncommitted monies in early 2021 to reflect stimulus spending by the Biden Administration. Strategies were also updated in a targeted manner in summer 2020 as part of the Final Blueprint to better reflect some of the near-term needs related to transit service restoration, legal assistance for renters, universal broadband access, and job retraining programs, among other changes.
- **Impacts from the 2020 recession and ongoing recovery.** Over the past 20 months, economic conditions have changed rapidly due to the continued COVID-19 pandemic. Unemployment for lower-wage workers has risen even as the cost of housing in much of the region has continued to grow[7], exacerbating income inequality and housing unaffordability crises. Such shifts have been integrated to affect near-term growth forecasts – between 2020 and 2029 – as part of the adopted Regional Growth Forecast in September 2020[8]. This helps to capture the weaker economic conditions and lower employment levels at the start of the planning period, while recognizing the longer-term fundamental strengths of the Bay Area.
- **Identification of potential policies to address the housing crisis.** The CASA initiative – a collaborative effort of stakeholders supported by MTC/ABAG – led to a regional compact identifying a set of reforms that could help to address the region's severe housing crisis[9]. CASA

---

[4] Reference information on service cuts can be found here: https://www.mercurynews.com/2020/04/07/bay-area-coronavirus-transit-cuts-cant-keep-up-heres-a-round-up/
[5] Joint MTC Planning/ABAG Administrative Committee, June 2020. More information available at: https://mtc.ca.gov/whats-happening/meetings/meetings-archive/joint-mtc-planning-committee-abag-administrative-45
[6] Joint MTC Planning/ABAG Administrative Committee, September 2020. More information available at: https://mtc.ca.gov/whats-happening/meetings/meetings-archive/joint-mtc-planning-committee-abag-administrative-47
[7] Reference information on Bay Area housing boom can be found here: https://www.bayareamarketreports.com/trend/bay-area-market-survey
[8] ABAG Executive Board, September 2020. More information available at: https://abag.ca.gov/meetings/executive-board-september-17-2020
[9] More information available here: https://mtc.ca.gov/our-work/plans-projects/casa-committee-house-bay-area

was a key implementation action of *Plan Bay Area 2040*. While wide-ranging in its recommendations, the CASA effort made clear that significant reforms to the Regional Growth Framework were necessary to bring down the cost of housing[10]. The region's focus solely on existing locally-nominated Priority Development Areas – the central element of the Bay Area's focused growth land use pattern – was fundamentally adjusted to account for a broader range of Growth Geographies in *Plan Bay Area 2050*.

- **New transportation funding approved.** Regional Measure 3 was approved by voters in June 2018, which will generate new toll revenue that will help fund key regional transportation projects[11]. Senate Bill 1, while approved prior to *Plan Bay Area 2040*'s adoption, was spared elimination by voters in November 2018 – meaning that gas tax revenues for discretionary and formula programs will continue to be available to fund major priorities from the prior Plan[12].
- **Completion of some major transportation projects**. Several major transportation projects have been completed in the last three years. BART was extended[13] to Antioch and to North San Jose, new ferry and BRT services were initiated in Richmond and Oakland, the Salesforce Transit Center opened in downtown San Francisco, and new express (HOT) lanes were activated on Interstates 580 and 680. Still, others have experienced significant delays, most notably Caltrain Electrification/Modernization[14] and the Central Subway[15].
- **Increasing congestion due in part to transportation network companies (TNCs).** Reports such as TNCs Today[16] by the San Francisco County Transportation Authority indicate that these vehicles significantly contributed to rising congestion in the years prior to the COVID-19 pandemic, despite their mobility benefits to many residents. In addition, autonomous vehicles (AVs) are logging thousands of testing miles on Bay Area streets; while public offerings are not available yet, the introduction of AVs in the coming years could further exacerbate the trends associated with human-driven TNCs.
- **Establishment of a Vision Zero performance target.** In November 2018, MTC set a target to achieve zero deaths from road fatalities by year 2030, in part to reverse the recent rise of fatalities in the Bay Area. A significant and growing number of Bay Area cities have set similar Vision Zero goals in recent years, with MTC/ABAG continuing to work on regional safety planning and data analysis to support these local initiatives[17]. In summer 2020, MTC adopted a formal Vision Zero policy to further prioritize roadway safety. Local jurisdictions experimented with "slow streets" programs in 2020 and 2021 to provide safer spaces for walking and biking during and after the pandemic, with future augmentation through MTC-funded "quick-build" projects funded by the Safe and Seamless Mobility Quick-Strike Program[18].

---

[10] Refer to Horizon Perspective Paper 3, Regional Growth Strategies, available here: https://mtc.ca.gov/our-work/plans-projects/horizon/perspective-papers
[11] More information available here: https://mtc.ca.gov/our-work/fund-invest/toll-funded-investments/regional-measure-3
[12] More information available here: https://mtc.ca.gov/our-work/advocate-lead/state-advocacy/senate-bill-1-sb-1
[13] More information available here: https://www.bart.gov/about/planning/strategic
[14] More information available here: https://www.caltrain.com/about/MediaRelations/news/Caltrain_Electrification_Delayed_to_2024.html
[15] More information available here: https://www.sfmta.com/blog/central-subway-slowed-covid-19-still-making-progress
[16] More information available here: https://tncstoday.sfcta.org/
[17] More information available here: https://mtc.ca.gov/about-mtc/what-mtc/mtc-organization/interagency-committees/bay-area-vision-zero-working-group
[18] More information available here: https://mtc.ca.gov/tools-and-resources/digital-library/safe-seamless-mobility-quick-strike-program-grant-program

<u>Key Regional Issues</u>

As part of the *Horizon* planning effort described above, MTC/ABAG held pop-up events and conducted online surveys to determine the primary concerns of Bay Area residents as we plan for 2050. Over 10,000 comments were received; combined with stakeholder and elected official input, these were used to craft the five Guiding Principles for the Bay Area. Bay Area residents want to live in a region that is **affordable, connected, diverse, healthy, and vibrant for all**. These Guiding Principles were then adopted as part of the Plan Bay Area 2050 Vision in fall 2019. The full text of the Vision, Guiding Principles, and Cross-Cutting Issues can be found on the *Plan Bay Area 2050* project website: https://www.planbayarea.org/about/plan-bay-area-2050-vision

- **Affordability.** Not surprisingly, affordability continues to be the most critical issue facing Bay Area residents today. Housing costs have grown significantly, both for prospective renters and homebuyers. The transportation and land use strategies in *Plan Bay Area 2040* were unable to make significant headway on this critical issue – spurring the creation of the CASA initiative highlighted above. MTC/ABAG staff integrated work both from CASA and from *Horizon* to take a fresh look at how to make progress on this front through the regional plan. Furthermore, the twin economic and health crises of COVID underscored how essential housing truly is to all Bay Area residents.
- **Connectivity.** Commuters and travelers in the Bay Area – regardless of their mode of choice – continue to seek solutions to congested freeways, crowded transit vehicles, and low-quality non-motorized options. While many residents highlighted their preference for a much-expanded regional transit system – with high speeds and frequent service – others remain concerned that highway capacity has plateaued in recent years. Regardless of mode, lack of transportation capacity remains a key impediment to focused growth.
- **Diversity.** Bay Area residents clearly value the diversity of our region – a place that is already majority-minority and that is expected to become even more so in the decades ahead. However, lack of sufficient housing production, as well as insufficient affordable housing funding, has meant that thousands of lower-income and minority residents have had to move to Sacramento or San Joaquin counties for relief. Achieving equity and sustainability goals simultaneously proved more challenging than prior iterations of *Plan Bay Area* that focused primarily on climate goals.
- **Environmental Health.** Perhaps the region's greatest strength is its preservation of open space and agricultural lands. As we worked on new solutions to address challenges in transportation, land use, economic development, and resilience to natural disasters, residents made clear to us that preserving the environment remains a key priority. Protecting communities from natural disasters and sea level rise has also emerged as a critical environmental issue addressed in the new Environment Element of *Plan Bay Area 2050*.
- **Economic Vibrancy.** While the past decade had seen the Bay Area's economy expanding at a rapid rate, we know both from past experience and from recent trends during the COVID pandemic that the Bay Area is not guaranteed to be an economic powerhouse through 2050. Maintaining the region's innovative edge while mitigating the adverse impacts during periods of strong economic growth will continue to prove a challenge for the Bay Area in the coming decades. This issue has been addressed in the new Economy Element of *Plan Bay Area 2050*, building upon work from *Horizon*'s Future of Jobs Perspective Paper.

POPULATION AND EMPLOYMENT FORECASTS

Development of population, employment, and housing forecasts for *Plan Bay Area 2050* was completed in September 2020 with the adoption of the Final Regional Growth Forecast. In short, the approach builds upon the framework established for *Plan Bay Area 2040*, applying the Bay Area version of the REMI model. Regional Economic Models, Inc. (REMI) creates comprehensive economic models of regional economies, which the user can customize to reflect the unique characteristics of their area. For *Plan Bay Area 2040*, ABAG staff modified version 1.7.8 of the REMI model to capture the region's innovative position in a range of tech- and social media-based sectors as well as the baseline conditions of very high housing prices.

The REMI model is updated annually; MTC/ABAG is using **REMI 2.3** to analyze regional growth for *Plan Bay Area 2050*. The methodology for forecasting population, employment, and housing was approved by the ABAG Executive Board following consultation with technical experts in fall 2019. **Attachment C** summarizes the Final Regional Growth Forecast, including updated regional totals over the Plan period and changes from *Plan Bay Area 2040*. A brief summary table of differences between *Plan Bay Area 2040* and *Plan Bay Area 2050*'s Final Regional Growth Forecasts is shown below.

Table 2. Comparison of Plan Bay Area 2040 and Plan Bay Area 2050 Forecasts

Variable	2030 *Plan Bay Area 2040*	2030 *Plan Bay Area 2050*	2040 *Plan Bay Area 2040*	2040 *Plan Bay Area 2050*	2050 *Plan Bay Area 2040*	2050 *Plan Bay Area 2050*
Employment	4.4 million	**4.7 million**	4.7 million	**5.1 million**	N/A	**5.4 million**
Population	8.7 million	**8.7 million**	9.7 million	**9.5 million**	N/A	**10.3 million**
Households	3.1 million	**3.3 million**	3.4 million	**3.7 million**	N/A	**4.0 million**
Housing Units	3.2 million	**3.4 million**	3.6 million	**3.9 million**	N/A	**4.3 million**

Beyond the traditional transportation-land use nexus of induced demand that staff captured through Travel Model 1.5 and Bay Area UrbanSim 2.0 (discussed below), iterative analysis with REMI 2.3 and other models discussed below was able to capture induced growth at the regional and interregional levels. For example, by integrating strategies that allow for housing development within the San Francisco Bay Area, this may induce more people from the U.S. or abroad to locate in the Bay Area. This type of induced demand consideration is new to *Plan Bay Area 2050*, and MTC/ABAG is one of the first regions in the state to consider such impacts.

Following some iterations between the models, the Final Regional Growth Forecast is loaded into Bay Area UrbanSim 2.0 (discussed below), which then forecasts localized growth patterns based on the overall regional forecast and local land use policies, resulting in a forecasted development pattern. The Regional Growth Forecast consists of growth totals for the entire nine-county region, whose ultimate distribution to counties, cities, and parcels can be influenced by market conditions and strategies (e.g., zoning) in the UrbanSim context.

QUANTIFICATION APPROACHES

Plan Bay Area 2050 Strategies

In February 2020, the MTC and ABAG boards directed staff to study a suite of over two dozen strategies cutting across transportation, housing, the economy, and the environment – known as the Draft Blueprint. Not all Plan strategies are focused on climate change, given the depth and breadth of *Plan Bay Area 2050*; instead, the combined suite of strategies is designed to advance the Plan's vision of ensuring a Bay Area that affordable, connected, diverse, healthy, and vibrant for all.

However, this initial list of strategies in the Draft Blueprint did not fully achieve the Plan's Vision and Guiding Principles, and given that the Draft Blueprint fell short of the greenhouse gas reduction target established by CARB, the MTC and ABAG boards directed staff to study a revised suite of 35 strategies in fall 2020 known as the Final Blueprint. Similar to the Draft, some strategies may reduce greenhouse gas emissions for cars and light-duty trucks, other strategies may reduce greenhouse gas emissions for other sectors *(for which MTC/ABAG cannot "take credit" under the existing laws)*, while other strategies may have minimal impacts on this metric. Again, this is reflective of the Plan's intent to create a more comprehensive vision beyond transportation-related climate mitigation. All that being said, the Final Blueprint's expanded strategy list enabled the Bay Area to meet and exceed the 19 percent target established by CARB. Ultimately, the Final Blueprint was adopted as the Final Plan Bay Area 2050 in October 2021.

Adopted strategies, as well as the associated quantification approaches, are shown in the table below. Off-model analyses of specific initiatives, are described in greater detail later in this document. Additional information on this topic can be found in Plan Bay Area 2050 supplemental reports, in particular the Forecasting and Modeling Report, which are available here: https://www.planbayarea.org/2050-plan/final-plan-bay-area-2050/final-supplemental-reports

Table 3. Plan Bay Area 2050 Strategies & Quantification Approaches

Strategy Description	Quantification Approach	High-Level Modeling Notes
Transportation		
T1. Restore, Operate and Maintain the Existing System. Set aside the funding required to maintain existing conditions for freeways, bridges, local streets, and transit assets and to operate the same number of transit service hours that were in operation as of 2019, accelerating the recovery of transit service from reduced service in effect during the COVID-19 pandemic. This strategy would include investments that make transit stations and vehicles safer, cleaner, and more accessible – with investments targeted at meeting the needs of transit-dependent or limited mobility passengers. In instances where the Draft Blueprint identified potential high levels of transit crowding or slowed bus speeds due to congestion, apply	REMI; Travel Model 1.5	Transportation modeling includes sustained transit service cuts in years 2025 and 2030, with full restoration by year 2035.

Strategy Description	Quantification Approach	High-Level Modeling Notes
targeted investments like frequency boosts, transit-only lanes, or transit signal priority to alleviate crowding or delay.		
T2. Support Community-Led Transportation Enhancements in Equity Priority Communities. Build upon existing regional efforts like the Participatory Budgeting pilots in Vallejo and San Francisco and MTC/ABAG's Community-Based Transportation Plan program by creating an expanded funding source for transportation priorities identified by historically marginalized communities. Such investments could include lighting and safety measures, improvements to transit stations and stops, and subsidies for shared mobility like bike share or car share, while advancing racial equity.	N/A	As this strategy reflects programmatic transportation improvements at the neighborhood level, its benefits are not able to be well-captured by the travel demand model or by off-model techniques.
T3. Enable a Seamless Mobility Experience. Reduce the friction of taking multi-operator or multi-modal trips by integrating every step of the travel process, from trip planning and fare payment to schedule coordination to smoother transfers between operators at key transfer nodes. Key elements of this strategy could include a smartphone app for trip planning, payment, and real-time passenger information, a unified transportation wallet that can be used to pay for all mobility services, cross-operator schedule coordination to reduce transfer wait times at timed transfer locations, and capital improvements ranging from wayfinding signage to station upgrades to make transfers faster and simpler.	Travel Model 1.5	Transportation modeling reflects "seamless nodes" at 15 timed transfer points in the region where timed transfers are assumed to reduce transfer times to no more than three minutes (for regional-to-regional service transfers) to five minutes (for regional-to-local service transfers).
T4. Reform Regional Transit Fare Policy. Streamline fare structures across the region's 27 transit operators and replace existing operator-specific discount fare programs with an integrated fare structure across all transit operators and a regional means-based fare discount. The regional integrated fare structure would consist of a flat local fare with free transfers across operators and a distance or zone-based fare for regional trips, with discounts for youth, people with disabilities, and very low-income people.	REMI; Travel Model 1.5	In addition to integrated fares as described to the left, transportation modeling includes a 50 percent fare discount for households in the lowest income quantile.

Strategy Description	Quantification Approach	High-Level Modeling Notes
T5. Implement Per-Mile Tolling on Congested Freeways with Transit Alternatives. Apply a per-mile charge on auto travel on congested freeway corridors where transit alternatives exist today or through major planned investments before 2035 (BART, Caltrain, SMART, Valley Link, VTA Light Rail, and Regional Express Bus), with revenues directed toward transportation investments serving the corridor. Drivers on priced corridors would pay a higher charge during the morning and evening peak periods, with discounts for off-peak travel, carpools with three or more occupants, or travelers with a qualifying disability. Toll rates would be similar to the Draft Blueprint, with 15 cents per mile for solo travel in peak periods and 5 cents per mile for travelers in discount categories above. To offset the regressive nature of road pricing, lower-income drivers would be charged a discounted per-mile rate. Bridge tolls would remain in effect, with no per-mile toll on the bridges. Express Lanes on corridors without a transit alternative would continue to operate, while Express Lanes on tolled corridors would revert to carpool lanes.	REMI; Travel Model 1.5	*Refer to summary information to the left.*
T6. Improve Interchanges and Address Highway Bottlenecks. Fund a package of projects targeted at reducing congestion, reducing collisions, and improving operational efficiency of interchanges. For projects with a widening component, complementary strategies would help to offset the adverse greenhouse gas emission effects of these projects, including pricing and speed limit reductions.	REMI; Travel Model 1.5	*Refer to summary information to the left; transportation project list is available as part of Final Plan Bay Area 2050 materials.*
T7. Advance Other Regional Programs and Local Priorities. Fund the implementation of complementary programs and minor transportation investments at the regional and local levels. Examples of regional programs included within this strategy include the climate initiatives program, 511 traveler information services, and the Priority Development Area implementation program. Local initiatives include county-driven planning efforts, emissions reductions strategy, intelligent transportation systems projects, and minor local road and intersection improvement projects.	REMI; Travel Model 1.5	*Refer to summary information to the left; transportation project list is available as part of Final Plan Bay Area 2050 materials. Most projects within this strategy are non-modelable.*

Strategy Description	Quantification Approach	High-Level Modeling Notes
T8. Build a Complete Streets Network. Enhance streets to promote walking, biking, and other micromobility through by (1) building out a contiguous regional network of 10,000 miles of bike lanes or multi-use paths, (2) providing support to local jurisdictions to maintain and expand car-free slow streets, and (3) supporting other amenities like improved lighting, safer intersections, and secure bike parking at transit stations. This strategy would emphasize Complete Streets improvements near transit to improve access and in Equity Priority Communities to advance equity outcomes.	REMI; Travel Model 1.5	Transportation modeling begins with an off-model approach to identifying modal shift, averaging the most conservative and optimistic of the three peer-reviewed papers cited in the CARB guidance for bike infrastructure, based upon the level of infrastructure investment. The anticipated modal shift is then integrated into Travel Model 1.5 to identify secondary effects, building upon the off-model approach from *Plan Bay Area 2040*.
T9. Advance Regional Vision Zero Policy through Street Design and Reduced Speeds. Reduce speed limits to between 20 and 35 miles per hour on arterials and local streets, depending on the setting, and 55 miles per hour on freeways. Enforce lower speeds using design elements like speed bumps, lane narrowings, and intersection bulbouts on local streets and automated speed enforcement on freeways and local roads as needed, with a special emphasis on enforcement near schools, community centers, and parks. Engage with local communities to identify priority locations for enforcement, and reinvest revenues generated from violation fines into safety initiatives, including education and capital investments.	Travel Model 1.5	Transportation modeling includes range of local street speed limits depending on facility type and area type in model.
T10. Enhance Local Transit Frequency, Capacity, and Reliability. Improve the quality and availability of local bus and light rail service, with a focus on projects that meet the transportation needs of the region's lower-income residents. Projects nested within this strategy include capital improvements that make bus travel faster and more reliable – such as bus rapid transit and	REMI; Travel Model 1.5	*Refer to summary information to the left; transportation project list is available as part of Final Plan Bay Area 2050 materials.*

Strategy Description	Quantification Approach	High-Level Modeling Notes
transit signal priority – as well as service increases on bus systems throughout the region, extensions of the light rail network in the South Bay to accommodate future growth in population, jobs, and transportation demand, and investments that ensure sufficient service levels in all of the region's Priority Development Areas.		
T11. Expand and Modernize the Regional Rail Network. Strategically invest in a coordinated suite of projects that extend the regional rail network and increase frequencies and capacity to address peak-hour crowding. This strategy envisions a new Transbay rail crossing linking Oakland and San Francisco, with complementary rail extensions connecting Caltrain and High-Speed Rail to Salesforce Transit Center, BART to Diridon Station, and the Central Valley to the Bay Area via Valley Link. Furthermore, this strategy funds capital improvements such as electrification, grade separation and other modernization projects along the Caltrain corridor, prioritizing dual-purpose investments from south to north that help to connect High-Speed Rail to the Bay Area. Service frequency boosts on the Altamont Corridor Express, BART, and Caltrain reduce crowding and wait times for rail passengers. To add redundancy and capacity for regional transit trips, also invest in select water transit enhancements, including ferry service frequency boosts and new routes serving Treasure Island, Berkeley, Foster City, and Redwood City.	REMI; Travel Model 1.5	*Refer to summary information to the left; transportation project list is available as part of Final Plan Bay Area 2050 materials.*
T12. Build an Integrated Regional Express Lane and Express Bus Network. Complete the buildout of the Express Lanes network, providing an uncongested freeway lane for buses, carpoolers, and toll-paying single- or zero-occupant vehicles. Where possible, convert existing carpool or general-purpose lanes to Express Lanes. When widening is required, complementary strategies help to offset the adverse effects of these projects, including pricing and speed limit reductions. Further leverage this investment through the provision of new Regional Express Bus routes serving destinations in 6 of the 9 Bay Area counties and by boosting frequencies on existing	REMI; Travel Model 1.5	*Refer to summary information to the left; transportation project list is available as part of Final Plan Bay Area 2050 materials.*

Strategy Description	Quantification Approach	High-Level Modeling Notes
Express Bus service from Napa VINE, AC Transit, and other operators.		
Housing		
H1. Further Strengthen Renter Protections Beyond State Law. Building upon recent tenant protection laws, limit annual rent increases to the rate of inflation, while exempting units less than 10 years old, the timeframe developers and lenders analyze to determine project feasibility. Augment robust renter protection with expanded services such as legal assistance and strengthened enforcement of recently adopted and longstanding protections, including fair housing requirements.	UrbanSim 2.0	Land use modeling in UrbanSim 2.0 represents this strategy by decreasing the rate at which low-income households relocate.
H2. Preserve Existing Affordable Housing. Acquire homes currently affordable to low-and middle-income residents for preservation as permanently deed-restricted affordable housing. Preserve all existing deed-restricted units that are at risk of conversion to market rate housing. Pursue tax incentives, targeted subsidies, favorable financing, and other strategies to transfer ownership of units without deed-restrictions (also known as "naturally occurring affordable housing") to individual tenants, housing cooperatives, or public or non-profit housing organizations including community land trusts for preservation as permanently affordable housing.	REMI; UrbanSim 2.0	Land use modeling includes conversion of affordable housing funding levels into direct investment into affordable housing on a county-specific basis. In UrbanSim 2.0, this strategy locates units currently affordably occupied by low-income (Q1) households and converts them to deed-restricted housing locking in both affordability and occupancy by Q1 households.
H3. Allow a Greater Mix of Housing Densities and Types in Blueprint Growth Geographies. Allow a variety of housing types at a range of densities to be built in Blueprint Growth Geographies, including Priority Development Areas (PDAs) identified by local governments, High Resource Areas (HRAs) with the region's best schools and economic opportunities, and Transit Rich Areas (TRAs) with convenient access to frequent public transportation. Furthermore, reduce project review times and parking requirements, with 100% affordable projects permitted "by-right." Specific densities and housing types are based upon	REMI; UrbanSim 2.0	Land use modeling includes upzoning of dwelling units per acre based upon level of transit service, high-resource status, and existing use.

Strategy Description	Quantification Approach	High-Level Modeling Notes
regional and local context, including local zoning, type and frequency of transit service, existing land uses, and access to jobs and other opportunities.		
H4. Build Adequate Affordable Housing to Ensure Homes for All. Build enough deed-restricted affordable homes necessary to fill the existing gap in homeless housing and to meet the needs of low-income households, including those currently living in overcrowded or unstable housing. Prioritize projects that advance racial equity and greenhouse gas reduction, including those in High Resource Areas, Transit Rich Areas, and communities facing displacement risk.	REMI; UrbanSim 2.0	Land use modeling includes conversion of affordable housing funding levels into affordable housing on a county-specific basis. In UrbanSim 2.0, this strategy builds "almost-feasible" residential projects as deed-restricted units.
H5. Integrate Affordable Housing into All Major Housing Projects. Require a baseline of 10 percent to 20 percent of new market-rate housing developments of 5 units or more to be permanently deed-restricted affordable to low-income households[19], with the threshold determined by local real estate market strength, access to opportunity, public transit, and displacement risk. Smaller units, such as Accessory Dwelling Units (ADUs) and fourplexes, are exempted to increase feasibility.	REMI; UrbanSim 2.0	UrbanSim 2.0 implements this strategy as an inclusionary housing policy that requires the construction of deed-restricted units at a particular ratio whenever the model build market-rate residential.
H6. Transform Aging Malls and Office Parks into Neighborhoods. Permit and promote the reuse of shopping malls and office parks with limited commercial viability as neighborhoods with housing at all income levels, local and regional services, and public spaces. Support projects within Transit-Rich and High Resource Areas that exceed deed-restricted affordable housing requirements by providing technical assistance and low-interest loans. Prioritize a handful of regional pilot projects that add 1,000+ homes and dedicate land for affordable housing and public institutions such as community colleges and university extensions.	REMI; UrbanSim 2.0	Land use modeling incorporates these mall and office park transformations as a series of events that were sketched out using consistent assumptions. The events enter UrbanSim 2.0 in particular forecast years and then may influence explicitly modeled changes in prices and redevelopment feasibility nearby.
H7. Provide Targeted Mortgage, Rental, and Small Business Assistance to Equity Priority	Off-Model	As this strategy reflects household-level

[19] Assumes requirement is met through on-site affordable units, as opposed to payments to an "in lieu" affordable housing fund.

Strategy Description	Quantification Approach	High-Level Modeling Notes
Communities. Provide mortgage and rental assistance in Equity Priority Communities, prioritizing longtime previous or existing residents of communities of color that have experienced disinvestment or displacement resulting from policies such as redlining, exclusionary zoning, predatory lending, and infrastructure siting. Provide targeted grants and low-interest loans to start up and expand locally-owned businesses.		investments that cannot be well captured by UrbanSim 2.0, MTC/ABAG used off-model approaches to estimate affordability benefits, etc. of the strategy. GHG emission impacts of this strategy are anticipated to be negligible.
H8. Accelerate Reuse of Public and Community Land for Mixed-Income Housing and Essential Services. Establish a regional network of land owned by public agencies, community land trusts, and other non-profit land owners and coordinate its reuse as deed-restricted mixed-income affordable housing, essential services, and public spaces. Align with the Build Adequate Affordable Housing to Ensure Homes for All and Provide Targeted Mortgage, Rental, and Small Business Assistance strategies to match sites with funding, developers, and service providers, and to ensure projects benefit communities of color and other historically disinvested communities.	REMI; UrbanSim 2.0	Land use modeling incorporates these public and community land transformations as a series of events that were sketched out using consistent assumptions. The events enter UrbanSim 2.0 during particular forecast years and then may influence explicitly modeled changes in prices and redevelopment feasibility nearby.
Economy		
EC1. Implement a Statewide Universal Basic Income. Provide an average payment of $500 a month to all households in the Bay Area (payments vary based upon household size and composition), paired with tax increases for those outside the low-income tax bracket that offset any gains from this strategy. Although a small amount such as $500 cannot make up for a lost job, it can and does help with everyday emergencies, reduce anxiety, improve family stability, health, and improve access to opportunity.	REMI/Off-Model	*Refer to summary information to the left.*
EC2. Expand Job Training and Incubator Programs. Fund technical assistance for establishing a new business, access to workspaces, mentorship and financing through a series of co-located business incubation and job training centers. Support training for high-growth in	REMI; UrbanSim 2.0	Land use modeling assumes the creation of sufficient industrial space to hold approximately 20 jobs annually in each Priority

Strategy Description	Quantification Approach	High-Level Modeling Notes
demand occupations in collaboration with local community colleges in disadvantaged communities, working with community colleges and other training partners. Incubators would be co-located in select Priority Production Areas in housing-rich locations to encourage job opportunities are focused in support of locational objectives as well.		Production Area in a city with a jobs-housing ratio less than 1.4.
EC3. Invest in High-Speed Internet in Underserved Low-Income Communities. Connect low-income communities with high-speed internet to broaden opportunities through (1) direct subsidies for internet access to reduce costs for low-income households to $0 per month and/or (2) invest in public infrastructure to create additional high-speed fiber connections. This strategy is designed to be complementary to the telecommuting strategy featured in the Environment Element, while recognizing that internet connectivity benefits extend telework. Given the immediate needs during and after the COVID-19 pandemic, this strategy addresses near-term needs while supporting a more equitable long-term future.	N/A	While this strategy is not able to be well-captured by any of the three models, the strategy is an essential complement to ensure that the requirement for major employers to expand commute trip reduction programs is effective & equitable.
EC4. Allow Greater Commercial Densities in Growth Geographies. Allow greater densities for new commercial development in select Priority Development Areas and select Transit-Rich Areas to encourage more jobs to locate near public transit. This strategy supports focused growth near transit to support climate goals, while recognizing the need for a balanced approach that does not exacerbate the region's jobs-housing imbalance.	UrbanSim 2.0	Land use modeling includes upzoning of mixed-use areas based upon level of transit service, high-resource status, and existing use.
EC5. Provide Incentives to Employers to Shift Jobs to Housing-Rich Areas Well Served by Transit. Provide a subsidy from new tax revenues that encourages employers to locate in housing-rich areas near existing transit, (e.g. Concord or San Leandro). Subsidies would be used to incentivize development at existing regional rail stations to improve jobs housing balance and reverse commuting and support new transit where auto trips tend to be shorter, and there are many more homes than jobs.	UrbanSim 2.0	In UrbanSim 2.0, each affected jurisdiction is provided with funding to subsidize development near particular high-quality transit stations. The fund is used to build commercial projects that are close to feasible under market conditions, intensifying

Strategy Description	Quantification Approach	High-Level Modeling Notes
		the level of job growth in these locations.
EC6. Retain and Invest in Key Industrial Lands. Implement local land use policies to retain key industrial lands identified as Priority Production Areas. This would include preservation of industrial zoning and an assumed increase in development capacity to enable new development to “pencil out” in these zones, without competition from residential and other commercial uses. It would also provide limited annual funding for high-growth PPAs for non-transportation infrastructure improvements including fiber, broadband, and building improvements.	UrbanSim 2.0	UrbanSim 2.0 represents this strategy by upzoning industrial land and disallowing residential uses within Priority Production Areas. Land use modeling assumes that, within Priority Production Areas, only industrial development is allowed going forward and that allowable floor-area ratios are doubled to provide additional capacity if needed.
Environment		
EN1. Adapt to Sea Level Rise. Address adaptation needs in locations that are permanently inundated with less than two feet of sea level rise providing protection from king tides and storms. Protect shoreline communities, prioritizing areas of low costs and high benefits and providing additional support to vulnerable populations. Using anticipated ($3 billion) and new revenues ($16 billion), the strategy would fund a suite of protective strategies (e.g. ecotone levees, traditional levees, sea walls), marsh restoration and adaptation, the elevation of critical infrastructure and support some lower density communities with managed retreat. The strategy prioritizes nature-based actions and resources in Equity Priority Communities as well as areas of high impacts and low costs. The adaptation actions are intended to balance multiple goals of flood protection, habitat restoration, and public access - protecting existing and future communities while also dedicating sufficient funds to support the 100,000 acre marsh restoration goal for the region.	REMI; UrbanSim 2.0; Travel Model 1.5	Transportation modeling includes protecting most vulnerable highway and rail infrastructure from inundation; land use modeling includes protecting select parcels in high-growth or high-risk areas (and the buildings on them) from inundation.
EN2. Provide Means-Based Financial Support to Retrofit Existing Residential Buildings. Adopt building ordinances and incentivize retrofits to bring existing buildings up to higher seismic,	REMI; Off-Model	*GHG reductions from more energy-efficient buildings associated with this strategy would*

Strategy Description	Quantification Approach	High-Level Modeling Notes
wildfire, water and energy standards, providing means-based subsidies to offset costs. To ease the burden of residential building retrofits, this strategy would prioritize assistance to Equity Priority Communities, multi-family structures, as well as for residential dwellings built before current codes. Seismic improvements would focus action in 385,000 housing units with likely crawl space and soft story deficiencies for which retrofit standards exist. 125,000 homes would be retrofit with proven fire-resistant roofing and defensible space retrofits. 650,000 units would be boosted by energy efficiency and electrification subsidies and 175,000 units would undergo water efficiency and in-building, safer plumbing measures. The combined strategies reduce risk, improve affordability through lower utility and insurance bills, and reduce building-sector related emissions and water use.		*not accrue to the CARB target related to cars and light-duty trucks.*
EN3. Fund Energy Upgrades to Enable Carbon-Neutrality in All Existing Commercial and Public Buildings. Support electrification and resilient power system upgrades in all public and commercial buildings. To reach longer-term greenhouse gas emissions goals communities need to eliminate natural gas. As building components reach the end of their useful life funds can be used to transition to electric building systems. Subsidies would make up the difference in cost for higher efficiency electric building systems, and full costs of enabling components like panel upgrades and necessary building modifications. As these investments are made, backup energy systems like microgrids and solar-plus-storage solutions can be paired to ensure buildings remain open during acute events or power shut off events. Focusing action on these buildings in the near term will help advance action in community facilities and help local governments adopt broader resilient, sustainable, and equitable energy policy.	Off-Model	*GHG reductions from more energy-efficient buildings associated with this strategy would not accrue to the CARB target related to cars and light-duty trucks.*
EN4. Maintain Urban Growth Boundaries. Using 2020 urban growth boundaries and other existing environmental protections, confine new development within areas of existing development or areas otherwise suitable for growth, as	UrbanSim 2.0	Land use modeling assumes that all lands outside urban growth boundaries are ineligible for urban or suburban

Strategy Description	Quantification Approach	High-Level Modeling Notes
established by local jurisdictions. These measures include urban growth boundaries, urban service areas, environmental corridors, slope & density restrictions, stream conservation areas, and riparian buffers. This strategy would support regional resilience by limiting new growth in unincorporated areas in the wildland-urban interface and other high-risk areas.		development; development is limited to rural uses (e.g., 1 home per 10 acres).
EN5. Protect and Manage High-Value Conservation Lands. Provide strategic matching funds to help conserve and manage high-priority natural and agricultural lands, including but not limited to Priority Conservation Areas, wildland-urban interface lands, and other areas at high risk of wildfires, floods, or other natural hazards. Conserving the region's biodiversity and agricultural abundance requires planning and investment to support natural and working land protection, acquisition, and management. Management actions would prioritize protection of public health and safety, enhancement of environmental and recreational benefits, and sequestration of carbon to promote community and watershed resilience. This strategy would support regional goals for agriculture, open space, and public access, which include a vision of 2.2 million acres of preserved open space, enhanced wildfire, flood, and drought resilience, and a thriving agricultural economy. Bayland conservation, restoration and adaptation is included within the Adapt to Sea Level Rise strategy.	Off-Model	*GHG reductions from agriculture and/or conservation associated with this strategy would not accrue to the CARB target related to cars and light-duty trucks.*
EN6. Modernize and Expand Parks, Trails and Recreation Facilities. Strategically plan and invest in quality parks, trails, and open spaces that provide inclusive recreation opportunities for people from all backgrounds, abilities, and ages to enjoy. Recognizing how the COVID-19 pandemic has highlighted the importance of easy access to parks and open space, as well as the disparities within the Bay Area, this strategy would fund enhancements to regional and local parks, development and maintenance of parks and recreation facilities, acquisition of new open space, and construction of cross-jurisdictional	Off-Model	*GHG reductions from parks & recreation investments associated with this strategy would not accrue to the CARB target related to cars and light-duty trucks.*

Strategy Description	Quantification Approach	High-Level Modeling Notes
trails and greenways with an emphasis on expanding recreation opportunities in Equity Priority Communities and other underserved areas.		
EN7. Expand Commute Trip Reduction Programs at Major Employers. Set a sustainable commute target for all major employers as part of an expanded Bay Area Commuter Benefits Program. Employers would then be responsible for expanding their commute trip reduction programs, identifying and funding sufficient incentives and/or disincentives to achieve or exceed the target. By the year 2035, no more than 40 percent of each employer's workforce would be eligible to commute by auto on an average workday. To minimize impacts on small businesses, businesses with fewer than 50 employees would be exempt from this policy; furthermore, recognizing the difficulty in serving rural jobs by transit and non-motorized modes, agricultural employers would also be exempt from this policy. While each employer would have the flexibility to choose the right set of incentives and disincentives for their employees to meet or exceed the target, examples of employer-funded incentives include free or subsidized transit passes, bike & e-bike subsidies and giveaways, free bikeshare memberships, free commuter shuttles for employees, provision of on-site employee housing on current parking lots or other available land, rent or mortgage subsidies for employees residing in walkable transit-rich communities, and direct cash subsidies for walking, biking, or telecommuting. Employer-managed disincentives could include reduction or elimination of parking lots or garages, higher on-site or off-site parking fees, compressed work schedules, and elimination of dedicated workspaces in lieu of shared space.	UrbanSim 2.0; Travel Model 1.5	Transportation modeling assumes that workplace superdistricts with high auto mode share will increase telecommute rates up to estimated maximum (which is based on industry mix and existing firm size). Land use modeling assumes that workplace superdistricts with increased telecommuting will reduce average square foot per employee to account for workspace "hoteling". Note that many workplace superdistricts continue to have modeled auto mode share higher than the policy allows; we assume that these employers might implement auto mode share reductions through other means (e.g., shuttles to home or to transit), but we do not model these types of interventions in order to be conservative about strategy benefits).
EN8. Expand Clean Vehicle Initiatives. Expand investments in programs that support the adoption and use of clean vehicles, which include more fuel-efficient vehicles and electric vehicles (EVs), through purchase incentives and deployment of charging and fueling infrastructure, in partnership with the Air District and the State. These	Off-Model	Refer to Off-Model GHG Analysis section for methodologies to calculate GHG impacts of the EN8 initiatives.

Strategy Description	Quantification Approach	High-Level Modeling Notes
investments would expand existing strategies in MTC's Climate Initiatives Program, which include investing in a Vehicle Buyback & Electric Vehicle Incentives initiative and a Regional Electric Vehicle Charger initiative. The Vehicle Buyback & Electric Vehicle Incentive initiative would be expanded to subsidize at least 630,000 new electric vehicles, with a priority for income-qualifying buyers. The Regional EV Charger initiative subsidizes over 50,000 public EV chargers to expand charging opportunities for plug-in hybrid electric vehicles (PHEVs).		
EN9. Expand Transportation Demand Management Initiatives. Expand investments in transportation demand management (TDM) programs through MTC's Climate Initiatives Program to reduce greenhouse gas emissions for other transportation sectors. This includes a wide range of programs that discourage single-occupancy vehicle (SOV) trips and support use of other travel modes. Vanpool programs help organize and subsidize shared commute trips that reduce the number of vehicles on the road. Bike share services enable users to take short-distance trips to destinations or transit by bike instead of by car. Targeted transportation alternatives are a set of engagement and behavioral economic approaches to provide residents and workers personalized information on transportation alternatives to driving alone and trigger sustained behavior change that reduces the amount of vehicle driving across the region. Car share services offer an alternative to personal vehicle ownership; car share users drive fewer miles than vehicle owners and have access to vehicles that are more fuel efficient than average vehicles. Vanpool programs help organize and subsidize shared commute trips that reduce the number of vehicles on the road. A regional parking pricing initiative helps manage driving demand by increasing the cost of parking at more destinations.	Travel Model 1.5; Off-Model	Refer to Off-Model GHG Analysis section for methodologies to calculate GHG impacts of all EN9 initiatives excluding parking pricing. For the parking pricing component of this strategy, transportation modeling assumes that employers cease to subsidize parking at the workplace. Additionally, it is assumed that parking costs are increased in all Growth Geographies to a minimum of 25 cents per hour; where parking costs are currently non-zero and in Transit-Rich Areas, parking rates are assumed to increase by 25%.

Interregional Travel Assumptions

To develop interregional highway volumes for *Plan Bay Area 2050*, staff conducted a historical trend analysis for all of the regional gateways, looking at volumes of both commute and non-commute travel. Under the provisions of Senate Bill 375 and a related settlement agreement with the Business Industry Association (BIA Bay Area), the Bay Area is required to accommodate housing growth sufficient to ensure that commute travel between regions does not increase between the Plan baseline year (2015) and the Plan horizon year (2050); these households will be reflected in the regional forecasting process described above. As such, a trendline analysis was used to continue scaling up volumes at regional gateways for non-commute travel to reflect increased freight, recreational, and other non-commute trip growth in the Northern California megaregion, while commute trips were assumed to remain fixed at year 2015 levels.

A table of key regional gateways with baseline and future year highway volumes for *Plan Bay Area 2050* is included below. Staff have coordinated with neighboring regions including SACOG, SJCOG, and AMBAG to ensure maximum consistency between assumed gateway volumes. Note that gateway volumes are expected to grow for all of the region's largest gateways, with the notable exception of SR-17 between Santa Cruz and Santa Clara counties (which has seen a slow but steady decline in traffic volumes for more than two decades). Furthermore, access trips to high speed rail stations and airports have been incorporated into Travel Model 1.5 in a manner similar to *Plan Bay Area 2040*. Passenger forecasts come from the 2016 High Speed Rail Business Plan, as well as the Bay Area's most recent Regional Airport Plan.

Table 4. Interregional Volume Assumptions for Key Gateways

Gateway (County)	Year 2015 Baseline (AADT[20])	Year 2035 Forecast (AADT)	Year 2050 Forecast (AADT)
State Route 113 (Solano)	40,800	50,000	55,600
Interstate 80 (Solano)	132,200	153,000	167,500
Interstates 205 + 580 (Alameda)	155,000	181,700	196,000
State Route 152 (Santa Clara/East)	33,500	39,700	42,700
U.S. Route 101 (Santa Clara)	56,000	63,600	68,700
State Route 17 (Santa Clara)	57,000	53,300	51,400

EMFAC Version

For *Plan Bay Area 2050*, MTC/ABAG is using **EMFAC 2014** for air quality and emissions modeling to meet state requirements in Senate Bill 375. EMFAC 2014 takes travel data – specifically vehicle miles traveled

[20] AADT = average annual daily traffic (i.e., typical weekday bidirectional traffic volumes)

by speed profile - from Travel Model 1.5 (described below) to calculate emissions for *Plan Bay Area 2050*. MTC/ABAG is using EMFAC 2014 based on the latest SCS Guidelines, which state that MPOs should use the same version of EMFAC as they used for the second cycle (i.e., *Plan Bay Area 2040*). Similar CO_2 post-processing, approved by ARB in prior cycles, has been integrated for *Plan Bay Area 2050*.

LAND USE/TRAVEL MODELING

Land Use Modeling

Bay Area UrbanSim 2.0 is a spatially explicit economic model that forecasts future business and household locations. MTC/ABAG used a version of the Bay Area UrbanSim 1.0 model to inform the environmental assessment for our first RTP/SCS (*Plan Bay Area*) and both the Plan process and the environmental assessment for our second RTP/SCS (*Plan Bay Area 2040*). An updated version of Bay Area UrbanSim (Version 1.5) was also used for the Horizon long-range planning process.

Bay Area UrbanSim 2.0 forecasts future land use change (e.g., development or redevelopment) starting from an integrated (across different source data) base year database containing information on the buildings, households, businesses and land use policies within the region. Running in five-year steps, the model predicts that some households will relocate and a number of new households will be formed or enter the region (as determined by the adopted regional growth forecasts). The model system micro-simulates the behavior of both these types of currently unplaced households and assigns each of them to a currently empty housing unit. A similar process is undertaken for businesses. During the simulation, Bay Area UrbanSim 2.0 micro-simulates the choices real estate developers make on how much, what, and where to build. This adds additional housing units and commercial space in profitable locations (i.e., land use policies at the site allow the construction of a building that is profitable under forecast demand).

In this way, the preferences of households, businesses and real estate developers are combined with the existing landscape of building and policies to generate a forecast of the overall land use pattern in future years. The land use policies in place in the base year can be changed (e.g., allowable zoned residential density could be increased) and Bay Area UrbanSim 2.0 responds by forecasting a different land use pattern consistent with the constraints or opportunities resulting from the change. After each five-year step, the model produces a zonal output file for the transportation model that contains household counts and employee counts by sector. This provides the travel model with information on land use intensity in different locations and the spatial distribution of potential origins and destinations within the region. Documentation for Bay Area UrbanSim 2.0 is available online.[21]

To build the forecasted land use development pattern, Bay Area UrbanSim 2.0 will be used to iteratively build the Blueprint in a manner that is vetted and assessed for realism by regional planners and feedback from local jurisdictions. Through this iterative process, we intend to bring to bear a forecasted development pattern that provides the best from both human planners and computer simulation tools before presenting them to the Commission and the ABAG Board for their consideration.

Key improvements between Bay Area UrbanSim 1.0 and Bay Area UrbanSim 2.0 include the following:

- Upgraded baseline data from local jurisdictions on year 2015 conditions
    - Integrated general plan & zoning information via the Bay Area Spatial Information System (BASIS) effort *(see Other Data Collection Efforts section below)*

[21] Bay Area UrbanSim documentation is available at: http://bayareametro.github.io/bayarea_urbansim/

- Integrated updated pipeline data on new developments
- New modeling features that allow for simulation of natural disasters and sea level rise
- Improved implementation of accessibility changes from Travel Model 1.5 into land use pattern shifts

Travel Modeling

Travel Model 1.5 is an updated version of Travel Model 1.0, which was used for *Plan Bay Area 2040*. Travel Model 1.5 is a regional activity-based travel model for the Bay Area. This model is a set of individual sub models that perform different functions leading to forecasts of Bay Area travel. In addition to exogenous variables highlighted below, Travel Model 1.5 takes land use inputs from UrbanSim 2.0 for the location of housing and jobs by travel analysis zone (TAZ).

Key improvements between Travel Model 1.0 and Travel Model 1.5 include the following:

- Incorporation of taxi and transportation network company (TNC) services – such as Uber and Lyft – as well as the ability to incorporate different levels of autonomous vehicle market penetration
- New features that allow for simulation of natural disasters and sea level rise
- Updated calibration and validation for year 2015 using observed data for the new baseline year
- A modular representation of network projects, enabling staff to build networks by layering projects onto a base network
- A new, open source population synthesizer, PopulationSim, which incorporates person- and household-level variables

Travel Model 1.5 accounts for many types of induced demand, including:

- Increased or decreased trip-making as a result of accessibility shifts
- Changes in trip or tour departure time as a result of accessibility shifts
- Changes in trip or tour destinations as a result of accessibility shifts
- Changes in mode choice as a result of accessibility shifts
- Changes in vehicle ownership as a result of accessibility shifts

Travel Model 1.5 documentation, including calibration and validation reports, is available online.[22] A peer review was conducted of the regional travel demand model in 2013, and additional updates to the model since then have been reviewed with partner agencies in the region through the Regional Modeling Working Group in 2018 and 2019.

MTC/ABAG staff met with CARB staff in fall 2021 to discuss proposed sensitivity tests. The sensitivity tests included in the submittal of *Plan Bay Area 2050* to CARB primarily relate to new transportation strategies not previously included in prior iterations of *Plan Bay Area*:

- Changes to transit fares (-50%, 0%, +50%)
- Changes to per-mile toll rates (0 cents, +15 cents, +30 cents)
- Changes to speed limits (-10 mph, -5 mph, 0, +5 mph, +10 mph)
- Changes to telecommute mode share (0%, +5%, +10%)
- Changes to parking costs (-50%, 0%, +50%)

Induced Travel and Land Use and Travel Model Interaction

[22] Travel Model 1.5 documentation is available at: https://github.com/BayAreaMetro/modeling-website/wiki/TravelModel1.5

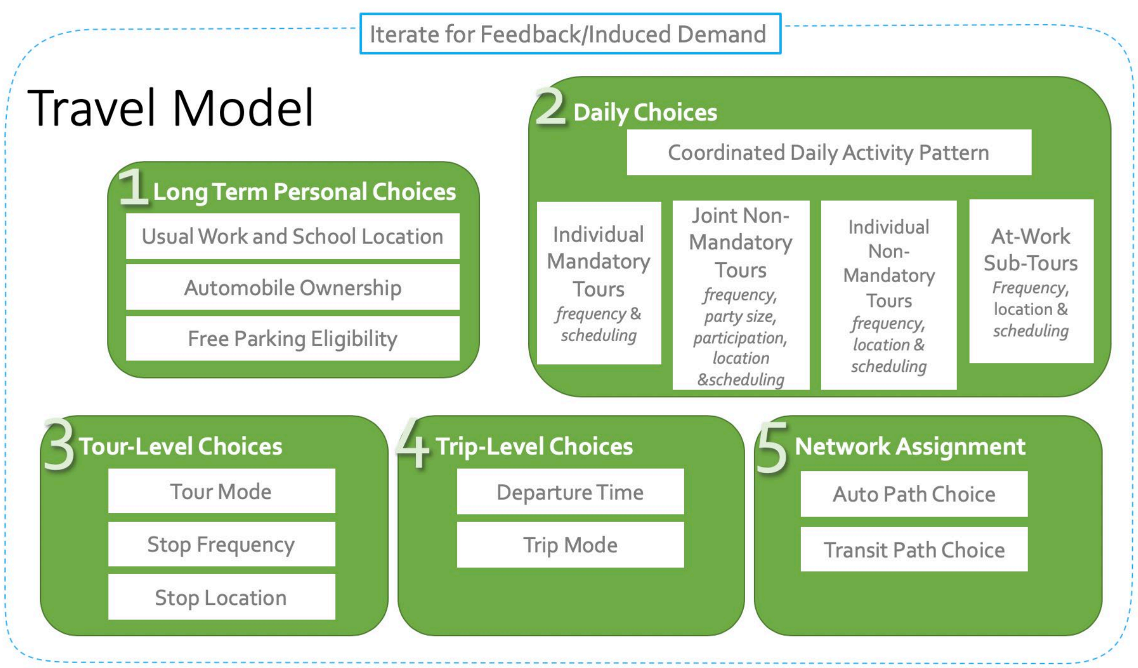
Vehicle miles traveled can be said to be "induced" by a variety of sources. These fall into two categories: short-run induced travel and long-run induced travel, both of which are incorporated into the MTC/ABAG modeling system.

Short-run induced travel consists of changes to trip length, travel routes, and travel modes, as well as the generation of new tours and trips. These are accounted for within a single run of the Travel Model, which includes three global iterations of all sub-models (see Figure 1). That is, for a given model year (e.g., 2035), a transportation network-based strategy, such as the construction of new express lanes, will induce travel as follows: when the roadway facility is added to the network, auto times will initially decrease because of the additional capacity which facilitates faster travel for the existing users of the facility. In the next global iteration, these updated travel times will influence all of the sub-models, including:

- Tour locations may change due to the increased accessibility from these shorter travel times (affecting trip length).
- New tours (and trips) may be generated in the Coordinated Daily Activity Pattern sub-model due to the increased accessibility from these shorter travel times.
- Tours and trips may shift modes to automobile travel due to the shorter auto travel times.
- Finally, in Network Assignment, travel routes will change to utilize the new facilities.

Note that in the next global iteration of the travel model, these sub-models will run again, this time reflecting the travel and resulting congestion on the new facility, which will reduce its travel time benefits somewhat. The Travel Model includes three global iterations to represent this feedback and equilibrate the short-run induced travel. The long-run induced travel from this strategy is reflected by iterating with Bay Area UrbanSim, which is described in the next section.

Figure 1. Travel Model Sub-Models & Iteration Framework (three iterations required)



Long-run induced travel is captured by interactions between the land use model and the travel model. When land use strategies are represented in Bay Area UrbanSim, the outputs from the model then reflect the following:

- Changes in residential location decisions within the region
- Changes in employment location decisions within the region
- Changes in residential development locations within the region
- Changes in commercial/industrial development locations within the region

This updated land use gets passed to the travel model for future years, which models travel behavior that is influenced by these new household locations. The travel behavior results in differing levels of congestion on the network, which in turn affects accessibilities that are output by the travel model, represented as destination choice logsums. These accessibilities are then passed back to the next iteration of Bay Area UrbanSim, where accessibility is valued by developers and increase the profitability of developing on a parcel. More information on this interaction is detailed in **Attachment D**.

Implications for Transportation Investments in Plan Bay Area 2050

CARB staff has also inquired how transportation investments, specifically highway projects, are selected for integration into *Plan Bay Area 2050* given induced demand concerns raised above. MTC/ABAG has a robust project evaluation & prioritization process, now in its third generation, with quantitative and qualitative components. More information on the benefit-cost analyses, Guiding Principles analysis, and equity analysis on the project level can be found here: https://mtc.ca.gov/our-work/plans-projects/horizon/project-performance-assessment. This process helps to identify projects that are in alignment with Plan goals and flag challenge areas (and require mitigation commitments) from transportation projects with any adverse impacts. Importantly, roadway expansion investments constitute a small portion of the transportation investment portfolio for the Bay Area, with Strategy T6 (Improve Interchanges and Address Highway Bottlenecks) only totaling $11 billion of the $579 billion total in *Plan Bay Area 2050*'s Transportation Element.

When transportation projects are coded into the long-range plan as part of the overall Travel Model 1.5 network, positive effects (TOD around new rail stations) and negative effects (additional traffic volumes from highway capacity expansions) from induced demand are reflected in the modeling process described above. Furthermore, recent projects in the past decade are coded into Travel Model 1.5 to ensure such investments' induced demand effects are captured in the analysis done for *Plan Bay Area 2050*. The integrated model approach used by MTC/ABAG helps to ensure that a wide range of induced demand considerations are accounted for, rather than assuming a fixed land use pattern as was done prior to the passage of SB 375.

PROPOSED LIST OF EXOGENOUS VARIABLES AND ASSUMPTIONS FOR PLAN BAY AREA 2050

Table 5. Preliminary List of Exogenous Variables and Assumptions

Variable	Variable Details *(if available)*	Year 2035 Assumption *(Target Year)*	Year 2050 Assumption *(Horizon Year)*
Regional Forecast			
Economic Model Version		REMI 2.3	
Population		9.1 million	10.3 million
Employment		4.8 million	5.4 million
Housing Units		3.7 million	4.3 million
Households		3.5 million	4.0 million
Household Income Distribution *(prior to Strategy EC1 - universal basic income)*	Households within each of the four quantiles used across models	Less than $51K: 27% $51K to $103K: 21% $103K to $171K: 20% More than $171K: 32%	Less than $51K: 27% $51K to $103K: 20% $103K to $171K: 20% More than $171K: 33%
Population Age Distribution	Population within each of the age buckets used across models	Age 0-14: 14% Age 15-24: 11% Age 25-64: 53% Age 65+: 21%	Age 0-14: 14% Age 15-24: 10% Age 25-64: 53% Age 65+: 23%
Persons per Household		2.6	2.6
Workers per Households		1.4	1.4
Land Use			
Land Use Model Version		Bay Area UrbanSim 2.0 Parcel-Based Land Use Model	
Building Costs		*Based on RSMeans Construction Cost Data*	
Construction Profit Margin	Minimum profit margin to advance for-profit development	7%	7%
Sea Level Rise		1 foot + flooding	2 feet + flooding
Transportation			
Travel Demand Model Version		Travel Model 1.5 Activity-Based Travel Model	

Variable	Variable Details *(if available)*	Year 2035 Assumption *(Target Year)*	Year 2050 Assumption *(Horizon Year)*
Auto Operating Cost *(additional context in Attachment E)*	Fuel and non-fuel related costs (maintenance, repair, and tire wear)	15.9 cents/mile *(in year 2000 dollars)* 24.2 cents/mile *(in year 2017 dollars)*	17.4 cents/mile *(in year 2000 dollars)* 26.6 cents/mile *(in year 2017 dollars)*
Vehicle Fleet Efficiency		Use same vehicle fleet assumptions as EMFAC 2014.	
TNC and TNC-Pool: In-Vehicle Time Coefficient for Mode Choice		Same as drive alone, etc.	
TNC and TNC-Pool: Alternative-Specific Constant for Mode Choice		TNC constants will be asserted to account for presumed wider availability compared to base year.	
TNC and TNC-Pool: Wait Time, Tolls, and Fares		Based on 2015 data. See detail in Travel Model 1.5 Documentation: Ride-hailing and Taxi Modes.[23]	
TNC and TNC-Pool: In-Vehicle Time Multiplier	In-vehicle time multiplier for shared TNCs to reflect out-of-direction travel to pick-up or drop-off additional customers	1.5 based on data reported in literature.[24]	
TNC and TNC-Pool: Vehicle Occupancy Factor		Based on data collected from the pilot of the Bay Area Transportation Study.[25] The pilot was conducted in Fall 2018, with close to 1,300 rail-hailing trips.[26]	

[23] Travel Model 1.5 Documentation: Ride-hailing and Taxi Modes is available at https://github.com/BayAreaMetro/modeling-website/wiki/TravelModel1.5#ride-hailing-and-taxi-modes
[24] https://las.depaul.edu/centers-and-institutes/chaddick-institute-for-metropolitan-development/research-and-publications/Documents/Uber%20Economics_Live.pdf
[25] https://mtc.ca.gov/our-work/plans-projects/other-plans/bay-area-transportation-study
[26] According to data collected from the pilot of the Bay Area Transportation Study, 53% of the nonpooled TNC trips were 2 person occupancy and 47% were 3+ person occupancy in 2018 (there are no single occupancy nonpooled TNC because each trip should have at least one driver and one passenger). For future years (2035 onwards), it is assumed that TNCs will become autonomous, and therefore the 53% that were 2 person occupancy are assumed to be single occupancy, and the 47% of that were 3+ person occupancy are assumed to be 2+ person occupancy. As for pooled TNC, the data suggests that 18% of the pooled TNC trips were 2 person occupancy (one driver plus one passenger) and 82% were 3+ person occupancy (one driver plus at least 2 passengers) in 2018. For future years (2035 onwards), again it is assumed that TNC will become autonomous, and therefore the 18% that were 2 person

Variable	Variable Details *(if available)*	Year 2035 Assumption *(Target Year)*	Year 2050 Assumption *(Horizon Year)*
TNC and TNC-Pool: Zero-Vehicle Factor	Factor reflecting every TNC mile driven with passengers yields additional mileage without passengers	0.7 *(additional 0.7 miles driven without passengers for every passenger-mile)*[27]	
Taxi: In-Vehicle Time Coefficient for Mode Choice		Same as drive alone.	
Taxi: Alternative-Specific Constant for Mode Choice		Taxi constant will be assumed to be the same as the base year.	
Taxi: Wait Time, Tolls, and Fares		Based on 2015 data. See detail in Travel Model 1.5 Documentation: Ride-hailing and Taxi Modes.[28]	
Taxi: Vehicle Occupancy Factor		Taxis are assumed to have the same occupancy as nonpooled TNCs in the base year; i.e. 53% of the taxi trips are 2 person occupancy and 47% are 3+ person occupancy (based on the pilot of the Bay Area Transportation Study). Taxi occupancy is assumed to remain constant in future years.	
Taxi: Zero-Vehicle Factor	Factor reflecting every taxi mile driven with passengers yields additional mileage without passengers	0.7 *(additional 0.7 miles driven without passengers for every passenger-miles)*[29]	
Autonomous Vehicles: Fleet Penetration	Share of total passenger vehicle fleet that is autonomous	5%	20%

occupancy are assumed to be single occupancy, and the 82% that were 3+ person occupancy are assumed to be 2+ person occupancy.

[27] Based on aggregated statewide data released by the California Public Utilities Commission: http://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/About_Us/Organization/Divisions/Policy_and_Planning/PPD_Work/PPD_Work_Products_(2014_forward)/Electrifying%20the%20Ride%20Sourcing%20Sector.pdf

[28] Travel Model 1.5 Documentation: Ride-hailing and Taxi Modes is available at https://github.com/BayAreaMetro/modeling-website/wiki/TravelModel1.5#ride-hailing-and-taxi-modes

[29] Based on aggregated statewide data released by the California Public Utilities Commission: http://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/About_Us/Organization/Divisions/Policy_and_Planning/PPD_Work/PPD_Work_Products_(2014_forward)/Electrifying%20the%20Ride%20Sourcing%20Sector.pdf

Variable	Variable Details *(if available)*	Year 2035 Assumption *(Target Year)*	Year 2050 Assumption *(Horizon Year)*
Autonomous Vehicles[30]: Overall Auto Ownership		Assumed to be similar to world without AVs.	
Autonomous Vehicles: Auto Ownership Likelihood by Households	Coefficients representing different likelihood of AV ownership by household types	Based on recent research for FHWA.[31]	
Autonomous Vehicles: Household Use Allocation	Probability boosts representing that, for AV-owning households, AVs may be more likely to be used than human-driven vehicles	The probability boost is set to 1 (i.e., the assumption was that AV and human driven vehicles are equally likely to be used within an AV owning household). [32][33]	
Autonomous Vehicles: In-Vehicle Time Coefficient for Mode Choice		Same as human driven vehicles.	
Autonomous Vehicles: Parking + Auto Operating Cost and Terminal Time		Same as human driven vehicles.	
Autonomous Vehicles: Effective Roadway Capacity	Passenger-car equivalent reflecting improved vehicle spacing	1.0	
Autonomous Vehicles: Zero-Vehicle Factor	Factor reflecting every AV mile driven with passengers yields additional mileage without passengers	0.7 *(additional 0.7 miles driven without passengers for every passenger-miles)*[34]	

[30] Assumptions pertaining to the impact of AVs were developed based on the outcomes of a literature search, a series of presentations, a workshop and a survey of Regional Modeling Working Group participants.
[31] https://www.fhwa.dot.gov/planning/tmip/publications/other_reports/model_impacts_cavs/

[33] https://github.com/BayAreaMetro/modeling-website/wiki/TravelModel1.5#AV_Tour_Availability
[34] Based on aggregated statewide data released by the California Public Utilities Commission: http://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/About_Us/Organization/Divisions/Policy_and_Planning/PPD_Work/PPD_Work_Products_(2014_forward)/Electrifying%20the%20Ride%20Sourcing%20Sector.pdf

Variable	Variable Details *(if available)*	Year 2035 Assumption *(Target Year)*	Year 2050 Assumption *(Horizon Year)*
Commercial/ Freight VMT	Truck trip generation for various types of employment; K-factors for truck trip distribution; diurnal factors	Continue to use the same assumptions as used in *Plan Bay Area* and *Plan Bay Area 2040*.	
Interregional Highway Travel	AADT volumes at highway gateways	See table above.	
Interregional Rail Travel	Number of passenger boardings/alightings at four Bay Area HSR stations	High Speed Rail 2016 Business Plan Ridership and Revenue Model Forecast	
Workers Not Working	Share of full-time workers who are not working (vacation, sick or not scheduled to work) on typical day	10.8%	
Baseline Commute Mode Share - Work from Home[35] *(prior to regulatory impacts of Strategy EN7 on regional telecommuting levels)*	Share of full-time workers who work from home (i.e., telecommute) on a typical day	11.8%	13.2%
Sea Level Rise		1 foot + flooding	2 feet + flooding

[35] Assuming constant rate from 2015, which is based on calibrated Coordinated Daily Activity Pattern model, which estimates that 19.2% of full-time workers do not make a work tour on a typical day; these are then split into two groups -- those who are not working versus those who are telecommuting -- based on data from the 2018-2019 Bay Area Transportation Study.

PER-CAPITA GHG EMISSIONS FROM PRIOR PLAN

In compliance with CARB requirements, staff conducted an Incremental Progress Assessment in 2020 and 2021. This analysis required MTC/ABAG to disaggregate forecasted GHG emission reductions between existing strategies (those from *Plan Bay Area 2040*) and new strategies (those added *in Plan Bay Area 2050*). This also enables all parties to understand how external forces, like future growth forecasts or new technologies, may affect future forecasted reductions.

To quantify the revised GHG emissions forecast for *Plan Bay Area 2040* strategies, staff updated assumptions on external forces that impact travel behavior based on any available new research, as highlighted above. Staff also updated from Travel Model One to Travel Model 1.5, which includes representation of ride-hailing and autonomous vehicles, as well as updated approaches for strategies that are analyzed outside of the travel model. Using the refined models, staff updated GHG emissions estimates for the suite of strategies included in *Plan Bay Area 2040*. This model run was paired with data from various EIR model runs to generate the summary table below.

Table 6. Incremental Progress Assessment Findings (2021)

GHG Performance by Plan Iteration	Past Exogenous Assumptions (2017)	Current Exogenous Assumptions (2021)	State-Mandated GHG Target
No Project	**-2%** per-capita reduction by 2035	**+2%** per-capita increase by 2035	**N/A**
Final Plan Bay Area 2040	**-15%** per-capita reduction by 2035	**-8%** per-capita reduction by 2035	**-15%** per-capita reduction by 2035
Final Plan Bay Area 2050	**N/A**	**-20%** per-capita reduction by 2035	**-19%** per-capita reduction by 2035
Data Source	*Plan Bay Area 2040 Final EIR (2017)*	*Plan Bay Area 2050 Final EIR & Incremental Progress Assessment (2021)*	*CARB (2010, 2018)*

Based upon these various model runs, the following findings can be intuited:

- **No Project GHG performance between Plan Bay Area 2040 and Plan Bay Area 2050 differs by four percentage points.** This likely indicates the relative magnitude of changes in exogenous variables, including reduced auto operating costs compared to prior Plan cycles, integration of TNCs/autonomous vehicles and the associated zero-passenger miles, and other external factors.
- **Plan Bay Area 2040 GHG performance is estimated to see an increase of seven percentage points when exogenous variables and methodologies applied in Plan Bay Area 2050.** This reflects the compound effect of exogenous variables making it harder to achieve the greenhouse gas target mixed with more conservative strategy assumptions, such as sharing GHG reductions from regional electrification initiatives with the State.
- **This highlights why it was so challenging for the Bay Area to meet the new target, which was adopted before exogenous variables could be updated and before GHG calculation methodologies were updated.** Ultimately, this Plan cycle required 11 additional “GHG points” worth of new and expanded strategies, not the 4 “GHG points” as anticipated in CARB’s 2018 action.

- **The new and expanded strategies in Plan Bay Area 2050 ultimately achieved the state target and outperformed Plan Bay Area 2040 by twelve percentage points of GHG reduction.** Policies like tolling of all freeway lanes in corridors with high-quality transit options, integration of a regional 55 mph speed limit, and increased development capacity in regionally-identified Transit-Rich and High-Resource Areas likely played a key role on this front.

Table 7. Estimated Impacts of Changes between 2017 and 2021

Source	Estimate of Performance Impact	Information Source
Plan Bay Area 2040	**-15 GHG "points"**	*Plan Bay Area 2040 Final EIR*
Updates to Exogenous Assumptions, Methodologies, and Models (CARB + MTC/ABAG Consultation Process)	**+7 GHG "points"**	*Comparison of Incremental Progress Assessment with Plan Bay Area 2040 Final EIR*
New & Improved Strategies (MTC/ABAG Action)	**-12 GHG "points"**	*Plan Bay Area 2050 Final EIR, minus Incremental Progress Assessment*
Plan Bay Area 2050	**-20 GHG "points"**	*Plan Bay Area 2050 Final EIR*

OFF-MODEL GHG ANALYSIS

Plan Bay Area 2050 includes a variety of climate-related initiatives that cannot be captured in the regional travel model. This is due to the fact that Travel Model 1.5 is not sensitive to the full range of policies MTC/ABAG may choose to pursue. Marketing and education campaigns, as well as non-capacity-increasing transportation investments like bikeshare programs, are examples of strategies with the potential to change behavior in ways that result in reduced vehicle emissions. Travel Model 1.5 and EMFAC2014 do not estimate reductions in emissions in response to these types of changes in traveler behavior. As such, MTC/ABAG uses "off-model" approaches to quantify the GHG reduction benefits of these important climate initiatives, which constitute most of the key subcomponents of **Strategy EN8: Expand Clean Vehicle Initiatives** and **Strategy EN9: Expand Transportation Demand Management Initiatives**:

- Initiative EN8a: Regional Electric Vehicle Chargers
- Initiative EN8b: Vehicle Buyback & Electric Vehicle Incentives
- Initiative EN9a: Bike Share
- Initiative EN9b: Car Share
- Initiative EN9c: Targeted Transportation Alternatives
- Initiative EN9d: Vanpool

All of these initiatives were included in the previous regional plan, *Plan Bay Area 2040*, and the primary GHG emission calculation approaches remain unchanged. However, the calculation inputs and assumptions have been updated to reflect new data and research, where available, and travel model outputs reflecting *Plan Bay Area 2050*. The initiative descriptions, implementation activities, and GHG emission quantification approaches are summarized in the following section by initiative.

Please note: Excel calculators for all off-model initiatives are available for download at the following link: https://mtcdrive.box.com/s/w0y85i2tne14jw59msn4sq651yxsel5e

Strategy EN8: Initiative EN8a – Regional Electric Vehicle Chargers

Initiative Description

Electric vehicles (EVs) have the potential to significantly reduce GHG emissions from motor vehicles. Today, the Bay Area is the leading market for EV sales, including both plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs). PHEVs have a hybridized powertrain that is fueled by chemical energy from a battery or by gasoline/diesel. BEVs are powered exclusively by the chemical energy from a battery. The focus of this initiative is on expanding the charging opportunities for the population of PHEVs in the Bay Area by establishing a regional public network of electric vehicle charging stations.

The costs of installing charging stations can be high, and there are other barriers (e.g., on-site electrical capacity) that may also limit the potential for deploying charging at workplaces. This program will be designed to help overcome some of those barriers by providing financial assistance to interested employers, retailers, parking management companies, and others that qualify. A regional network of charging infrastructure will provide drivers an opportunity to plug in while at work, which is where most vehicles spend most of their time parked when not at home. This will mean that PHEVs are able to travel more miles using electricity and fewer miles using gasoline, reducing GHG emissions.

This initiative was included in *Plan Bay Area 2040* and continues in *Plan Bay Area 2050*. In 2017, MTC transferred a total of $10 million to the Bay Area Air Quality Management District (BAAQMD) to advance EV activities. BAAQMD currently administers the Charge! Program, providing grant funding for the purchase and installation of publicly accessible chargers for light-duty EVs. MTC continues to work with BAAQMD to monitor investments and to develop a coordinated approach to implementing charging infrastructure throughout the region.

GHG Reduction Quantification Approach

This initiative invests in charging infrastructure to expand the network of chargers available to Bay Area drivers. As a result, PHEV drivers will be able to drive a larger share of miles in electric mode, as opposed to gasoline-powered mode, reducing GHG emissions. The impacts of this initiative are not otherwise captured in MTC's emissions calculations, which rely on default EMFAC assumptions for the fraction of PHEV miles in electric vs. gasoline mode.

Inputs and Assumptions

The prior *Plan Bay Area* analysis was updated to account for improved fuel economy estimates, updated vehicle populations, and new vehicle sales in the Bay Area based on data included in the EMFAC2014 (v1.0.7) Emissions Inventory and the ZEV Compliance Mid-Range Scenario of the Advanced Clean Cars Mid-term Review. The analysis also updated the number of chargers to be funded by MTC and deployed to support the region's PHEV population.

In the baseline, it was assumed that 46 to 60 percent of miles traveled by PHEVs would be in charge-depleting mode, i.e., electric miles instead of gasoline-powered miles. This assumption comes from EMFAC2017 Technical Documentation, which indicates that "[CARB] staff modeled PHEVs as having a 25-mile all-electric range, which equates to a utility factor of 0.40. For the average commute, this would mean that 40 percent of the VMT could be from all-electric, and 60% would be from gasoline operations."[36]

To estimate the fraction of PHEVs that operates like pure ZEVs, EMFAC uses utility factors, which are defined as the fraction of VMT the PHEV obtains from the electrical grid. EMFAC2014 was assuming a constant utility factor of 0.4 for all model years of PHEVs, while in EMFAC2017 this fraction is more dynamic and varies by model years from 0.46 for MY2018 to 0.6 for MY2025+.[37]

The electric VMT (eVMT) percentage is assumed to increase to 80 percent due to the Regional Charger Program. Based on a review of EV user surveys and analytics included in the Advanced Clean Cars Mid-Term Report[38], data suggest that PHEV owners can reach 80 percent eVMT with access to adequate supportive charging infrastructure. This analysis assumes that if the entire region has sufficient workplace and opportunity (public) charging infrastructure, then all PHEVs in the region could operate at this assumed maximum eVMT percentage.

[36] California Air Resources Board, EMFAC2014 Volume III – Technical Documentation v1.0.7, May 2015. Available online at http://www.arb.ca.gov/msei/downloads/emfac2014/emfac2014-vol3-technical-documentation-052015.pdf.

[37] California Air Resources Board, EMFAC2017 Volume III – Technical Documentation V1.0.2, July 20, 2018. Available online at https://ww3.arb.ca.gov/msei/downloads/emfac2017-volume-iii-technical-documentation.pdf.

[38] California Air Resources Board, Advanced Clean Cars Mid-Term Report, Appendix G: Plug-in Electric Vehicle In-Use and Charging Data Analysis, January 18, 2017. Available online at https://ww2.arb.ca.gov/resources/documents/2017-midterm-review-report

The analysis methodology assumes:

- Each charger deployed through the Regional Charger Network serves multiple vehicles each day
- The chargers deployed are Level 2 chargers
- Each charger consists of two plugs

The National Renewable Energy Laboratory's EVI Pro Lite tool was used to determine the number of chargers required to support the forecasted PHEV population. While the ratios vary by PHEV penetration, it is approximately one charger plug for every four vehicles over the program period. For the financial analysis, the initiative assumes a $3,000 subsidy per charger is provided.[39] The table below summarizes the number of expected PHEVs, plugs, and chargers by analysis year.

Table 11. Regional EV Charger Initiative Inputs and Assumptions

Parameter	2035	2050	Source
PHEV population	363,012	458,818	EMFAC2014
Plug/PHEV ratio	0.2352	0.2352	EVI-Pro
Charging plugs needed	85,384	107,918	calculation
Chargers needed	42,692	53,959	Calculation
Incentive amount ($/charger)	$3,000	$3,000	Investment assumption

In addition to increasing the percentage of electric miles driven in PHEVs, the increased availability of chargers could mitigate consumer "range anxiety" concerns and increase the adoption and use of EVs and further reduce GHG emissions, but this potential effect is not included in this approach, as a conservative assumption. Furthermore, this approach does not include any additional PHEVs incentivized through the Vehicle Buyback & EV Incentive initiative and any increased eVMT share for those PHEVs; the baseline eVMT share is applied to PHEVs realized through that initiative rather than the higher eVMT share assumed in the regional charger network scenario, also as a conservative assumption.

Calculation of emissions impacts relies on the parameters shown in the table below.

Table 12. Regional EV Charger Program Calculation Parameters

Parameter	Value	Source
Fuel efficiency of PHEV gasoline engine	40 mpg	24.9 mpg for gasoline LDV, based on EPA Automotive Trends Report, 2020; 62% improvement for PHEV engine based on comparison of similar gasoline and hybrid models
Baseline eVMT share for PHEVs - pre MY2025	46%	EMFAC2017 Volume III Technical Documentation
Baseline eVMT share for PHEVs - MY2025+	60%	EMFAC2017 Volume III Technical Documentation
Initiative eVMT share for PHEVs	80%	CARB, Advanced Clean Cars Mid-Term Report, 2017
Energy density of gasoline	115.83 MJ/gallon	CA GREET 3.0

[39] Note that the methodology uses the projected PHEV population from EMFAC and EVI-Pro to estimate the total number of chargers required across the region to meet that forecasted PHEV population; the incentive amount is used to calculate the total investment required to meet this demand

Carbon intensity of gasoline (tailpipe)	72.89 gCO2/MJ	CA GREET 3.0

Calculation Methodology

To determine the GHG emission reductions from the Regional Charger Program, the analysis method employs the following steps:

1. Use EMFAC to obtain the forecast population of EVs in the Bay Area through 2050, by calendar year and model year.
2. Process EV population data to estimate the population of PHEVs by calendar year and model year.
3. Calculate baseline PHEV eVMT by calendar year, using assumptions in EMFAC2017 that eVMT percentage is 46% for MY2018-2024 and 60% for MY2025+.
4. Calculate baseline PHEV emissions, multiplying baseline PHEV VMT for each calendar year by average fuel efficiency, energy density, and carbon intensity.
5. Apply initiative eVMT percentage to calculate difference in eVMT between baseline and initiative scenario.
6. Calculate PHEV emissions in initiative scenario.
7. Calculate GHG emissions reduction as the difference between the baseline and initiative scenario PHEV emissions.

Strategy EN8: Initiative EN8b – Vehicle Buyback & Electric Vehicle Incentive

Initiative Description

Despite a rapid increase in commercially available electric vehicle (EV) models, EV sales are still relatively small, representing about 8 percent of total new light-duty vehicle sales in California. While falling battery prices are expected to make EVs more attractive to consumers, there are also barriers related to EV costs and benefits. The price of new EVs is still beyond the reach of many potential new vehicle buyers, particularly lower income consumers. To begin addressing this challenge, California's Clean Vehicle Rebate Program (CVRP) was changed in 2016 to adjust incentive amounts based on household income. HOV lane access for some EVs has been eliminated, reducing the non-financial incentives to own an EV. And without additional Congressional action, federal EV tax credits will phase out in its current format because the full tax credit only applies to the first 200,000 EVs sold per automaker; once the 200,000 unit limit is reached, the tax credit value decreases on a quarterly basis until it is phased out completely approximately one year after the automaker surpasses the threshold. Tesla was the first automaker to surpass the sales threshold in July 2018 and General Motors followed suit in December 2018. The early phase out and elimination of these tax credits could potentially have negative sales implications for the Tesla Model 3 and Chevy Bolt – two of the most popular EVs sold in California. Other EV manufacturers are expected to surpass the threshold in the coming years.

This program will provide an incentive to purchase an EV when trading in older, higher emission vehicles. This is intended to extend the market for EVs into a broader range of income classes. Research indicates that the early adopters of EVs have been higher income individuals who own their homes, and in many cases, own or have owned a hybrid vehicle (e.g., a Toyota Prius). The higher purchase price of EVs makes it difficult for middle- and low-income consumers to purchase them. Older and wealthier individuals tend to buy more new vehicles than other cross-sections of the population. This demographic also tends to buy newer cars more frequently. Furthermore, research from IHS Markit has shown that owners of both new and used vehicles are holding on to their vehicles longer, the scrappage rate has flattened, and the average age of vehicles has increased; the researchers forecast that the population of oldest vehicles (16 or more years) will grow the fastest, increasing by 30 percent by 2021.[40] This will impact the turnover of the fleet significantly and may slow the purchase of new vehicles, including electric vehicles.

In this program, qualifying consumers can receive a subsidy to purchase a plug-in hybrid electric vehicle (PHEV) or battery electric vehicle (BEV) for scrapping a vehicle that is 15 or more years old. The incentive amount will vary with the vehicle type being purchased (e.g., PHEV or BEV). Additionally, to provide more equitable access to clean transportation options, incentive amounts will vary by household income level, with incentives phased out entirely for higher income buyers.

This initiative was included in *Plan Bay Area 2040*. In 2017, MTC transferred a total of $10 million to the Bay Area Air Quality Management District (BAAQMD) to advance the EV activities. MTC continues to coordinate with BAAQMD, the lead agency for electric vehicle programs in the region, to advance this initiative and track progress. In *Plan Bay Area 2050*, a significantly larger investment is envisioned with incentive amounts adjusted based on buyer income.

GHG Reduction Quantification Approach

The vehicle buyback program seeks to accelerate fleet turnover while also incentivizing the purchase of EVs. The combination vehicle buyback and incentive program is intended to induce demand in middle- and lower-income brackets that might otherwise delay car purchasing or purchase a new or used conventional vehicle (i.e., non-EV). The program will result in a higher fraction of EVs owned and operated in the Bay Area than assumed in default EMFAC assumptions.

Inputs and Assumptions

Plan Bay Area 2040 analysis was revised to account for improved fuel economy estimates, increased incentive amounts and program participation, and the mix of PHEVs vs. BEVs incentivized. The program is assumed to be implemented through 2035 and participation is assumed to be equal across the program years. The age of the vehicles being replaced is assumed to be 15 years or older.

The program incentives are assumed to range from $1,800 to $13,600, with average incentive levels of $3,600 per PHEV and $8,160 per BEV; the program incentive will vary based on income and EV type.[41] The State's primary EV incentive program, the Clean Vehicle Rebate Project (CVRP), is assumed to provide additional purchase incentive amounts on top of the plan initiative in the amount of $3,500 per PHEV and $4,500 per BEV for households with incomes below $50,000, $1,000 per PHEV and $2,000 per

[40] Vehicles Getting Older: Average Age of Light Cars and Trucks in U.S. Rises Again in 2016 to 11.6 Year, IHS Markit Says." Press release from IHS Markit, November 2016.
[41] A consultant review of EV models and equivalent non-EV models (e.g., Volkswagen Golf vs eGolf) found the average difference in cost to be $13,600 The program is assumed to cover the full difference in cost for households in the lowest income quartile. Purchase subsidies for the second and third quartile households are scaled relative to income quartile thresholds; no subsidies are assumed for the highest quartile earners. It is assumed that the participation level across the three qualifying income groups will be equal.

BEV for households earning up to $170,000, and no rebates for the highest income households.[42] The region's GHG benefits for this initiative are calculated as a proportion of the region's incentive amount relative to the total combined regional and state incentive amount.

The program assumes a $5.1 billion investment through 2035, incentivizing buyback and purchase of 630,000 EVs. It is assumed that 30 percent of incentives are used for PHEVs and 70 percent for BEVs, based on the share of EV types receiving CVRP incentives over the period 2017-2019.

Table 13. Vehicle Buyback and EV Incentive Initiative Inputs and Assumptions

Parameter	Value	Source
Fuel efficiency of PHEV gasoline engine	40 mpg	24.9 mpg for gasoline LDV, based on EPA Automotive Trends Report, 2020; 62% improvement for PHEV engine based on comparison of similar gasoline and hybrid models
Share of incentivized EV types	70% BEV, 30% PHEV	CVRP rebate data, average 2017-19
eVMT share for PHEVs - pre MY2025	46%	EMFAC2017
eVMT share for PHEVs - MY2025+	60%	EMFAC2017
Energy density of gasoline	115.83 MJ/gallon	CA GREET 3.0
Carbon intensity of gasoline (tailpipe)	72.89 gCO2/MJ	CA GREET 3.0

Calculation Methodology

To determine the GHG emission reductions from the Vehicle Buyback & EV Incentive initiative, the analysis method employs the following steps:

1. Calculate the number of new PHEVs and BEVs incentivized through initiative for each program year.
2. Calculate the cumulative number of incentivized PHEVs and BEVs operating in each calendar year, accounting for average vehicle turnover by vehicle age.[43]
3. Use EMFAC forecasts of vehicle populations, fuel consumption, and VMT for gasoline light-duty automobiles (LDA – Gas) in the Bay Area to calculate the average gasoline consumption per replaced vehicle (for vehicles 15 years old), by calendar year.
4. Calculate the GHG emissions impact of the program, by calendar year, as the difference between emissions from the replaced vehicles and the emissions from the incentivized EVs, using average carbon intensity values for electricity and gasoline, average energy density for electricity and gasoline, and average energy efficiency for gasoline and electric motors.

[42] California Clean Vehicle Rebate Project incentive amounts based on current (2021) program structure offering $1,000 per PHEV and $2,000 per BEV for consumers earning up to $150,000 (single filers) and an additional $2,500 for consumers earning less than $51,520 (household size 1). Rebate amounts and income eligibility information collected from CVRP website (accessed August 11, 2021): https://cleanvehiclerebate.org/eng.
[43] A share of these new EVs are assumed to be removed from operation (e.g., as a result of collisions) each year, with higher turnover rates for older model years.

5. Calculate MPO regional incentive share of combined MPO and State incentive amount for PHEVs and BEVs.
6. Apply MPO incentive share to GHG emissions impact for each program calendar year to calculate MPO share of GHG emission reductions.

Strategy EN9: Initiative EN9a - Bike Share

Initiative Description

Bike share systems provide bicycles that members of the public can borrow and use for limited durations in exchange for a fee. In traditional systems, bike share bicycles must be borrowed from and returned to designated docking stations. More recently, dockless bike share systems have emerged, allowing users to leave the bicycles anywhere in the service area. Additionally, bike share providers offer electric bikes, or e-bikes, that can be both parked at a station or docklessly. Dockless e-bikes have the opportunity to attract more users and replace more motorized vehicle trips by making bike trips more convenient for users and by expanding the trip distances that can be made by bike share. In an analysis of docked, dockless, and e-bike bike share services in San Francisco, researchers found that a dockless e-bike service was used for more bike trips per bike and for longer trips.[44]

In August 2013, in collaboration with MTC, the Bay Area Air Quality Management District implemented a bike share system in the Bay Area on a limited pilot basis called Bay Area Bike Share (BABS). BABS consisted of approximately 700 bikes deployed across 70 stations with approximately half in San Francisco and the other half in South Bay cities. This pilot program provided valuable information regarding the potential for bike share systems to reduce VMT and emissions.

Since the initial pilot program, bike share has expanded widely across the Bay Area both in the number of bikes and the service areas. The system, now called Bay Wheels, is growing to 7,000 bikes and operates across San Francisco, Berkeley, Emeryville, Oakland, and San Jose. Lyft owns and operates the system with MTC serving as contract administrator. As part of these agreements, Lyft shares ridership and other data publicly, allowing MTC to track bike share system use and update the GHG analysis using the data. MTC has also provided grants to initiate other bike share services that will expand access in the East Bay and bring bike share to the counties of Marin and Sonoma along the SMART train corridor. MTC also manages the Clipper Card, which can also be used to access and unlock bike share bikes.

GHG Reduction Quantification Approach

Bike share reduces GHG emissions by enabling users to take short-distance trips by bicycle instead of by car, and in some cases bike share can eliminate longer trips by enabling users to connect to transit. Bike share program expansion is not captured in MTC' s travel model. The mode choice models in Travel Model 1.5 were calibrated using the California Household Travel Survey from 2012-2013, before bikeshare deployment. Although MTC's travel model includes bicycling as a travel mode, it is not structured to capture the travel effects of expansion of a bike share system.

Previously, in *Plan Bay Area 2040*, bike share ridership was estimated based on studies of other systems. For *Plan Bay Area 2050*, the approach has been updated to incorporate recent ridership data collected

[44] Lazarus, Jessica, Jean Carpentier Pourquier, Frank Feng, Henry Hammel, and Susan Shaheen. Bikesharing Evolution and Expansion: Understanding How Docked and Dockless Models Complement and Compete--A Case Study of San Francisco. No. 19-02761. 2019.

from the regional bike share operator. Additionally, the approach now includes modeling the impacts of the rapid introduction of e-bikes in the regional bike share system.

Inputs and Assumptions

Travel and emissions impacts are calculated based on the number of Bay Wheels bike share trips and the relationship between bike share trips and VMT reduction. Lyft reported the number of trips using the Bay Wheels system for the period May to October 2019, shown in the table below. The daily average during this period was 7,089 trips per day.

Table 6. Bike Share Trips using Bay Wheels System, 2019

City	May	June	July	Aug	Sept	Oct
Berkeley	15,854	14,173	12,738	17,985	20,324	20,307
Emeryville	1,795	1,989	1,916	2,159	2,071	1,987
Oakland	21,310	22,286	38,145	24,395	24,003	23,723
San Francisco	132,452	142,594	189,313	156,762	160,512	182,369
San Jose	10,945	12,355	17,142	9,416	11,444	11,847
Monthly Total	**182,356**	**193,397**	**259,254**	**210,717**	**218,354**	**240,233**

During this same period, there were 3,203 Bay Wheels bicycles available per day. Full deployment of the bike share system will consist of 7,000 bicycles, including 4,500 in San Francisco, 1,500 in the East Bay, and 1,000 in San Jose. Usage of the system is expected to grow in proportion of the number of bicycles available. Once the system is fully deployed, use of the bike share system is expected to grow in proportion to population; this is a conservative assumption that does not account for expansion of bike share service beyond the planned Bay Wheels program, including service provided by other private providers and service funded through more recent MTC bike share grants.

The bike share trips were then converted to VMT reductions based on results from MTC's evaluation of the Bay Area Bike Share program, which found that each bike share trip, using conventional bicycles, reduced an average of 1.3 VMT.[45] Many bike share trips do not reduce any VMT because they do not displace vehicle trips, while others only reduce short trips. However, the evaluation found that a significant share of bike share trips enables users to connect to transit, eliminating longer personal vehicle trips.

Over the last several years, bike share systems have begun transitioning to electric bicycles, which are popular with users and enable longer trips. In early 2020, only about 5 percent of Bay Wheels bicycles were electric, but the system is expected to continue the transition to electric over the next several years. By 2035, it is assumed that all bike share bicycles will be electric.

Based on bike share system research conducted in the Bay Area, trips using dockless electric bicycles were 36 percent longer than trips using conventional bike share bicycles.[46] Using e-bikes, it is assumed

[45] MTC Climate Initiatives Program Evaluation: Pilot Bike-sharing Program, Prepared for MTC by Eisen-Letunic, 2015.
[46] Lazarus, Jessica, Jean Carpentier Pourquier, Frank Feng, Henry Hammel, and Susan Shaheen. Bikesharing Evolution and Expansion: Understanding How Docked and Dockless Models Complement and Compete--A Case Study of San Francisco. No. 19-02761. 2019.

that the VMT reduced per bike share trip will be 36 percent higher than the 1.3 VMT observed during the BABS pilot.

Table 7. Bike Share Inputs and Assumptions

Parameter	Value	Source
Planned bike share bike availability (Bay Wheels)	7,000	MTC
Daily bike share trips	15,492	May-October 2019 bike availability and trips, Lyft Bay Wheels System Data
Average VMT displaced per conventional bike share trip	1.30	MTC Climate Initiatives Program Evaluation: Pilot Bike - sharing Program, 2015.
Average VMT displaced per e-bike share trip	1.77	Calculated based on Lazarus, J. et al. Bikesharing Evolution and Expansion: Understanding How Docked and Dockless Models Complement and Compete – A Case Study of San Francisco, Paper No. 19-02761. 2019.
Assumed share of e-bikes in bike share fleet, 2035 and 2050	100%	Assumption based on market trends

Calculation Methodology

The methodology for calculating the GHG reductions from the bike share initiative is as follows:

1. Calculate or obtain average bike share trips per day for base year.
2. Calculate percentage growth of Bay Area total population relative to base year.
3. Multiply the percentage population growth by the baseline average daily bike share trips to calculate the average daily bike share trips for modeled years.
4. Multiply the percentage share of e-bikes by the average bike share trips per day to calculate the number of conventional versus e-bike share trips per day for each modeled year.
5. Multiply the average VMT displaced per conventional bike share trip by the number of conventional bike share trips per day for each modeled year.
6. Multiply the average VMT displaced per e-bike share trip by the number of e-bike share trips per day for each modeled year.
7. Sum the VMT displaced by conventional bike share and e-bike share trips per day.
8. Multiply daily VMT displaced by exhaust emission rates to calculate GHG emission reductions.

Strategy EN9: Initiative EN9b - Car Share

Initiative Description

Car sharing offers individuals the opportunity to conveniently rent vehicles by the hour or less, thus giving them access to an automobile without the costs (vehicle purchase, operations and maintenance, insurance) and responsibilities of personal vehicle ownership. Car sharing offers the opportunity for users to replace making trips in their own vehicles, particularly short trips such as for errands, shopping, or airport pick-ups. Car sharing can be particularly effective in neighborhoods with bus, rail, bike share, or other alternatives to driving where cars are infrequently needed and households in these neighborhoods can shed one or more vehicles. Even in less dense neighborhoods without high-quality alternatives to driving, car sharing can allow a two- or three-car household to shed one car by making a vehicle accessible for the infrequent instances that multiple vehicles are needed at the same time. Car sharing may also help extend the trend of younger generations putting off or never owning a vehicle. Businesses can also sign up for business memberships (known as corporate car sharing) to avoid maintaining or reduce the size of a company fleet of vehicles.[47]

Car sharing has been growing in the Bay Area since 2001, with multiple car share operators offering different service models, including traditional car share requiring pick-up and return of a company-owned vehicle at a specific location (e.g., Zipcar) and one-way or free-floating car share (e.g., Gig). Traditional car sharing businesses typically operate on a membership basis, where users pay an annual fee in addition to hourly and sometimes per-mile rates. Users benefit by not having to worry about fueling, maintenance, parking, and insurance, which are included in the membership and usage rates.

One-way car sharing allows a driver to pick up a vehicle in one location and drop it off at another, either at a specific location or anywhere within a service zone. This model provides an opportunity to incorporate driving as part of a longer multimodal trip chain. For example, Gig Car Share partnered with Bay Area Rapid Transit (BART) to provide designated Gig parking spaces at six BART stations, allowing users to drive a Gig car to transit, or alternatively, drive home after arriving at the station. This model also allows for more frequent vehicle turn over and higher utilization of vehicles, as the cars are rented just to get to destinations rather than rented and parked while the user completes their activities at the destination before returning the vehicle.

The expansion of car sharing helps reduce GHG emissions by both reducing the amount participants drive and shifting their driving to more fuel-efficient vehicles. The cumulative effect of car sharing, from a study conducted by UC Berkeley's Transportation Sustainability Research Center, found that for each car share vehicle, 9 to 13 privately owned vehicles are shed from the region's vehicle fleet.[48] Vehicle owners drive more than those who do not own their own vehicle. Additionally, car share vehicles are newer and more fuel efficient than the average vehicle and thus contribute fewer emissions.

In Plan Bay Area 2050, this initiative is part of the suite of initiatives under **Strategy EN9: Expand Transportation Demand Management Initiatives**. Car sharing was also included in the previous regional plans and MTC will continue implementing relevant programs. Six grants were awarded to the following agencies to implement car sharing services:

- Contra Costa Transportation Authority
- Sonoma County Transportation Authority
- City of San Mateo
- City of Oakland
- City of Hayward
- Transportation Authority of Marin

[47] Reed, John. 2017. Corporate Car Sharing: an innovative solution to save the cost for company employee' car and taxi work travel. URL: https://www.sharedmobility.news/corporate-car-sharing/

[48] Martin, Shaheen, and Lidicker, 2010, "Impact of Carsharing on Household Vehicle Holdings: Results from a North American Shared-Use Vehicle Survey." Transportation Research Record Volume 2143, Issue 1, Pages 150-158. URL: https://escholarship.org/uc/item/3bn9n6pq

MTC tracked grant project progress through regular reports and check-in meetings with grant recipients. Additionally, MTC is implementing a program for mobility hubs which will include car sharing as well as other shared transportation modes. Work has started on pilot projects with full implementation to follow.

GHG Reduction Quantification Approach

Car sharing is not explicitly captured in MTC's travel model, and a car share expansion initiative accordingly is accounted for off-model. Car sharing reduces emissions in two primary ways — by lowering the average VMT of members and by allowing trips to be taken with more fuel-efficient vehicles than would have been used without car sharing.

The primary calculation approach remains unchanged from *Plan Bay Area 2040*, estimating GHG reductions based on the reduced VMT and use of more fuel-efficient vehicles among car share program participants. However, the approach has been updated to reflect the increasing deployment of electric vehicles in car sharing fleets.

Inputs and Assumptions

Participation in the car share initiative is based on the number of Bay Area residents who are in the age groups likely to adopt car sharing and who live in communities that are compact enough to promote shared use. Research shows that adults between the ages of 20 and 64 are most likely to adopt car sharing, with estimates that between 10% and 13% of the eligible population in more compact areas when car sharing is available.[49, 50] With the implementation of regional initiatives to support car sharing and the introduction of one-way car sharing, adoption rates are assumed to reach 14 percent of the eligible population in dense urban areas (i.e., areas with at least ten people per residential acre) by 2035, while 3 percent of the eligible population could adopt car sharing by 2035 in suburban areas (i.e., areas with less than ten people per residential acre). The table below summarizes the assumptions with respect to car sharing participation rates.

As one-way car sharing programs expand in the Bay Area, it is expected that participation in car sharing programs will increase. Recent research suggests that while one-way car sharing still reduces emissions, the reductions are not as large as with traditional car sharing, as discussed below. In this analysis, it is assumed that one-way car sharing comprises 20 percent of carshare members in 2020 and remains at this level for 2035 and 2050.

[49] Zipcar. http://www.zipcar.com/is-it#greenbenefits. Accessed March 20, 2017.
[50] Zhou, B., Kockelman, K, and Gao, R. "Opportunities for and Impacts of Carsharing: A Survey of the Austin, Texas Market." International Journal of Sustainable Transportation 5 (3): 135-152, 2011.

Table 8. Car Share Participation Assumptions

Category	2020	2035	2050
Participation rates in urban areas	12%	14%	14%
Participation rates in suburban areas	0%	3%	3%
Percent of car share members that participate in one-way car sharing programs	19%	20%	25%

Research by Robert Cervero indicates that on average traditional car share members drive seven fewer miles per day than non-members.[51] This is mostly due to the members who shed a vehicle after joining carsharing. Daily VMT of these car share members drops substantially and outweighs the increase in VMT from car share members that previously did not have access to a vehicle.

In addition to the reduction in VMT, when members drive in car share vehicles, their per-mile emissions are generally lower because car share vehicles are more fuel efficient than the average vehicle. Research by Martin and Shaheen found that the car share vehicles in their study used 29 percent less fuel per mile than the passenger vehicle fleet in general.[52] This reduction is used for year 2020 in this analysis and increases to 36 percent and 43 percent for 2035 and 2050, respectively, based on a conservative assumption of 10 to 20 percent of the car share fleet becoming fully electric. The same study also shows that on average, members of traditional car sharing programs drive an average of 1,200 miles in car sharing vehicles per year. MTC assumes this individual annual car share mileage will remain constant over time.

Martin and Shaheen conducted an analysis of one-way car share services in five cities across North America and estimated VMT reduction of participants.[53] Based on the study's findings, this approach assumes that one-way car share members drive an average of 104 miles in car sharing vehicles per year but overall drive 1.07 fewer miles per day than non-members. Also based on the study's findings, it is assumed that one-way car sharing fleets use 45 percent less fuel per mile. Furthermore, based on observed offerings from recent one-way car share providers, it is assumed that one-way car sharing service fleets will include a share of battery electric vehicles in future years. For this analysis, it is assumed that this mileage will remain constant over time.

Table 9. Car Share Inputs and Assumptions

Parameter	Value	Source
VMT per member per year, traditional carshare	1,200	Estimate based on Martin and Shaheen, MTI report, 2010 (figure 7); assume constant over time
VMT per member per year, one-way carshare	104	Martin and Shaheen, July 2016

[51] Cervero, Golub, and Nee, "City CarShare: Longer-Term Travel-Demand and Car Ownership Impacts", July 2006, TRB 2007 Annual Meeting paper.
[52] Martin, Elliot, and Susan Shaheen, "Greenhouse Gas Emission Impacts of Carshaing in North America," 2010, Mineta Transportation Institute. MTI Report 09-11.
[53] Martin, Elliot, and Susan Shaheen, "Impacts of Car2Go on Vehicle Ownership, Modal Shift, Vehicle Miles Traveled, and Greenhouse Gas Emissions", July 2016, Working Paper.

Parameter	Value	Source
VMT reduction per member per day, traditional car share	7	Cervero, Golub, and Nee, July 2006
VMT reduction per member per day, one-way car share	1.07	Martin and Shaheen, July 2016
Average mpg, traditional car share vehicles	32.8	Average US/Canada mpg from Martin and Shaheen, MTI report, page 65; assumed constant from 2010
Average mpg, one-way car share vehicles	24.4	Martin and Shaheen, July 2016
Average mpg, cars avoided by traditional car share service members	23.3	Average US/Canada mpg from Martin and Shaheen, MTI report, page 65; assumed constant from 2010
Average mpg, cars avoided by one-way car share service members	44.0	Martin and Shaheen, July 2016
Battery electric vehicle share of fleet, traditional car share	10% (2035); 20% (2050)	Assumption
Battery electric vehicle share of fleet, one-way car share	50%	Assumption based on current 100% electric one-way Gig car share fleet in Sacramento area
Travel days per year	347	State's (CARB) annualization assumption

Calculation Methodology

To calculate the GHG emission reductions due to car sharing, the individual steps were as follows:

1. Calculate the residential density of each transportation analysis zone (TAZ) during the scenario year by dividing the total population by the residential acres (from travel demand model).
2. Sum total car sharing eligible population (between the ages of 20 and 64) for urban areas (TAZs with a population density greater than 10 residents per residential acre) and for suburban areas (TAZs with a population density less than 10 residents per residential acre).
3. Multiply participation rates, urban and suburban, by the car sharing eligible population in urban and suburban areas, respectively, and sum to calculate car share program members.
4. Multiply the one-way car share participation rate to calculate the number of members in traditional and one-way car sharing services.

Number of traditional (station-based) car share members	$= [P_{>10} \times QP_{urban} + P_{<10} \times QP_{suburban}] \times (1 - QP_{1-way})$
Number of one-way car share members	$= [P_{>10} \times QP_{urban} + P_{<10} \times QP_{suburban}] \times QP_{1-way}$

Where:

$P_{>10}$ = the total population in TAZs with density greater than 10 persons/residential acre
QP_{urban} = the percent of qualifying urban population expected to become members
$P_{<10}$ = the total population in TAZs with density less than 10 persons/residential acre
$QP_{suburban}$ = the percent of qualifying suburban population expected to become members
QP_{1-way} = the percent of car share members participating in one-way car share

5. Multiply the VMT reduced per day per member by the number of members of each service type and sum the result across both service types to calculate VMT reduction per day from car share users.

Total daily VMT reductions from car sharing members driving less	$= M_{trad} \times V_{trad} + M_{1-way} \times V_{1-way}$

Where:

M_{trad} = the number of traditional car share members
V_{trad} = the VMT reduction per traditional car share member per day
$M_{1\text{-}way}$ = the number of one-way car share members
$V_{1\text{-}way}$ = the VMT reduction per one-way car share member per day

6. Multiply daily VMT reductions by average vehicle emission rates from EMFAC2014 to calculate GHG emission reductions due to car share members driving less.
7. Multiply the number of car share members for traditional and one-way car sharing by the respective average VMT per day per member to calculate VMT per day by service type.
8. Multiply daily VMT in each car share service type by the percent vehicle efficiency improvements (based on average car share vs non-car share vehicle fuel consumption rate) for each service type and by average vehicle emission rates to calculate GHG reductions due to car share members driving more fuel-efficient vehicles.
9. Sum GHG emission reductions due to car share members driving less (Step 6) and GHG reductions due to car share members driving more fuel-efficient vehicles (Step 8) to calculate total GHG reductions due to car sharing.

Strategy EN9: Initiative EN9c - Targeted Transportation Alternatives

Initiative Description

Targeted transportation alternatives initiative employs a variety of approaches, including individual travel consultation, organized events, and distribution of outreach and informational materials to encourage people to shift from driving alone to carpooling, transit, biking, or walking for any of their trips. These programs are "targeted" because they tailor activities and materials to focus on the travel needs and transportation options that are available in specific job centers or residential neighborhoods. Several MPOs and large cities in the U.S. administer these programs, partnering with local governments, transit agencies, employers, and transportation management associations to customize projects to different communities. In several cities, these types of programs have been operating for more than 10 years with documented positive results, including Portland Metro's Regional Travel Options program, City of Portland's SmartTrips program, and King County's InMotion program.

Several public agencies in the Bay Area have successfully implemented similar programs. Two of the Climate Initiative Innovative Grant pilot projects funded by MTC from 2011-14, GoBerkeley and Connect, Redwood City!, included targeted transportation alternatives components. The former involved working with property managers to market travel options and provide free bus passes to residents of multifamily transit-oriented developments, while the latter included focused outreach to employers with billboard and print advertising to promote alternatives to driving alone.

MTC's Targeted Transportation Alternatives Program includes both residential and employer activities. The employer portion of the program will have a particular focus on supporting smaller employers to complement **Strategy EN7: Expand Commute Trip Reduction Programs at Major Employers** (reflected in the travel model) which focuses on larger employers. The program is expected to reduce drive alone trips and associated VMT by encouraging travelers to shift to using active and shared modes for their commute and non-commute trips. By reducing single occupancy vehicle trips, the program will reduce GHG emissions.

In Plan Bay Area 2050, this initiative is part of the suite of initiatives under **Strategy EN9: Expand Transportation Demand Management Initiatives**. The Targeted Transportation Alternatives initiative was also included in *Plan Bay Area 2040*. MTC is currently developing a pilot project of this approach, which will inform implementation of a broader program.

GHG Reduction Quantification Approach

Off-model analysis is necessary to capture GHG reductions from targeted transportation alternatives programs. The mode choice models in Travel Model 1.5 were calibrated using the 2012-2013 California Household Travel Survey, and so they do not capture the impacts of new strategies that change travel behavior such as this one. It is possible that these strategies will be captured by a future model once they have been implemented to the extent that they influence people's behavior and can be captured by the travel surveys, and once the model framework has been altered to include inputs that represent the presence of behavior change strategies.

Since *Plan Bay Area 2040*, the approach has been updated with a new cost per participant assumption based on a review of more recent evaluations from a broader set of similar programs across the country; the cost per household was increased significantly from $3.11 to $18.81 per household. This results in a more conservative estimate of program benefits per dollar of investment since the last plan.

Inputs and Assumptions

To estimate the impacts of this program on traveler behavior, the analysis relies on evaluation data collected for similar programs implemented in other regions. For residential-focused programs, program evaluation information was obtained for the City of Portland's SmartTrips program, King County's InMotion Program, SANDAG's Travel Encinitas pilot program, and the Community Transit (Snohomish County, WA) Curb the Congestion program. For employer-focused programs, evaluation information was obtained for Portland Metro's Regional Travel Options program. Some of these programs have conducted multiple rounds of evaluation, with each round covering multiple projects. Information was collected on the cost per year of marketing to an individual household/employee, the percentage of residents/employees receiving program information who change behavior (penetration rate), and the reduction in SOV mode share for those residents/employees from evaluations of these programs. These were then applied to the daily number and distance of trips for all trips (for households) and for commute trips (for employees) to estimate VMT impacts.

Evaluations of targeted transportation alternatives programs typically focus on impacts during the year after programs are implemented; however, long-term evaluations that provide information on how long behavior change persists due to marketing and outreach programs is not currently available. To account for this uncertainty, the methodology uses a conservative assumption that behavior change lasts for five years before participants revert to their previous travel patterns.

Table 9. Targeted Transportation Assumptions Inputs and Assumptions

Parameter	Households	Employees	Source
Average cost per year of marketing to a household/employee	$18.81	$4.34	Portland, OR and King and Snohomish Counties, WA program evaluations
Average penetration rate	19%	33%	Portland, OR and King and Snohomish Counties, WA program evaluations; Assumption based on discussion with Portland Metro Regional Travel Options program staff
Average reduction in SOV mode share among participants	12%	9%	Portland, OR and King and Snohomish Counties, WA program evaluations; Portland Metro, Regional Travel Options 2012 Program Evaluation
Average daily one-way driving trips affected	5.47	2	MTC, Characteristics of Rail and Ferry Station Area Residents in the SF Bay Area
Average one-way trip length (miles)	6.2 (2035); 5.8 (2050)	10.0 (2035); 9.8 (2050)	Travel Model 1.5, Final Blueprint
Number of years for which behavior change persists	5	5	Assumption based on discussion with SANDAG Community Based Travel Planning program consultant

MTC's investment in this initiative is the primary input in the GHG reduction estimates. MTC anticipates investing $5 million in this initiative per year, with $3 million going to residential programs and $2 million going to employee programs. MTC is working with consultants to develop an approach to implementation beginning in 2021. Implementation of the program is expected to continue through the lifetime of the plan years due to the assumption that behavior change from program interventions is temporary. The program is applied to all households and jobs in the region for each modeled year. Based on the annual investment assumption and cost per household or employee, the program is expected to reach approximately 160,000 households and 460,000 employees. A separate Plan Bay Area 2050 strategy, Strategy EN7: **Expand Commute Trip Reduction Programs at Major Employers**, establishes trip reduction targets for employers with 50 or more employees; the Targeted Transportation Alternatives program would complement that strategy by focusing on those who work for establishments with less than 50 employees.[54]

Calculation Methodology

The methodology for calculating the GHG reductions from the Targeted Transportation Alternatives initiative is as follows:

1. Allocate the investment between household and employee programs.
2. Divide the respective household/employee investments by the average cost per year of marketing to a household/employee and multiply by the penetration rate in order to calculate the total number of participants.
3. Multiply the total number of participants by the average reduction in SOV mode share among participants and the average daily one-way driving trips affected and the average number of

[54] 2018 National Establishment Time Series (NETS) data indicates that there are approximately 2.5 million people in the Bay Area who work for establishments with less than 50 employees.

years that behavior change will persist to calculate the total daily number of vehicle trips reduced due to total program funding.

4. Sum the total daily vehicle trip reductions for employees and households to calculate the total daily vehicle reductions.
5. Multiply daily vehicle trips reduced by the average one-way trip length to calculate the total daily VMT reductions.
6. Sum the product of trip-end emission rates and daily vehicle trip reductions and the product of exhaust emission rates and daily VMT reductions to calculate total GHG emission reductions.

Strategy EN9: Initiative EN9d – Vanpools

Initiative Description

MTC has coordinated a vanpool program since 1981 to encourage alternative commutes and reduce congestion and emissions. To date, MTC's 511 vanpool program recruitment has consisted of online passenger and driver matching, employer outreach, up to $500 for startup fees, empty seat subsidies to encourage continued participation when a passenger is lost, free bridge tolls, discounted parking permits, and various other incentives. With this program there is an operational vanpool fleet in the Bay Area of more than 500 vans.

As defined by the 511 program, a vanpool is a group of 7 to 15 people commuting together and being driven by an unpaid driver. There are a handful of options for drivers to procure a vehicle: the first is simply a vehicle that is owned by the driver, the second is a vehicle provided by an employer, and the third option is renting a vehicle from a third-party provider. MTC modified its vanpool program to be similar to programs in operation in San Diego, Los Angeles, Denver, Arizona and elsewhere. San Diego's program began in 2001 and saw 5 to 10 percent growth in the vanpool fleet every year through FY13. Los Angeles Metro began its program in 2007 and the vanpool fleet has grown about 14 percent per year.

The vanpool program was included in previous regional plans and MTC will continue to administer and monitor vanpool programs in *Plan Bay Area 2050*, as part of the suite of initiatives under Strategy EN9 *Expand Transportation Demand Management Initiatives*. Through a partnership between Enterprise Rent-A-Car, groups may be eligible for a $350 monthly subsidy if a vehicle rented for the purposes of vanpool in the Commute with Enterprise program.[55] Currently vanpool rentals cost approximately $1,300 to rent and operate per month.[56] The $350 per month subsidy would reduce these costs by 27 percent. MTC assumes this incentive will significantly increase the vanpool fleet. Combined with growth in Bay Area population, employment, and highway congestion, the size of the Bay Area vanpool fleet is expected to reach 1,030 vans 2035, after which the number of vanpools is assumed to stabilize. A sustained fleet of 1,030 vans is slightly more than the 1996 peak of 900 vans. Moreover, there is significant potential to expand vanpool operations in the Bay Area; for comparison, the Puget Sound region operates more than 1,700 vanpool vans, with a population that is 54 percent of the Bay Area's.[57] In addition to financial subsidies, MTC works with vanpool groups, both in Commute with Enterprise and other vanpools, to provide technical assistance to help form and fill vanpools, such as ridematching

[55] MTC Bay Area Vanpool Program, Commute with Enterprise, https://511.org/vanpool/enterprise
[56] Based on MTC staff conversations with vanpool users.
[57] Ennis, Michael (2010). Vanpools in the Puget Sound Region: The case for expanding vanpool programs to move the most people for the least cost. Washington Policy Center for Transportation.

tools, identification of incentives (e.g., parking and bridge toll discounts), form completion guidance, and social media promotion resources to help form and fill vanpools.

GHG Reduction Quantification Approach

Travel and emissions impacts are calculated based on the number of vanpool program vans, average vanpool occupancy, and the relationship between vehicle trip reductions and VMT reductions. The vanpool program reduces GHG emissions by encouraging groups of people to share a ride for their commute, which reduces travel by single occupancy vehicles and associated VMT. The vanpool program is not captured by MTC's travel model and thus, the emission reductions resulting from this initiative are not otherwise captured. Travel Model 1.5's mode choice models are calibrated using the 2012-2013 California Household Travel Survey (CHTS).

The overall quantification approach remains unchanged from *Plan Bay Area 2040* but uses updated driving mode shares from *Plan Bay Area 2050*. The impacts of the vanpool program are calculated based on the difference between the number of vanpools in existence since 2005 (515 vans) and the number expected in the future with an expanded program.

Inputs and Assumptions

In this analysis, the base year vanpool fleet of 515 vans is assumed to double by 2035 and remain at this level through 2050. Average vanpool occupancy, which is used to calculate the total daily vehicle trip reductions, is gathered from MTC data from their 511 program and is assumed to stay consistent over time.

The emission reduction analysis assumes that vanpools have an average of 10.8 passengers and roundtrip distance of 110 miles[58], both of which are expected to remain constant over time. To account for the emissions from the vanpool van itself, the calculations only account for 9.8 passengers in the van. Reducing the vanpool size is a simplified approach to account for the emissions from the shared van.

The population that shifts to vanpools is expected to be consistent with the commute mode share of the general population. Emissions reduced from a commuter switching from a single occupancy vehicle (SOV) are assumed to be 100 percent. Emissions reduced from a commuter switching from a two-person carpool are assumed to be 50 percent. Emissions reduced from a commuter switching from a 3+ person carpool are assumed to be 33 percent. Shifts from other modes (walking, biking, or transit modes) are not assumed to reduce emissions.

Since the baseline year for the SB 375 emissions reduction target is 2005, the current vanpool fleet of 515 vans is not included in the analysis; only growth above and beyond 515 vans is included in the calculations.

Table 10. Vanpool Calculation Inputs and Assumptions

Parameter	Value	Source
Baseline number of vans, 2005	515	MTC data, 2005-2011
Average vanpool occupancy	10.8	MTC data, 2005-2011
Vanpool program vans, 2035-2050	1,030	Assume doubling of the baseline fleet by 2035 and sustained stabilized fleet after 2035

[58] MTC Transit Finance Working Group memo, February 2015.

The vanpool program is expected to be self-funding. Reporting ridership mileage to the National Transit Database (NTD) returns Federal Transit Administration (FTA) funding to the region for transit. A number of other cities and regional agencies, including San Diego, Los Angeles, Denver, and Arizona, have found that NTD reporting of vanpool data returns more money to a jurisdiction than the amount spent to offset vanpool costs. For example, the Northern Virginia Transportation Commission found that failure to report vanpool data in the Washington, D.C. metropolitan area resulted in a \$6 to \$8 million loss per year, and that each \$1 invested would have returned more than \$2 in transit funds.[59] Los Angeles spends \$7 million annually to offset vanpool costs and brings back \$20 million in additional transit funding.[60] While the amount returned varies depending on the number of passenger miles traveled, vanpools that log more miles and carry more passengers have higher returns. MTC estimates that for every \$1 spent on vanpools, it could expect a return of about \$1.40 in transit funds.

Calculation Methodology

To calculate the GHG emission reductions resulting from the vanpool program, the analysis steps were as follows:

1. Multiply the projected increase in vanpools by the number of passengers (minus the driver) to obtain increased number of vanpool participants.

Number of vanpool participants	$= (V_{2035} - V_{2015}) * (Pass_{avg} - 1)$

Where:

V = number of vanpools
$Pass_{avg}$ = average number of passengers per van (10.8)

2. Estimate the number of vehicle round trips reduced by vanpools, accounting for the previous mode selection of the vanpool participants, by multiplying the number of vanpool participants by each of the vehicle mode shares and an adjustment factor that accounts for the number of passengers and summed the results.

Number of vehicle round trips reduced by vanpools	$= (P * MS_{SOV}) + (P * MS_{HOV2} * 0.5) + (P * MS_{HOV3} * 0.33)$

Where:

P = vanpool participants
MS_{SOV} = drive alone mode share
MS_{HOV2} = 2-person carpool mode share
MS_{HOV3} = 3+ person carpool mode share

3. Multiply number of vehicle round trips reduced by the round trip vanpool mileage to obtain daily VMT reduced.

[59] Northern Virginia Transportation Commission; FTA Section 5307 Earnings Potential from Vanpools in DC Metropolitan Region; Revised: August 7, 2009.
[60] MTC October 2014 interview with LA Metro program manager, Jamie Carrington.

4. Sum the product of trip-end emission rates and daily vehicle trip reductions and the product of exhaust emission rates and daily VMT reductions to calculate total GHG emission reductions.

Strategy EN9: Initiative EN9e – Parking Pricing

Please note that one initiative within Strategy EN9 is not detailed in this section (Parking Pricing). Because Initiative EN9e is captured by Travel Model 1.5, it therefore does not require an off-model calculator to estimate its GHG effects.

Initiatives Removed from Off-Model Analysis

The following initiatives from *Plan Bay Area 2040* have been removed from the off-model GHG emissions estimates for *Plan Bay Area 2050*:

- Bike Infrastructure
- Clean Vehicle Feebate
- Commuter Benefits Ordinance
- Employer Shuttles
- Smart Driving
- Trip Caps

Explanation for the removal of each initiative from the off-model assessment is described in the following section.

Bike Infrastructure

The initiative to invest in expanding bike facilities across the region is now part of the broader Strategy T8, **Build a Complete Streets Network**, and has been incorporated into the travel demand modeling (refer to Quantification Approaches section above). Funding levels have been significantly increased in comparison to past iterations of *Plan Bay Area* as well.

Clean Vehicle Feebate

This initiative requires state legislative action for regional authority to implement, but efforts from the regional agencies to initiate state action towards developing a feebate program was delayed. In revising the program start date in the off-model analysis to reflect a more realistic timeline for gaining regional authority, it was recognized that the GHG emission reduction benefits are greatly reduced because of the continued turnover and replacement of older vehicles with much more fuel-efficient models over time. Because of the small emissions benefit and significant advocacy and legislative effort require to establish a feebate program, MTC decided not to include this strategy in *Plan Bay Area 2050*.

Commuter Benefits Ordinance

A regional Commuter Benefits Ordinance was successfully enacted through state legislative actions – initially as a pilot program and since 2017 as a permanent program – and is now operated as the Bay Area Commuter Benefits Program by MTC and BAAQMD. *Plan Bay Area 2050* now includes Strategy EN7, **Expand Commute Trip Reduction Programs at Major Employers**, which is envisioned as an expansion of the Commuter Benefits Program and would establish vehicle trip reduction targets for employers with 50 or more employees. This more expansive strategy is included in the travel demand (refer to Quantification Approaches section above). Because this new policy overlaps significantly with the original Commuter Benefits Ordinance and an approach to analyze GHG emission impacts of the strategies separately has not been identified, the Commuter Benefits Ordinance will no longer assessed in an off-model analysis.

Employer Shuttles

In previous iterations of Plan Bay Area, an off-model approach was used to account for the GHG emission benefits of employers that were providing shuttle service to their workplaces for their employees because this service could not be captured in the travel model. However, shuttles are an option for employers to meet the vehicle trip reduction targets in the new Strategy EN7, **Expand Commute Trip Reduction Programs at Major Employers**, which is incorporated into the travel demand modeling (refer to Quantification Approaches section above). Because the employer shuttle strategy is part of a broader modeled policy, it will no longer be analyzed as an off-model initiative.

Smart Driving

The smart driving initiative aimed to reduce GHG emissions by getting drivers to employ more fuel-efficient driving behaviors, which included encouraging smoother acceleration and deceleration, slower driving speeds, and improved trip chaining. In 2015, MTC implemented a region-wide program called Drive Smart Bay Area to bring about these improved driving habits. The program included developing a marketing campaign and subsidizing the purchase of a vehicle plug-in device that would warn drivers when they were accelerating hard or speeding. While the marketing reached a wide audience, there were significant challenges to scaling the program and the campaign and uptake of plug-in devices fell far short of the original program vision. Also, *Plan Bay Area 2050* includes a new Strategy T9 to **Advance Regional Vision Zero Policy through Street Design and Reduced Speeds**, which includes modeling lower speed limits across the region’s roadways. With the implementation challenges and the inclusion of a key aspect of smart driving (slower driving speeds) into a broader modeled strategy, smart driving is no longer included as an off-model initiative.

Trip Caps

Trip caps establish limits on vehicle trips to workplaces or other designated zones. This policy envisioned establishing trip caps in urban and suburban areas with high employment density. Because trip caps can generally only be established by local governments, MTC developed technical assistance and implementation guidance for cities and counties. However, *Plan Bay Area 2050* now includes a new Strategy EN7 to **Expand Commute Trip Reduction Programs at Major Employers**, which similarly establishes vehicle trip reduction targets, albeit for all large employers in the region rather than just workplaces in employment centers. Because this new, much broader policy is included in the travel demand modeling (refer to Quantification Approaches section above), trip caps will no longer be analyzed as an off-model initiative.

OTHER DATA COLLECTION EFFORTS

MTC/ABAG regularly updates its **Vital Signs** performance monitoring tool, which relies upon observed data from federal, state, and regional sources to track implementation of current and past long-range plans, including *Plan Bay Area 2040* and *Plan Bay Area 2050*. This includes annual monitoring of greenhouse gas emissions from primary sources, including transportation, electricity, and natural gas; related indicators include modal shift, vehicle miles traveled, housing construction, and displacement risk. More information is available at http://vitalsigns.mtc.ca.gov.

In addition to facilitating Bay Area transit passenger surveys, MTC/ABAG also collects household-level trip and demographic data via a travel diary survey. This household travel survey has historically been collected roughly once a decade, with the most recent full effort completed in 2012-13 in partnership with the California Department of Transportation. MTC staff are currently evaluating a change from the decennial approach to more regular, possibly annual, data collection. An updated household travel survey program is expected to be launched in 2022, with refreshed data available soon after. MTC also conducted the more recent **2018-19 Bay Area Transportation Study** in coordination with the San Francisco County Transportation Authority (SFCTA). This smaller-scale effort collected the daily travel patterns from approximately 5,000 smartphone-owning adults, with a focus on emerging travel modes, particularly regional use of transportation network companies such as Uber and Lyft. Data from the Bay Area Transportation Study will be used to continue refinement of the next-generation regional travel model – Travel Model 2.0 – which could be used for the next *Plan Bay Area*, slated for adoption in 2025. More information is available at https://mtc.ca.gov/tools-resources/data-tools/bay-area-transportation-study.

On the land use front, MTC/ABAG also worked with local jurisdictions to collect better baseline and pipeline land use information through the **Bay Area Spatial Information System** (BASIS) initiative. This effort was completed in the early months of the *Plan Bay Area 2050* process. Staff has worked to compile improved zoning information, coordinating with cities and counties, which was then incorporated into UrbanSim 2.0. More information is available at https://basis.bayareametro.gov.

PRIMARY CONTACT FOR INQUIRIES RELATED TO PLAN BAY AREA 2050

David Vautin
Plan Bay Area 2050 Project Manager
dvautin@bayareametro.gov - (415) 778-6709

ATTACHMENTS

- Attachment A: 2020 Observed Data on GHG Trends
- Attachment B: *Horizon* and *Plan Bay Area 2050* Project Schedule
- Attachment C: ABAG Board Materials on Regional Growth Forecast for *Plan Bay Area 2050*
- Attachment D: Documentation on Model Iterations and Data Flow between Bay Area UrbanSim 2.0 and Travel Model 1.5
- Attachment E: Auto Operating Cost (AOC) Calculations for *Plan Bay Area 2050*

ATTACHMENT A: 2020 OBSERVED DATA ON GHG TRENDS

Fall 2021

Summary

Senate Bill 375 requires that Metropolitan Planning Organizations (MPOs) prepare regional plans that meet per-capita greenhouse gas reduction targets for cars and light- and medium-duty trucks as set by the California Air Resources Board (CARB). Plan Bay Area 2050, the long-range plan slated for adoption in October 2021, describes how it meets and exceeds the 19 percent per-capita reduction target, compared to 2005 levels, in the Plan and its corresponding supplemental reports.

CARB has also requested that MTC/ABAG evaluate performance against year 2020 and an updated 10 percent per-capita reduction target for that year, established in 2018[61]. As Plan Bay Area 2050 will not be adopted until fall 2021, and thus its strategies cannot influence historical performance in year 2020, staff will fulfill CARB's request instead through this technical memorandum that will be integrated into the Final Technical Methodology and Final Plan Submittal to CARB in late 2021. The analysis shown below demonstrates that the Bay Area met the 2020 greenhouse gas emissions reduction target.

Approach

2020 was an anomalous year in terms of economic activity and travel behavior due to the emergence of the COVID-19 pandemic. In March of 2020, Governor Newsom declared a state of emergency for the state and instituted a statewide shelter-in-place order. Most Bay Area counties continued to maintain some version of the shelter-in-place order throughout the entirety of 2020, and as a result, personal travel behavior was profoundly affected. Behavioral changes observed during the pandemic include changes to the following:

- work location, as most workers who were able to telecommute switched to doing so
- home location, as some remote workers moved to areas with support for childcare, extra space for home-based work or other areas where commute to a workplace did not need to be factored in
- mode choice, as people switched to modes with less perceived risk of exposure to COVID-19
- activity and destination choice, as social gatherings have been strongly discouraged and travel has been restricted to "essential" activities
- non-personal travel, as many residents have elected to use delivery services for groceries and other goods to reduce their exposure to COVID-19

As such, MTC/ABAG staff decided not to model year 2020 because of these impacts on travel behavior. Such a modeling exercise would require an enormous amount of work to perform quality analysis, including data collection (or assertion) to estimate the substance of these behavioral changes. Therefore, in order to estimate per capita greenhouse gas emissions due to transportation for residents of the Bay Area in 2020, staff instead looked at available data using the EMFAC2021 (v1.0.1) Emissions Inventory downloaded from the EMFAC web platform, which is a service provided by the California Air Resources Board. This resource provides annual emissions inventory and vehicle miles traveled (VMT) estimates for a span of years, including 2005 through 2020.

61 61 https://ww2.arb.ca.gov/our-work/programs/sustainable-communities-program/regional-plan-targets

While the dataset includes greenhouse gas emissions from exhaust in the form of CO_2, nitrous oxide and methane, these emissions are the result of a combination of total VMT as well as vehicle fleet technology. To be conservative, staff also looked at VMT directly instead of greenhouse gas emissions to exclude reductions from technology. EMFAC VMT estimates are derived from socioeconomic data and forecasts from UCLA; the California Energy Commission; the California Department of Finance and the California Department of Tax and Fee Administration (for statewide fuel sales); and Federal Reserve economic data. Consistent with SB 375 analysis, the following results are filtered to include only passenger cars and light- and medium-duty trucks (or vehicle categories LDA, LDT1, LDT2 and MDV in EMFAC2021).

To calculate per-capita outcomes consistent with state law, Bay Area population estimates from 2005 through 2020 were included in the analysis as well. These estimates were incorporated from the California Department of Finance: Population and Housing Estimates, Table E-5: Population and Housing Estimates[62] for 2010 and after, and from MTC's Vital Signs[63] for 2005 through 2009.

Findings

Figure A-1 shows annual estimates for Bay Area population, total daily VMT, total daily VMT per capita, and per capita percent change in daily VMT from 2005. In 2020, the per capita daily VMT was reduced by more than 10% from 2005 levels, so it can be inferred that the Bay Area achieved the 2020 per capita greenhouse gas emissions target of 10% from 2005 levels.

[62] https://www.dof.ca.gov/Forecasting/Demographics/Estimates/e-5/
[63] https://data.bayareametro.gov/dataset/Vital-Signs-Population-Bay-Area/2z9m-qam9

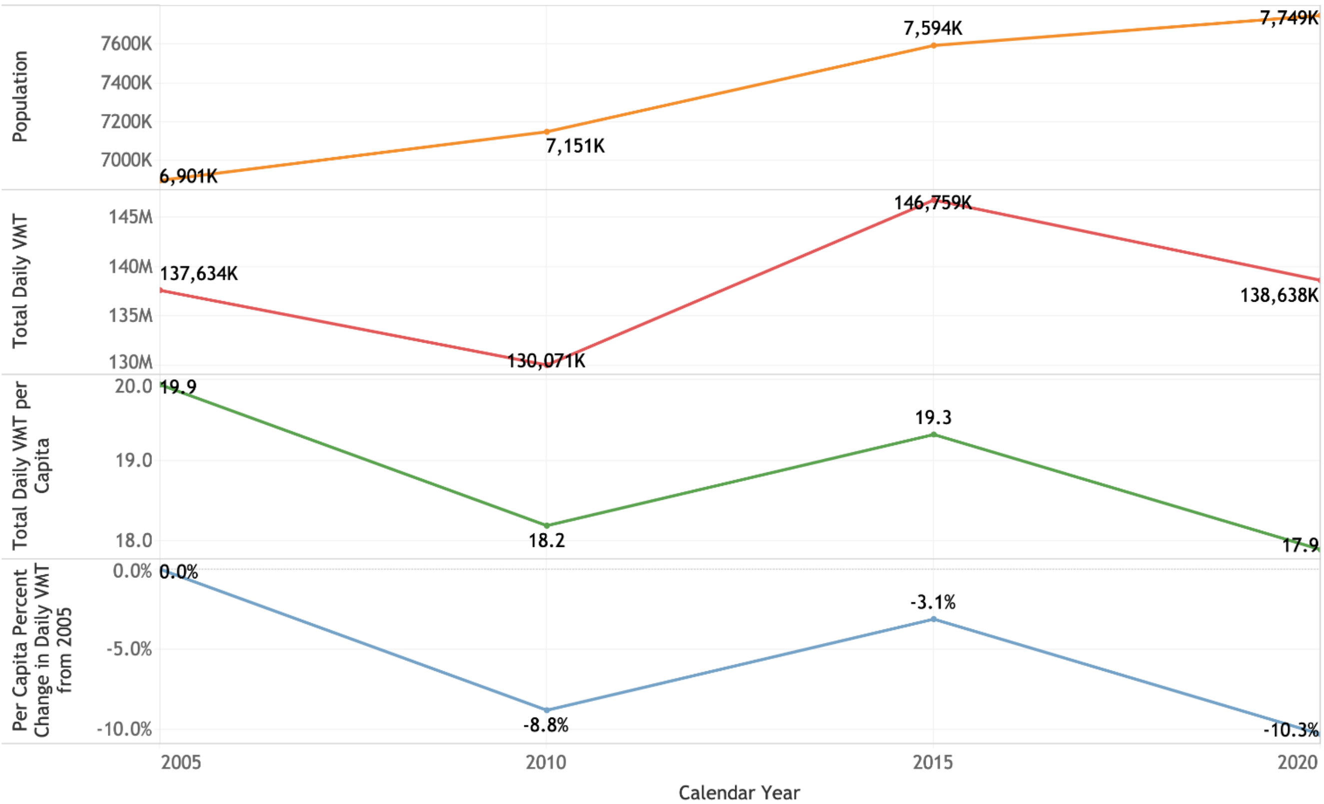


Figure A-1: Population, total daily VMT, total daily VMT per capita and per capita percent change in daily VMT from 2005 for the Bay Area

Figure A-2 shows annual estimates for Bay Area population, total daily CO_2 exhaust emissions, total daily CO_2 exhaust emissions per capita, and per capita percent change in daily CO_2 exhaust emissions from 2005. In 2020, per capita daily CO_2 exhaust emissions were reduced by more than 25% from 2005 levels, so it can be inferred that the Bay Area achieved the 2020 per capita greenhouse gas emissions target of 10% from 2005 levels. It should be noted that the data shown below is from the EMFAC2021 web tool, which does not reflect impacts associated with “SB 375 mode” which subtracts out benefits from light duty ZEV and GHG emission standards.

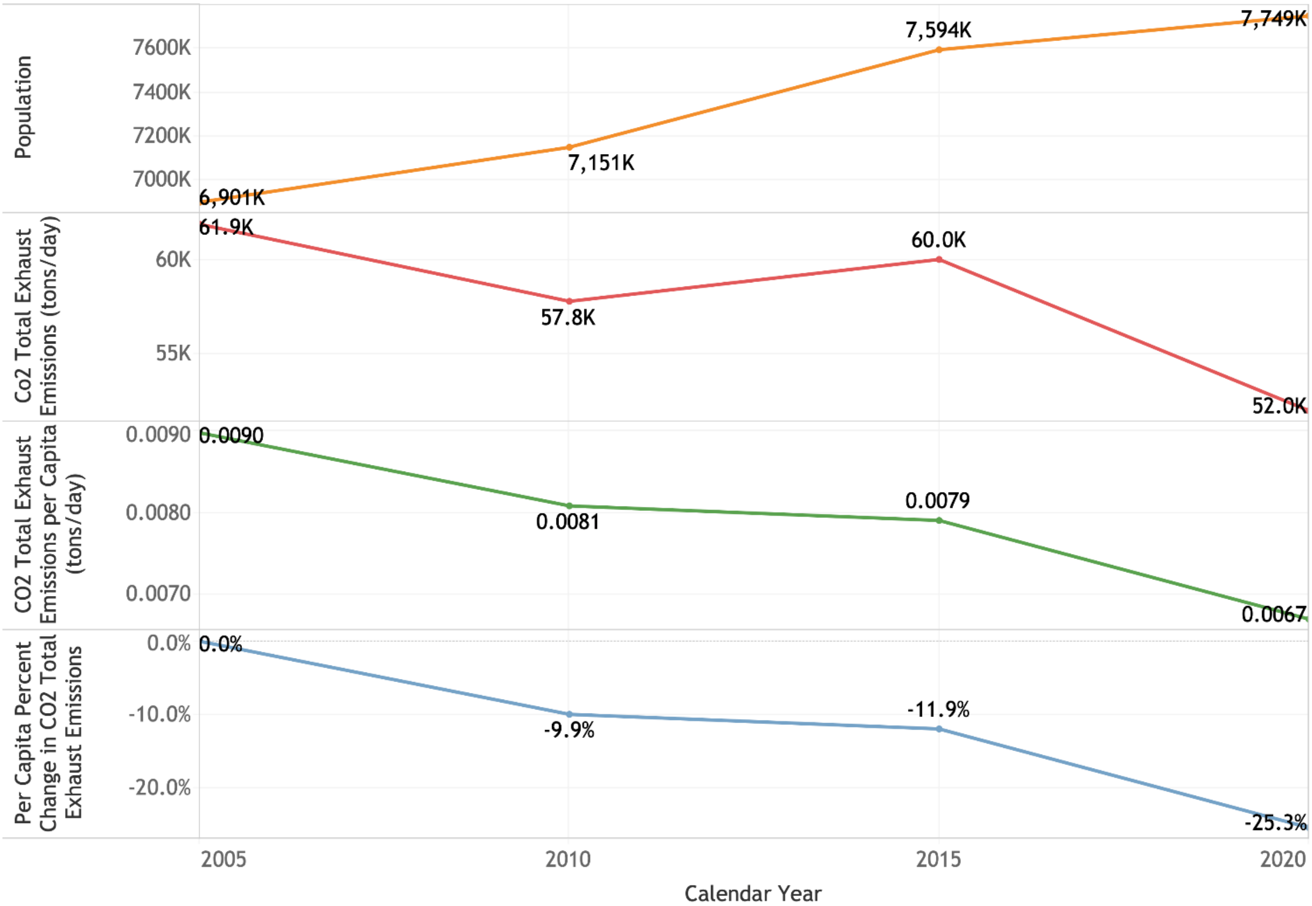


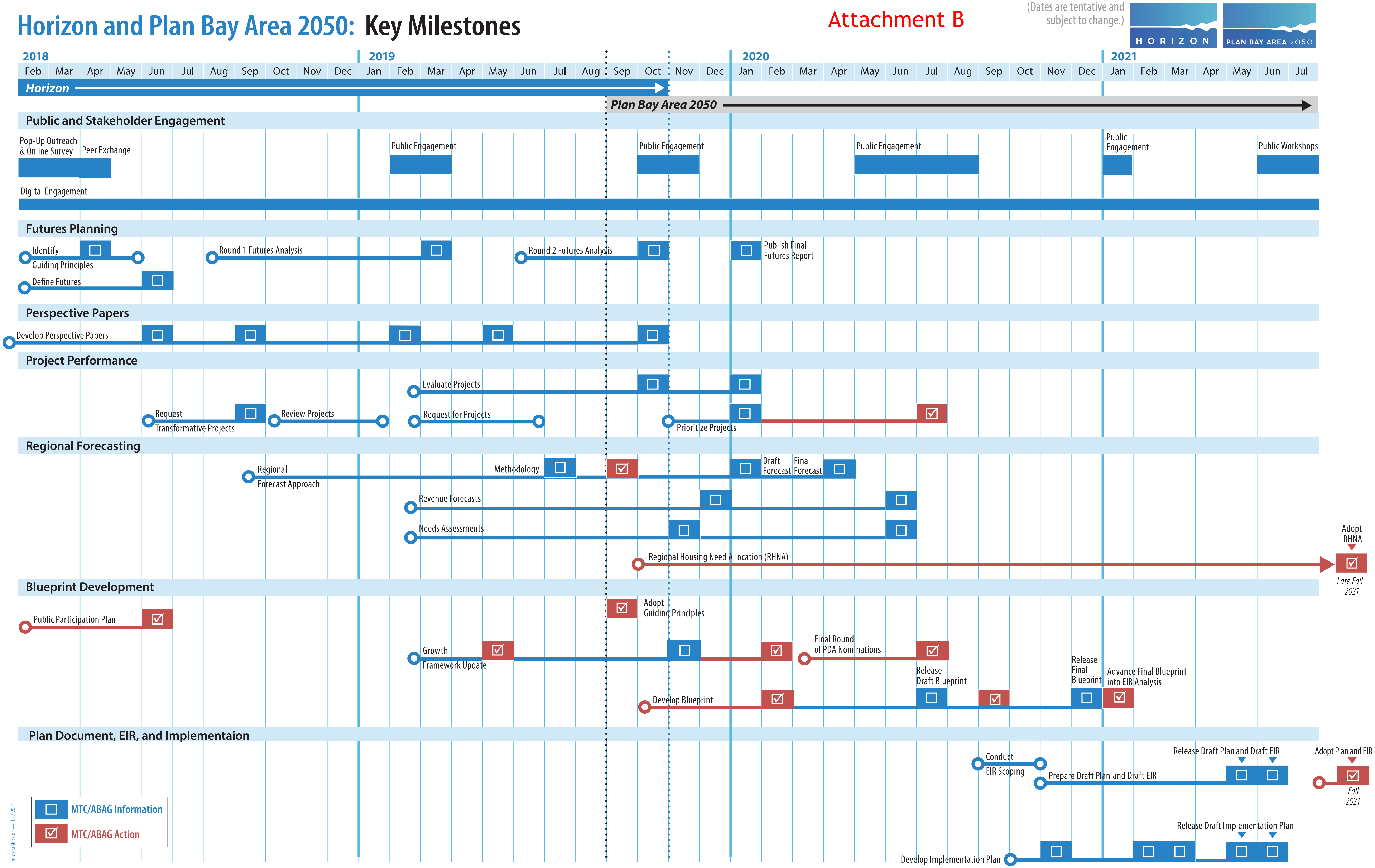
Figure A-2: Population, total daily CO_2 exhaust emissions, total daily CO_2 exhaust emissions per capita and per capita percent change in daily CO_2 exhaust emissions from 2005 for the Bay Area

Based upon the analyses above, “SB 375” greenhouse gas emission reductions between 2005 and 2020 most likely fall somewhere between the VMT per-capita and real GHG per-capita trends calculated using EMFAC2021 data – i.e., between 10 and 25 percent per-capita reduction. This is because “SB 375” GHG trends do rely on greenhouse gas emissions as a metric but omit some reductions generated by federal and state fleet efficiency requirements. Regardless of where the region falls within this spectrum, the region clearly exceeded the State’s 10 percent reduction target for year 2020 against the “SB 375” metric.

Horizon and Plan Bay Area 2050: Key Milestones

Attachment B

(Dates are tentative and subject to change.)



Attachment C

METROPOLITAN TRANSPORTATION COMMISSION
ASSOCIATION OF BAY AREA GOVERNMENTS

MEMORANDUM

PLAN BAY AREA 2050

TO: ABAG Executive Board DATE: April 16, 2020

FR: Bobby Lu and Paul Fassinger

RE: Plan Bay Area 2050: Final Regional Growth Forecast

Introduction

The Regional Growth Forecast is an important input to Plan Bay Area 2050, the San Francisco Bay Area's long-range plan developed by Metropolitan Transportation Commission (MTC) and Association of Bay Area Governments (ABAG). The Plan Bay Area 2050 Regional Growth Forecast identifies how much the Bay Area might grow between the Plan baseline year (2015) and the Plan horizon year (2050), including population, jobs, households, and associated housing units. The forecast also includes important components of that growth, including employment by sector, population by age and ethnic characteristics, and households by income level. During the Blueprint planning phase, the Regional Growth Forecast is being used to identify the total amount of growth. These figures are then integrated into the Bay Area UrbanSim 2.0 land use model; UrbanSim explores how Blueprint planning strategies might affect the local distribution of growth in households and employment. This memo focuses on the projections associated with the Regional Growth Forecast; local area forecasts will be released as part of the Draft Blueprint and Final Blueprint.

Setting the Stage: The Context for Plan Bay Area 2050

For decades, developing a Regional Growth Forecast has been a key element of the long-range transportation planning process for the Bay Area. However, in recent years, it has become apparent that critical issues need to be better addressed in the context of developing such a forecast.

The first is related to **regional affordability**. In Plan Bay Area 2040, it was estimated that the average share of lower-income household income spent on housing would rise by approximately 13 percentage points; this was due in part to the fact that regional housing strategies were limited in nature and affected only the geographic distribution of forecasted growth rather than overall level of housing growth in the Regional Growth Forecast itself. As part of this planning process, policymakers specifically asked "what it would take" to move the needle on affordability, but solutions for these affordability shortcomings were not identified in time for integration into that Plan. Plan Bay Area 2050 presents an opportunity to integrate new housing strategies specifically designed to increase supply for all income levels – consistent with policymaker direction for the Draft Blueprint – which will in turn contribute to a more affordable region and a slightly higher Regional Growth Forecast.

The second is related to **uncertainty**. While required by statute, the creation of a single Regional Growth Forecast in prior cycles did not provide the opportunity to explore how different trajectories for regional growth would affect critical environmental, economic, and other goals. To address this gap, MTC and ABAG staff undertook the Horizon initiative in 2018 and 2019, which explored not only how different growth trajectories would affect the region but also how the region could respond to those different trajectories through new strategies.

Both of these factors mean that developing the Regional Growth Forecast is a more policy-conscious effort, equally focused on contextual uncertainties as well as policy linkages and implications.

Upon the kickoff of the Plan Bay Area 2050 cycle, staff accordingly worked with technical stakeholders to make methodological refinements to incorporate lessons learned from both efforts. The methodology adopted by the ABAG Executive Board in September 2019 enables the Regional Growth Forecast to incorporate changes in strategies that would affect the level of growth in the region, while also affecting affordability, equity, economic mobility, and other critical outcomes.

This memo first introduces the economic and demographic assumptions underlying the Regional Growth Forecast. This presents a reasonable baseline for the future of the Bay Area. After that, the memo delves into how a selection of key strategies from the Draft Blueprint were incorporated into this forecast. Note that while the proposed strategies were approved for integration into the Plan Bay Area 2050 Draft Blueprint for further analysis by MTC and ABAG, these strategies may be further refined before being included in the Final Blueprint. Should significant changes be made, the forecast presented in this memo could be further revised later this year.

Methodology and Assumptions

Similar to Plan Bay Area 2040, the Regional Growth Forecast was primarily developed using the REMI (Regional Economic Modeling Inc.) model[1]. version 2.3. The REMI model integrates into one package a dynamic accounting of the core components of the economy, which are listed below. The population is explicitly connected to industry growth and demand for labor, with migration increasing in times of strong employment growth.

- Industry structure and competitiveness relative to other regions
- Propensity to export
- Population and labor market structure

To generate other key components of the Regional Growth Forecast, staff also developed a household model and a household income distribution model, built around the projections from

[1] Plan Bay Area 2050 was developed with REMI Bay Area version 2.3, whereas Plan Bay Area 2040 was developed with REMI Bay Area version 1.7.8.

the REMI analysis. The REMI model produces population and total income but does not estimate households or a household income distribution.[2] [3]

Working with the Technical Advisory Committee[4], staff has reviewed REMI data, assumptions and its default results, and made some changes to both national demographic data and regional economic data to get a better baseline picture of the region's future. In particular, staff factored in more recent historical trends where slowing Hispanic international migration and birth rates have been observed, in alignment with the most recent U.S Census Bureau projections, as well as observations and assumptions of California Department of Finance.

While this employment forecast recognizes the region's continued economic competitiveness compared to the rest of the United States, staff assumes that the Bay Area will face increasing challenges. Therefore, the region's share of national employment is assumed to stabilize by the last decade of the forecasting horizon. Without strategies and policies in place to address issues such as high housing costs and economic disparity, it would be difficult for the Bay Area to grow at the current rate. The following section describes how Blueprint strategies are included in the analysis.

Syncing the Regional Growth Forecast with Approved Draft Blueprint Strategies

The regional agencies agreed to investigate the impacts of a set of strategies, and with them, different revenue assumptions, that have implications for the Regional Growth Forecast. These strategies impact all of the models used, but in this memo, the focus is on the Regional Model shown in the lower left of Figure 1.

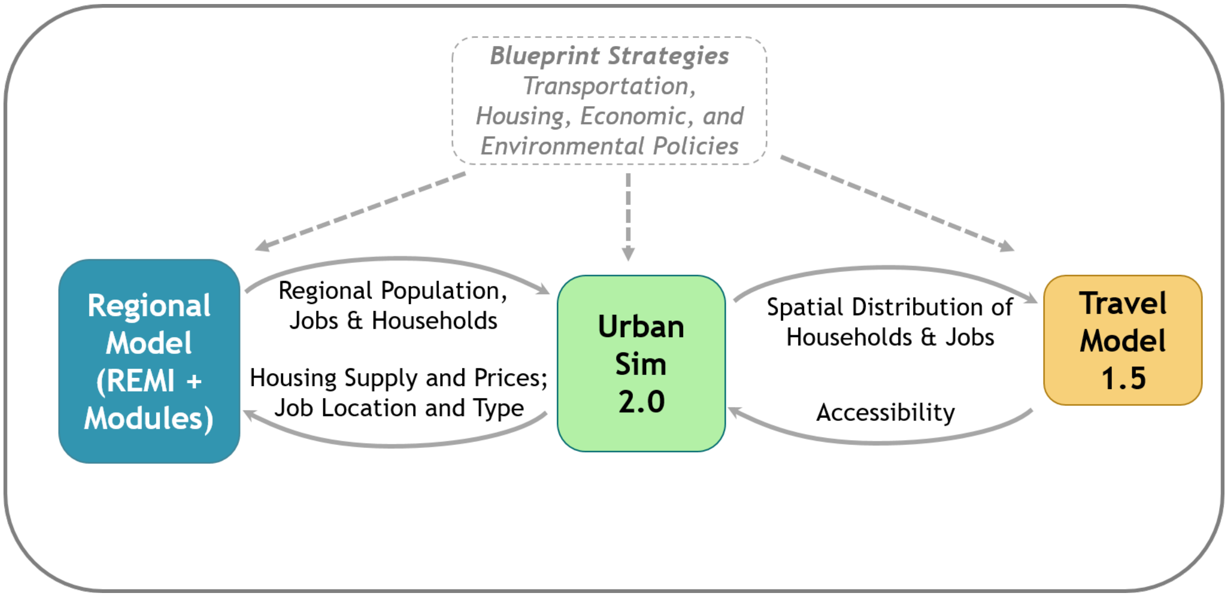
---

[2] Household projections are generated through a headship rate analysis. The household module uses the projected age and racial/ethnic composition of the adult population and an accounting of the percent of people in different age categories that are "heads of household" to project the expected number of households formed given the future composition of the population

[3] The household income distribution analysis estimates the share of households in each of four mutually exclusive income groups, to coincide with analysis required in the transportation model. The share of households in low, middle-low, middle-high, and high-income categories is estimated using a regression analysis which ties the share in each wage category with ethnic and age distribution, industry and occupational characteristics, relative housing prices, and per capita income.

[4] The technical advisory committee included: 6 Bay Area economists, 3 California Department of Finance experts, 3 megaregion representatives (Sacramento Area Council of Governments, San Joaquin Council of Governments, University of the Pacific), and 3 experienced REMI users (from the Atlanta Regional Commission, a Michigan think tank, and a Colorado nonprofit).

Figure 1: Integrating Strategies into the Regional Growth Forecast for Plan Bay Area 2050



Ultimately, not every strategy is anticipated to have significant impacts on the Regional Growth Forecast; many strategies only need to be incorporated in UrbanSim 2.0 and/or Travel Model 1.5. After reviewing the 25 strategies integrated into the Plan Bay Area 2050 Draft Blueprint, staff determined that the following strategies would likely influence the total amount of growth envisioned for the Bay Area, with impacts ranging widely across strategies (Table 1).

Table 1: Strategies Incorporated in Regional Growth Forecast

Category	***Strategy***	***Model Adjustments***
Transportation	Operate and Maintain the Existing System	Increase Construction, Admin
	Advance Low-Cost Transit Projects	Increase Construction, Admin
	Build a Complete Streets Network	Increase Construction, Admin
	Build New Transbay Rail Crossing	Increase Construction, Admin
	Reform Regional Transit Fare Policy	Increase Disposable Income (Consumer Spending)
	Fund Projects with Remaining Capacity (placeholder for Final Blueprint strategies/investments)	Increase Construction, Admin
Housing	Allow a Greater Mix of Housing Types and Densities in Growth Areas	Decrease Housing Cost, Increase Construction
	Reduce Barriers to Housing Near Transit and in Areas of High Opportunity	Decrease Housing Cost, Increase Construction
	Transform Aging Malls and Office Parks into Neighborhoods	Decrease Housing Cost, Increase Construction
	Fund Affordable Housing Protection, Preservation, and Production	Increase Disposable Income (Consumer Spending)
Economy	Expand Childcare Support for Low-Income Families	Increase Disposable Income (Consumer Spending)
	Create Incubator Programs in Economically-Challenged Areas	Increase Manufacturing & Education
Environment	Adapt to Sea Level Rise	Increase Construction Spending
	Modernize Existing Buildings with Seismic, Wildfire, Drought, and Energy Retrofits	Increase Construction Spending

Transportation Strategies

The economic impact of transportation investments generally fits into two categories: (1) direct effects from spending -- in operation and maintenance (O&M)[5] and construction of new projects -- as well as multiplier effects; (2) enhanced economic competitiveness through improved network efficiency and congestion reduction (which reduces cost for businesses), as well as improved air quality and quality of life. While staff recognizes the importance of capturing the

[5] O&M is where the majority of the forecasted transportation revenues will be spent. Staff considers current level of operation and maintenance spending to meet existing demand and to maintain existing conditions of the region's transportation assets will continue. Therefore, we do not simulate the impacts of these baseline investments separately. However, in cases where there are additional revenues to improve the condition beyond today's levels, reaching a full state of good repair, or to fund operation and maintenance demand necessitated by new projects, staff would make explicit assumptions of these investments.

comprehensive effects of the proposed transportation strategies, the forecast included in this memo only considers the impact in the first category due to limited model capacities. Therefore, the forecast reflects a more conservative estimate of the transportation spending in the Plan.

Four of the transportation strategies include transportation investment: *Operate and Maintain the Existing System*, *Advance Low-Cost Transit Projects*, *Build a Complete Streets Network*, and *Build New Transbay Rail Crossing*. These strategies are represented in the Regional Growth Forecast as increased demand within the construction industry. For the transportation strategy to *Reform Regional Transit Fare Policy*, staff expects that a $10 billion means-based fare discount, funded through existing transportation revenues, would increase transit subsidy and allow for consumer spending reallocation (i.e., money saved would be spent on other commodities).

Housing Strategies

Housing strategies are designed to spur housing production as well as to protect and preserve affordable housing. Boosting housing capacity is addressed through both strategic zoning changes, seeking to support the development of housing throughout the region where appropriate. Staff assumes these zoning change related strategies would allow and encourage private construction investment for market rate housing, which would significantly increase total jobs and population during the forecast period. This is modeled in REMI by changing the Bay Area housing cost relative to the nation and increasing the level of residential construction investment based on expected housing development. Staff expects the effect of the strategy to *Fund Affordable Housing Protection, Preservation, and Production* will be to increase disposable income and increasing consumer spending.

Economic Strategies

Economic strategies are primarily focused on improving economic mobility and shifting the location of jobs. Two of the strategies that are designed to improve economic mobility are included in the regional models: (1) *Expand Childcare Support for Low-Income Families*; and (2) *Create Incubator Programs in Economically Challenged Areas*. Other strategies designed to shift location of jobs are represented in the land use and travel models, but not the Regional Growth Forecast.

Reducing the cost of childcare is likely to increase labor force participation, primarily for mothers, but also for fathers. Providing childcare subsidy would also increase demand for the child care industry through increased spending, as well as reallocate consumer spending. Staff captures these changes by adjusting appropriate policy variables in REMI. The strategy to *Create Incubators in Economically Challenged Areas* is represented by increasing investment in the manufacturing and education industries.

Environmental Strategies

Adaptation to sea level rise focuses on protecting the shoreline as well as critical transportation infrastructure in areas at risk. To the extent that there would be increases in capital projects spending such as building levees and infrastructure enhancements (more likely in Blueprint Plus), staff increased demand for construction industry using REMI model.

The strategy to provide means based subsidy for retrofitting existing building assumes an additional $20 billion in revenue, which is applied to the construction industry. This is not modeled as increased consumer spending because it is assumed that without the subsidies, homeowners would not be incentivized to retrofit existing building at all.

Revenues to Fund Plan Strategies

Plan Bay Area 2050 currently is exploring two potential revenue levels: 1) Blueprint Basic, with funding levels for transportation, housing, economic development, and environmental resilience remaining in line with historical trends (a total of $608 billion for the 30 years of the Plan), and 2) Blueprint Plus, which includes a sizable influx of new revenues for all four areas of the Plan. Blueprint Plus assumes additional fiscal capacity for increased levels of investment in regional strategies to create a more aspirational plan, and these strategies are expected to further impact the economic growth and demographic changes of the region. There are two variants of Blueprint Plus: (a) Blueprint Plus Crossing, where $50 billion would be allocated to fund the construction of a new Transbay Rail Crossing, and (b) Blueprint Plus Fix It First, where greater share of transportation funding would be spent towards system operation and maintenance.

Staff assumed that the current levels of government funding for programs, including transportation operations, maintenance, and investment will continue. Although staff expects existing levels of forecasted revenues will fund the strategies proposed for Blueprint Basic, additional revenues are needed for Blueprint Plus to fund more ambitious regional strategies; this funding gap would be filled from additional taxes.

For the purposes of this forecast, staff assumed that:

- Additional transportation revenues would be funded by a sales tax increase;
- Additional housing revenues would be funded by a business tax increase;
- Additional economic revenues would be funded by a personal income tax increase; and
- Additional environment revenues would be funded by a property tax increase.

Staff analyzed the strategies in Blueprint Basic along with the effects of these additional taxes and the additional strategies included in Blueprint Plus. In doing so, staff determined that the set of housing strategies aimed at increasing housing production (at all income levels) had the largest impact to the region's demographics and economy, and these strategies are included in both Blueprint Basic and Blueprint Plus. Further, the effects of the taxes and strategies only in Blueprint Plus had a marginal impact on the Regional Growth Forecast. As a result, the total population, households and employment for Blueprint Basic as well as the two variants of Blueprint Plus do not significantly differ from each other, and only Blueprint Plus numbers will be presented in the following section for the sake of simplicity.

Regional Growth Forecast Results

The Final Regional Growth Forecast starts from the baseline assumptions about the demographic and economic trend of the region as described at the beginning of last section. For the Plan Bay Area 2050 Draft Blueprint, staff has been directed to propose and implement bold and ambitious strategies for the Bay Area's transportation, housing, economy, and the environment -- including moving the needle on regional housing affordability.

Table 2 shows the Plan Bay Area 2050 Final Regional Growth Forecast. Staff forecasts that between 2015 and 2050, the region's employment is projected to grow by 1.4 million to just over 5.4 million total jobs. Population is forecasted to grow by 2.7 million people to 10.3 million. This population will comprise over 4.0 million households, for an increase of nearly 1.3 million households from 2015. The number of housing units[6] plans for no net growth in the in-commute into the region, consistent with state law and MTC/ABAG legal settlements.

Table 2: Plan Bay Area 2050 - Final Regional Growth Forecast[7]

	2015	2030	2035	2040	2045	2050
Employment (in millions)	4.0	4.7	4.8	5.1	5.2	5.4
Population (in millions)	7.6	8.7	9.1	9.5	9.9	10.3
Households (in millions)	2.7	3.3	3.5	3.7	3.9	4.0
Housing Units (in millions)	2.7	3.4	3.7	3.9	4.1	4.3
Average Household Size	2.8	2.6	2.6	2.5	2.5	2.5

Source: MTC/ABAG from U.S. Bureau of Labor Statistics, U.S. Bureau of the Census, American Community Survey, and modeling results from ABAG REMI 2.3.1; *2020 and 2025 forecasts to be integrated later this month*

The Regional Growth Forecast projects approximately 400,000 more jobs, 200,000 fewer people, 300,000 more households and 300,000 more housing units in 2040 compared to the Plan Bay Area 2040 forecast. There are several reasons for the difference in the forecasts between Plan Bay Area 2040 and this latest forecast for the Bay Area. Differences in population are largely due to the assumption that the recent observed decline in Hispanic international migration and birth rates would continue, which is consistent with U.S. Census Bureau and California Department of Finance assumptions. Second, recent strong employment growth has caused us to adjust the early years of the forecast, and as a result the endpoint of the trend is also higher. Meanwhile, comparing the age composition of the population in these two forecasts, this forecast has a higher number of older adults, who usually have higher headship rates, forming more households. Finally, this forecast integrated housing strategies that would encourage more housing production and investment, resulting in higher household and housing unit numbers, as well as creating more jobs.

Employment Growth and Change

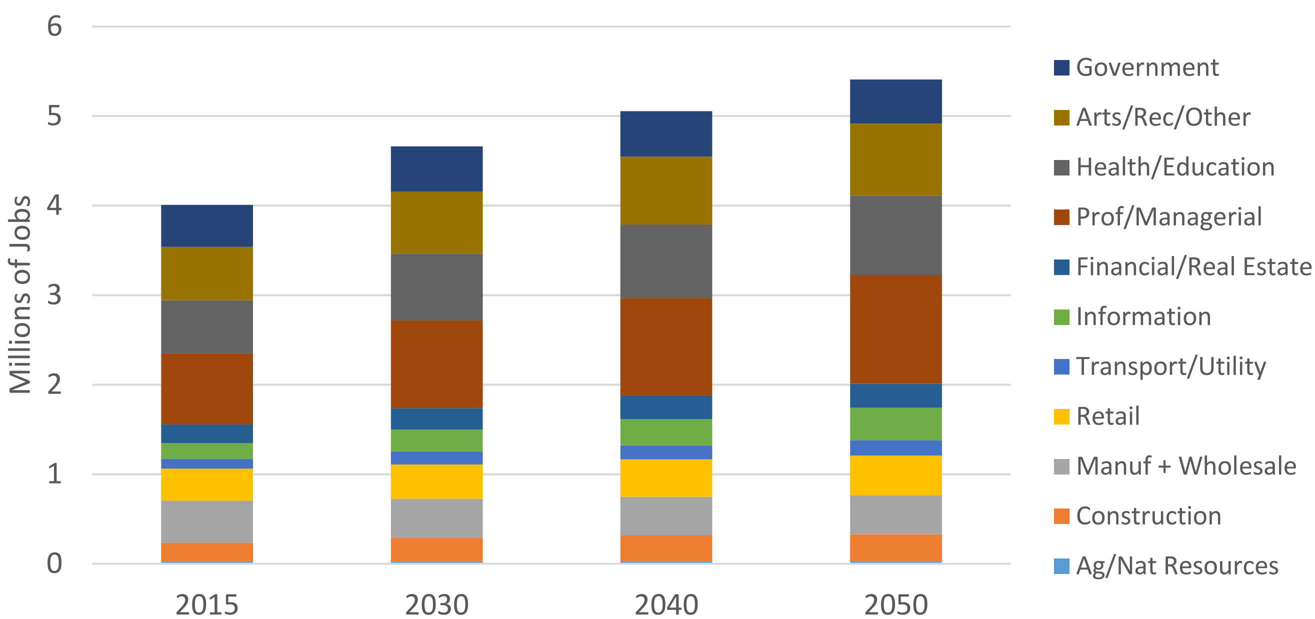
Figure 2 compares the level and distribution of employment in 2015 to projected employment in future years 2050. Professional & management and health & education industries are forecasted to continue dominating future employment in the San Francisco Bay Area, and the information

[6] Consistent with the legal settlement with the Building Industry Association, this housing unit projection includes housing for all projected households plus the number of units that would be needed to house the increased number of workers estimated to commute into the region. The in-commute change is estimated using REMI output for employment, and "residence adjusted employment". After adjusting for workers per household, an in-commuter household number is added to the base for estimating the regional housing control total. The regional housing control total is the sum of the households estimated for the projected population plus households equivalent to the maximum estimated in-commute number, plus a vacancy factor.

[7] Staff is currently working on an estimate for 2020 numbers using most recent published public data available, which will be incorporated into the Final Plan Document.

sector more than doubles its current job numbers. Meanwhile, despite increases in both output and demand in all sectors as well as stimulus strategies proposed, the forecast shows declining employment in a few sectors, due to both technologically induced higher productivity and changes in economic structure, particularly in the manufacturing and wholesale industries. Finally, job forecasts both for construction as well as transportation and warehousing are boosted by the infusion of investments.

Figure 2: Employment by Sector in the Final Regional Growth Forecast

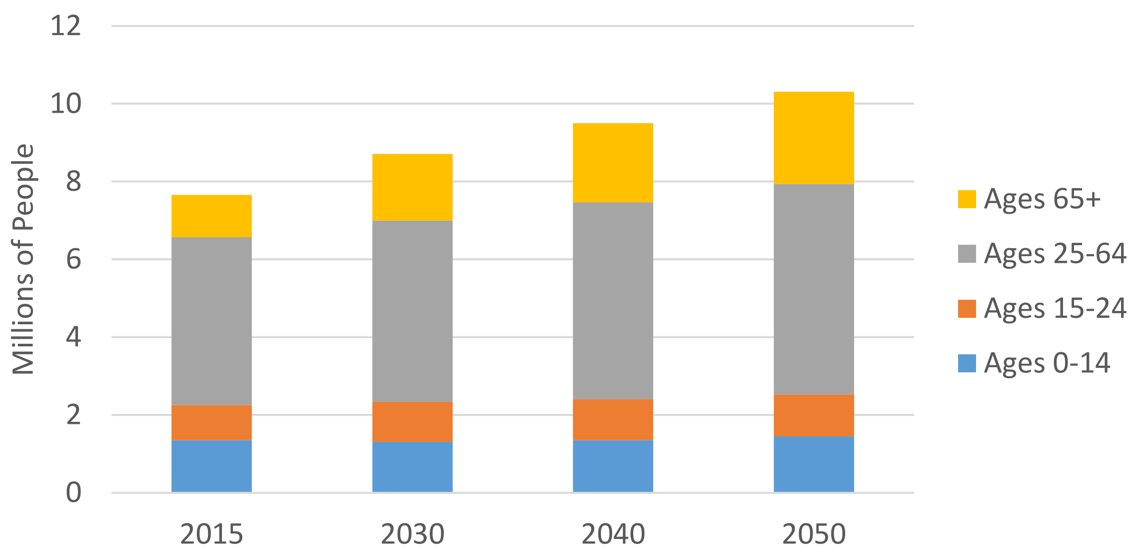


Source: MTC/ABAG from U.S. Bureau of Labor Statistics, U.S. Bureau of the Census, American Community Survey, and modeling results from REMI Bay Area 2.3.1

Population Growth and Change

Figure 3 compares the population by age group in 2015 with that of the projections for future years 2050. Between 2015 and 2050, the number of working-age adults is forecasted to grow by 25 percent, but the share declines by four percent (from 56 percent to 52 percent). The growth in the share of people in the 65+ age group is anticipated to continue in the decades ahead, more than doubling between 2015 and 2050, from 14 percent of the total population to 23 percent. While the 2050 total population is projected to be 35 percent higher than in 2015, growth will differ widely by age group.

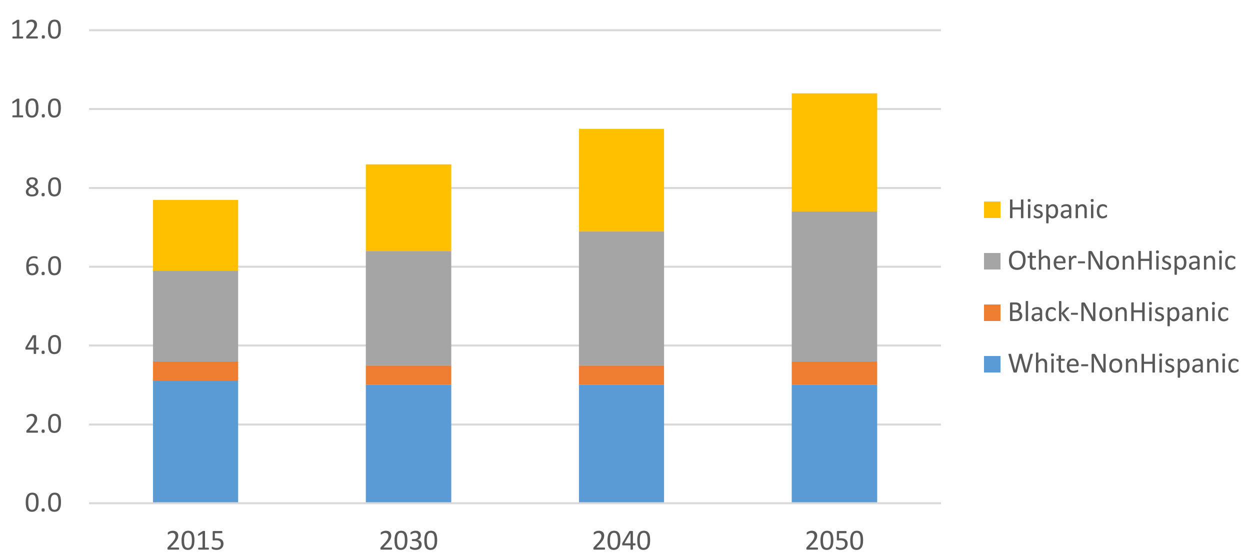
Figure 3: Population by Age Group in the Final Regional Growth Forecast



Source: MTC/ABAG from U.S. Bureau of the Census, American Community Survey, and modeling results from ABAG REMI 2.3.1

Ethnically, the region continues to diversify over time, as shown in Figure 4. Growth takes place mainly in Hispanic and Asian racial/ethnic groups (the largest group within the Other Non-Hispanic category in the figure). There is a small growth of the Black Non-Hispanic population, while the White Non-Hispanic population decreases steadily over time. By 2050, Asian, Native American, Pacific Islander, and More than One Racial group will reach 4 million people, while the Hispanic population will grow to the same level as White Non-Hispanics, to around 3 million people.

Figure 4: Population by Race/Ethnicity in the Final Regional Growth Forecast (in millions)



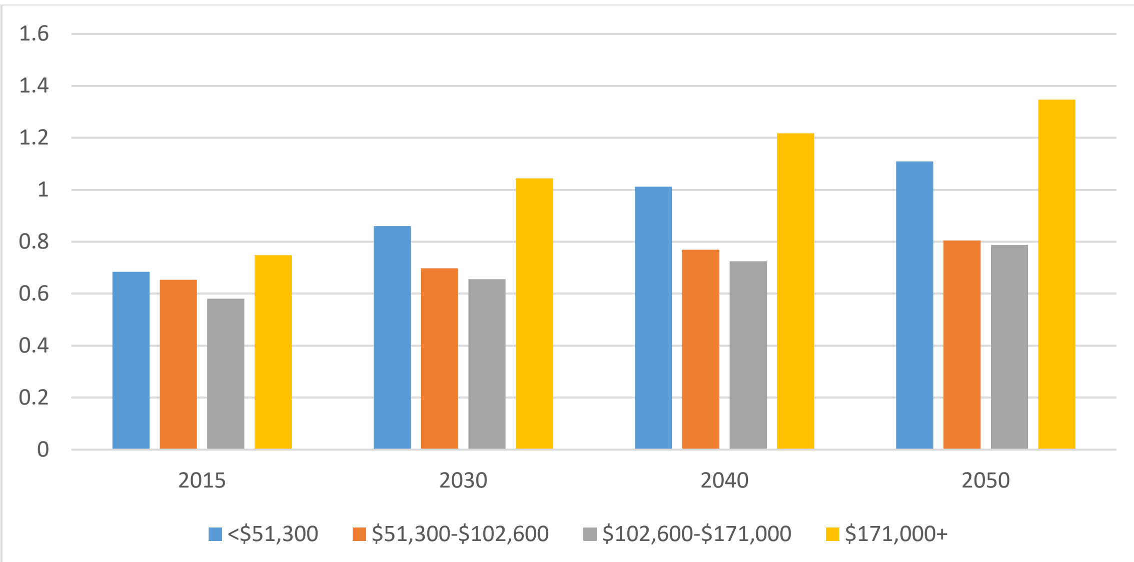
***Other Non-Hispanic includes:** individuals that are Asian-American, Native American, or Pacific Islander, as well as those of two or more races.*

Source: MTC/ABAG from U.S. Bureau of the Census, American Community Survey, and modeling results from ABAG REMI 2.3.1

Household Income Distribution

Figure 5 compares the household income distribution in 2015 with the projected income distribution for future years. The amount of household growth projected (1.3 million new households between 2015 and 2050) reflects strategies that encourage both market rate and affordable housing development, increasing the number of housing units produced.

Figure 5: Projected Income Distribution of Households
(in millions; Bay Area, 2019 dollars[8])



Source: MTC/ABAG household income distribution analysis

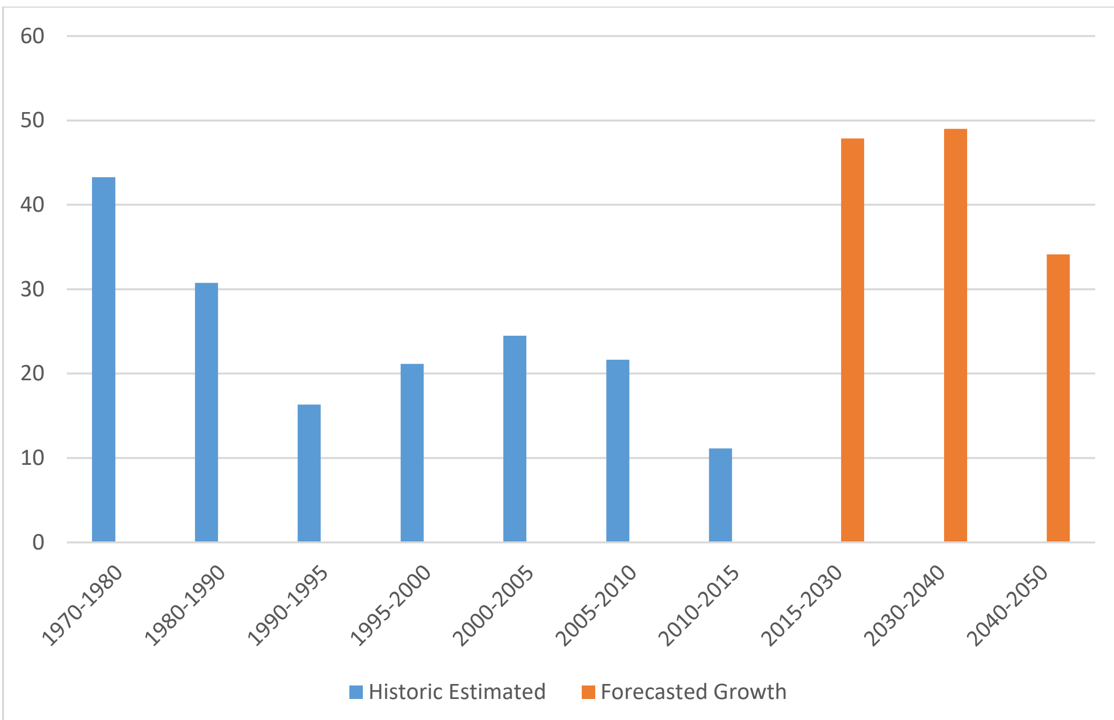
While the number of households in all four income categories are expected to grow, the greatest growth is expected in the lowest and highest income groups, despite strategies designed to strengthen the middle class in the Draft Blueprint. Household growth is anticipated to be strongest in the highest income category, reflecting the expected strength of growth in high-wage sectors combined with non-wage income (interest, dividends, capital gains, transfers). Household growth is also anticipated to be high in the lowest-wage category, reflecting possible occupational shifts, wage stagnation, the retirement of seniors without pension assets, as well as the proposed affordable housing strategies.

[8] The income categories were originally defined as approximate quartiles by MTC/ABAG in year 2000, but over the years as income inequality has risen, they have morphed into quantiles. Escalated to 2019 dollars and rounded to hundreds, the income thresholds are as follows: less than $51,300; from $51,3000 to $102,600; from $102,000 to $171,000; above $171,000.

Housing Production

To translate growth in households to the anticipated demand for housing units, staff assumed a healthy vacancy rate for the region of five percent beginning from 2030[9] - leading to a projected increase of housing units by 1.4 million through 2050[10]. The forecast implies an annual average rate of increase of between 35,000 and 56,000 units, depending on the time period; the level of demand for new housing units follows the formation of new households. As shown in Figure 6, this means a significant increase of production for the next three decades to a level of production above that of 1970s and 1980s, which requires the region successfully implement the housing strategies proposed in the Plan.

Figure 6: Annual Housing Production, Historic and Projected
(in thousands of housing units)



Source: MTC/ABAG household and housing unit analysis

Next Steps

The Regional Growth Forecast is being integrated into the Draft Blueprint, with analysis currently underway using UrbanSim 2.0 and Travel Model 1.5. Staff are also finalizing assumptions this month for the early years of the Final Forecast (2020 through 2029) to

---

[9] California Department of Finance estimates of Bay Area vacancies have varied from 3.4 to 6.4 percent since 2000. Current vacancy rate stands around 3 percent.
[10] New housing units includes 39,000 units associated with preventing growth in the number of in-commuters between 2015 and 2050.

integrate the effects of an anticipated economic downturn this year. If needed, any remaining refinements necessary to fully align with the Final Blueprint can be made later this year.

Staff will also provide the Final Regional Growth Forecast assumptions and results to California Housing and Community Development Department (HCD) as part of the Regional Housing Needs Allocation (RHNA) process. HCD will review MTC/ABAG projections and compare those with Department of Finance (DOF) projections to determine the regional housing needs (RHND) for the Bay Area. Per statute[11], if the MTC/ABAG forecast is within 1.5 percent of the DOF forecast, the MTC/ABAG forecast will be used as the base for HCD to calculate Bay Area housing needs target. Otherwise, following consultation with MTC/ABAG staff, HCD will determine which forecast to use for the RHND.

[11] California Code, Government Code - GOV § 65584.01

ATTACHMENT D: DOCUMENTATION ON MODEL ITERATIONS AND DATA FLOW BETWEEN BAY AREA URBANSIM 2.0 AND TRAVEL MODEL 1.5

Fall 2021

Induced Travel & Land Use and Travel Model Interaction

As discussed in the Technical Methodology Memorandum, long-run induced travel is captured by interactions between the land use model – Bay Area UrbanSim 2.0 – and the travel model – Travel Model 1.5 (see Figure D-1). When land use strategies are represented in Bay Area UrbanSim 2.0, the outputs from the model then reflect the following:

- Changes in residential location decisions within the region
- Changes in employment location decisions within the region
- Changes in residential development locations within the region
- Changes in commercial/industrial development locations within the region

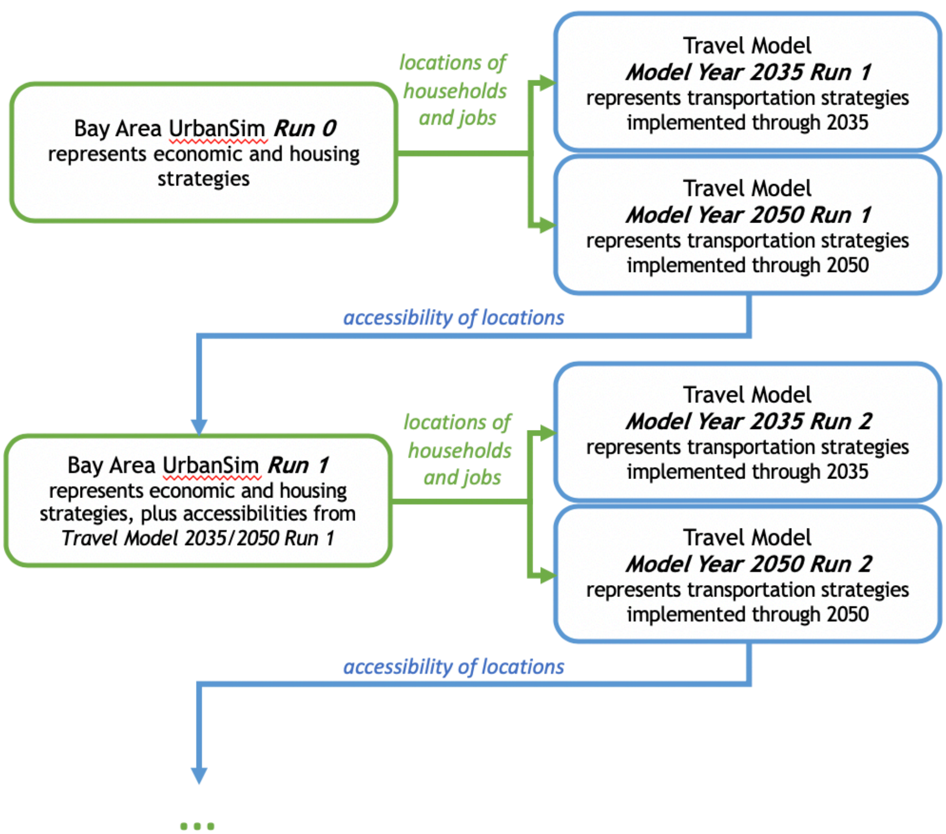


Figure D-1. Induced Demand Integration from Land Use iteration of Bay Area UrbanSim 2.0, where accessibility is valued by developers and increase the profitability of developing on a parcel.

Note that accessibility measures from the travel model are fed into earlier years in UrbanSim to represent the idea that developers anticipate future transportation network changes when considering the accessibility of a potential building site. That is, travel model accessibilities from the model year 2035 run are input to UrbanSim starting in 2010, and travel model accessibilities from the model year 2050 run are input to UrbanSim starting in 2030. Thus, transportation strategies and travel behavior have an effect on land use development, and housing and economic strategies have an effect on travel. For the Plan, MTC/ABAG staff typically run the UrbanSim/Travel Model sequence iteratively as strategies are developed and refined, with at least two complete iterations of each after the strategies are finalized.

Transportation projects that were recently completed (within the past five to seven years) are represented in the travel model network for both No Project and Final Blueprint. Bay Area UrbanSim takes the accessibility benefits or disbenefits rendered by these projects in the travel model into account when simulating developer, employer and household behavior beginning in year 2015, with simulations occurring every five years. UrbanSim inputs are then fed back into the travel model as origins and destinations. This approximates changes to long-run induced demand from changes to zoning or the development pipeline which may not be represented in the baseline data due to the project's recency.

Variables Exchanged Between Models

Bay Area UrbanSim 2.0 shares the following datasets with **Travel Model 1.5:**

- Population by traffic analysis zone (TAZ), by type (household vs. group quarters), by age, and by employment status for the appropriate model year
- Employment by TAZ and by industry for the appropriate model year
- Households by TAZ and by income level for the appropriate model year
- Housing units by TAZ for the appropriate model year
- Acreage by TAZ, by zoning and by zoning type for the appropriate model year

Travel Model 1.5 shares the following datasets back to **Bay Area UrbanSim 2.0**:

- Accessibility by TAZ across all modes (destination choice logsums) for mandatory and non-mandatory purposes, segmented by four income groups and three household autos vs. workers categories (zero autos, fewer autos than workers, one or more auto per worker).

These accessibilities are input into UrbanSim in advance of the travel model year as noted above; the logsum values are multiplied by the size of each segment in each zone to produce a weighted score and the mandatory and non-mandatory scores are combined to produce single index of generalized accessibility that enters UrbanSim's residential hedonic models.

Model Run Sets

The following iterations of model runs included data hand-offs between the land use model (Bay Area UrbanSim 2.0, or BAUS) and the travel model (Travel Model 1.5). This list of runs is not comprehensive, as many incremental runs were performed in between these runs (as can be seen by the version numbering).

1. **Draft Blueprint, BAUS v1.7.1, run98**

- This run was the last land use model run for the Draft Blueprint. This run was also the result of a sequence of travel model and land use model run iterations. More information about the strategies, growth geographies and resulting growth pattern in the Draft Blueprint can be found here: https://www.planbayarea.org/2050-plan/draft-blueprint/plan-bay-area-2050-draft-blueprint-documents.
- The travel model accessibilities fed into this run were from the Draft Blueprint travel model runs.

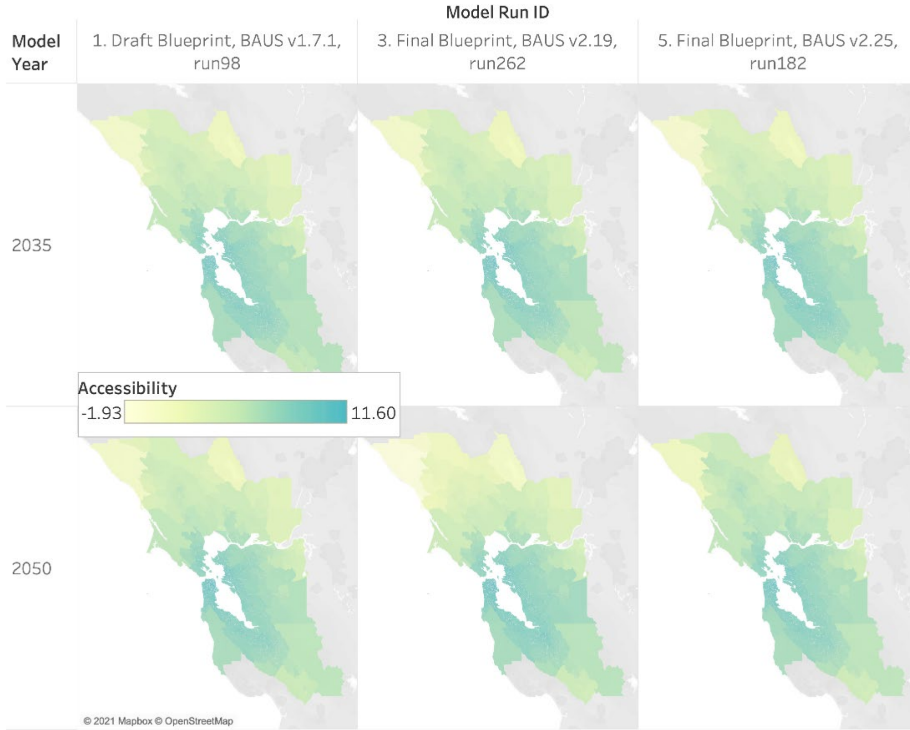
2. **Final Blueprint, Travel Model Runs [2035,2050]_TM152_FBP_[Plus,PlusCrossing]_10**
    - These travel model runs were early Final Blueprint runs which were used to hand-off accessibilities back to BAUS. These runs were performed during the period in which the Final Blueprint strategies were being defined and implemented. For more information on the Final Blueprint: https://www.planbayarea.org/2050-plan/plan-bay-area-2050-blueprint/plan-bay-area-2050-final-blueprint-documents
    - Not all strategies were completely implemented in this run. Dynamic tolling rates were also not yet optimized.
3. **Final Blueprint, BAUS v2.19, run262**
    - This run was an intermediate run during the Final Blueprint implementation. This run was also performed during the period in which the Final Blueprint strategies were being defined and implemented. In this run, all of the Final Blueprint strategies were implemented, but still needed to be refined.
4. **Final Blueprint, Travel Model Runs [2035,2050]_TM152_FBP_[Plus,PlusCrossing]_12**
    - These travel model runs were a couple iterations after the runs described in 2. Changes between these runs and 2. include the coding of more minor transportation projects, the delay of HSR service, and updated land use.
5. **Final Blueprint, BAUS v2.25, run182**
    - This run was the final land use model run for the Final Blueprint. This model run included the final implementation of all the Final Blueprint strategies relevant to the land use model.
6. **Draft Plan, Travel Model Runs [2035,2050]_TM152_FBP_[Plus,PlusCrossing]_[20,21]**
    - These travel model runs were used for the analysis in the Draft Plan Bay Area 2050 document as well as the Draft Environmental Impact Report and the Draft Supplemental Reports, including the Draft Forecasting and Modeling Report. They include the coding of all minor transportation projects as well as the final land use.
7. **Final Plan, Travel Model Runs [2035,2050]_TM152_FBP_[Plus,PlusCrossing]_24**
    - These travel model runs were used for the analysis in the Final Plan Bay Area 2050 document as well as the Final Environmental Impact Report and the Final Supplemental Reports, including the Final Forecasting and Modeling Report, and featured minor technical corrections to project coding, etc. The land use inputs were unchanged from the Draft Plan; the updates made to these runs from the Draft Plan runs are documented in detail in the last three pages of the Final Forecasting and Modeling Report.

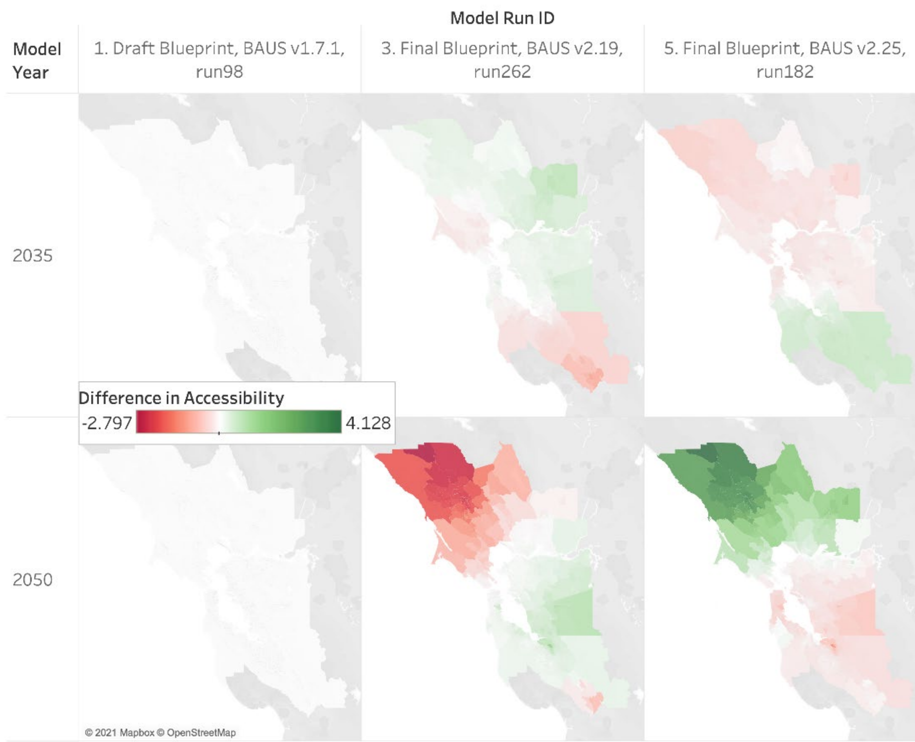
Changes to Travel Accessibilities and Land Use

As shown in Figure D-1, accessibilities are fed into Bay Area UrbanSim as destination choice logsums, which are segmented by income categories, household autos versus workers, presence of autonomous vehicles, and walk-to-transit subzone. An example map of the accessibilities input into each of the model runs is shown below in Figure D-2. These maps show that the accessibility is higher in the more urbanized areas (as expected); however, the differences between them are too subtle to be visible at this scale. Figure D-3 therefore shows the changes in accessibilities between each run and the previous run. Note that there is no color in the left most column (1. Draft Blueprint, BAUS v1.7.1, run98) because it is the first run being shown. The color in the middle column shows the change in accessibilities from 1. Draft Blueprint, BAUS v1.7.1, run98 compared to 3. Final Blueprint, BAUS v2.19, run262. The color in the right most column shows the change in accessibilities from 3. Final Blueprint, BAUS v2.19, run262 compared to 5. Final Blueprint, BAUS v2.25, run182. For context, these maps show accessibilities for the segment of households that are medium income, with fewer autos than workers, without autonomous vehicle households living in a short walk to transit. However, the maps for other segments look similar, and the general color patterns are the same.

Focusing on the center maps which compare accessibilities input to 1. Draft Blueprint, BAUS v1.7.1, run98 with accessibilities input to 3. Final Blueprint, BAUS v2.19, run262, there is a slight increase in accessibility in the North Bay as well as a slight decrease in accessibility in the southernmost part of the region in 2035 between 1. Draft Blueprint, BAUS v1.7.1, run98 and 3. Final Blueprint, BAUS v2.19, run262. These are likely due to numerous transportation investments were being coded throughout the Bay Area for the Final Blueprint due to expanded transportation strategies not featured in the Draft Blueprint. Looking at the year 2050 maps, a larger decrease in accessibility in the North Bay is visible; these changes are likely due to the expansion of Strategy T5: Implement Means-Based Per-Mile Tolling on Congested Freeways with Transit Alternatives into portions of the North Bay in 2. Final Blueprint, Travel Model Runs [2035,2050]_TM152_FBP_[Plus,PlusCrossing]_10.

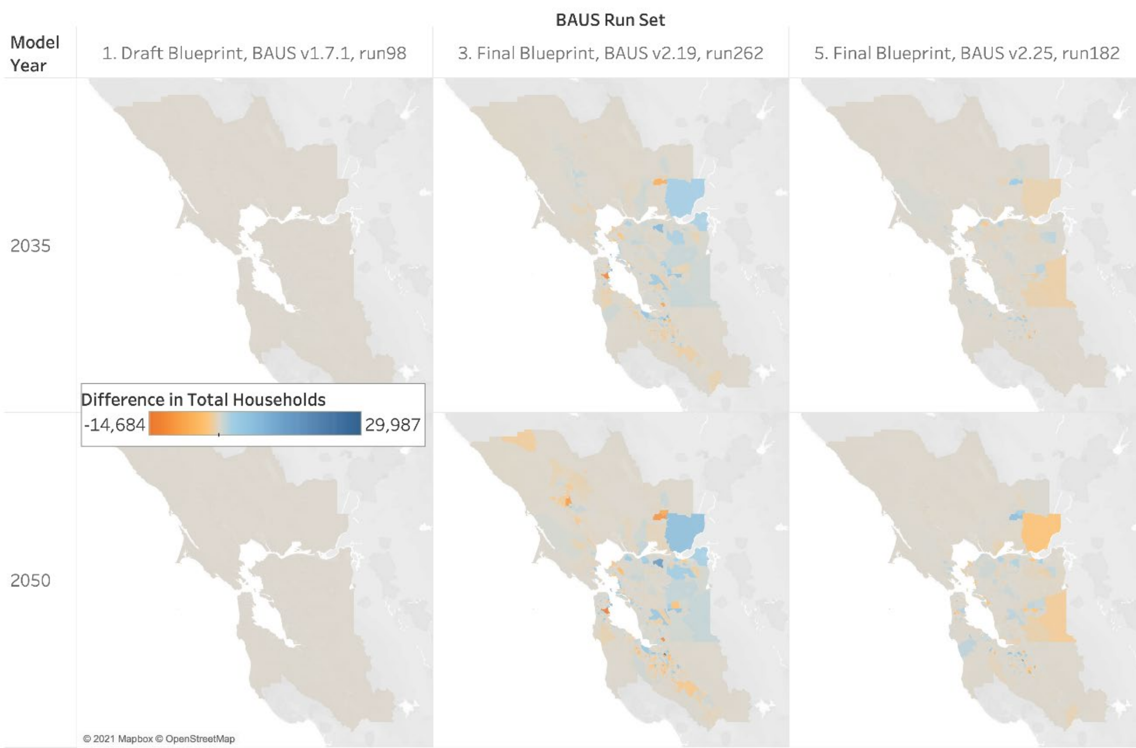
Moving on to the rightmost maps which compare accessibilities input to 3. Final Blueprint, BAUS v2.19, run262 with accessibilities input to 5. Final Blueprint, BAUS v2.25, run182, the patterns reverse. This is likely due to changes in land use input to 2. Final Blueprint, Travel Model Runs [2035,2050]_TM152_FBP_[Plus,PlusCrossing]_10 compared to 4. Final Blueprint, Travel Model Runs [2035,2050]_TM152_FBP_[Plus,PlusCrossing]_12 which shifted household growth from the North Bay, thus reducing congestion and increasing accessibility. As with any iterative process with negative feedback loops, the accessibility changes show some oscillation: increased land use intensity causes increased congestion, which in turn causes decreased accessibility which then causes decreased land use intensity. However, as previously mentioned, these iterations were also undergoing independent input updates as the 35 strategies were being developed and implemented in tandem, so this is only one factor in the changes occurring in these runs.


Model Run ID
Model Year
1. Draft Blueprint, BAUS v1.7.1, run98
3. Final Blueprint, BAUS v2.19, run262
5. Final Blueprint, BAUS v2.25, run182
2035
2050
Accessibility
-1.93
11.60
© 2021 Mapbox © OpenStreetMap


Model Run ID
Model Year
1. Draft Blueprint, BAUS v1.7.1, run98
3. Final Blueprint, BAUS v2.19, run262
5. Final Blueprint, BAUS v2.25, run182
2035
2050
Difference in Accessibility
-2.797
4.128
© 2021 Mapbox © OpenStreetMap

On the output side, change in household forecasts from these land use model runs is shown in Figure D-4, where each map shows the change in households for a given TAZ for a given model year (2035 in the top row and 2050 in the bottom row) compared to the previous set of model runs. Figure D-5 shows the change in employment between the BAUS run sets. Changes in the locations of jobs and households are the result of post-Draft Blueprint model improvements and the implementation of Final Blueprint strategies. Between the Draft and Final Blueprint, improvements were made to the development pipeline data and updates to the base zoning data were incorporated. A number of strategies were also added or modified, including:

- Upzoning focused more growth around transit-rich and high-resource areas.
- Additional subsidies were used for the production and preservation of affordable housing.
- New incentives were used to shift jobs to housing-rich areas served by transit.
- Aging malls, office parks, and public lands were transformed into major housing sites.
- Greater commercial densities were allowed near transit.



Changes to Transportation Supply and Travel Demand

Table D-1 and Table D-2 show how the roadway supply (in vehicle lane miles) and transit supply (in thousands of seat miles) input changed across the travel model run sets described above (see Model Runs Sets). The roadway supply is segmented by roadway type categories to show that some changes between run sets include moving lane miles from general purpose (GP) lanes to tolled lanes. Similarly, the transit supply is segmented by technology type, showing that much of the increase in supply in the Final Plan was in heavy and commuter rail. Table D-4 and Table D-5 show how roadway demand (in thousands of vehicle miles traveled) and transit demand (in thousands of transit boardings) output changed across the travel model run sets.

Discussion

The maps and figures included in this document show the iterative modeling process that was used to analyze Plan Bay Area 2050, including some concrete examples and summaries of the inputs and outputs to the different model run sets leading up to the final plan model runs. While the linkages include the theoretical framework for inducing long-run travel from development supported by transportation investments, in practice this induced demand is too subtle to be clear from these data sets. This is for a variety of reasons:

- **Land use development in the Bay Area is highly constrained by zoning**. Since the plan includes upzoning in Growth Geographies defined to support plan strategies, this schema drives land use development far more than the relatively minor roadway expansion projects included in the plan. However, since the Growth Geographies are designed to be supportive of transit, this upzoning schema encourages development in transit rich areas explicitly, even without the changes to accessibility made by increased transit service.

- **Plan Bay Area 2050 emphasizes optimization of existing roadway infrastructure over capacity increases**. As illustrated in Table D-1, freeway lane miles would increase by 387 miles (7%) between 2015 and 2050. Most of this increase in capacity is due to the construction of new managed lanes, while general purpose (GP) and high-occupancy vehicle (HOV) lane miles decrease between 2015 and 2050 due to the conversion of some of this capacity to managed lanes. These investments are complemented by a selection of non-capacity increasing highway optimization projects (such as interchange safety redesigns), arterial and collector projects, and a strategy to institute all lane tolling on corridors where high-quality transit alternatives are present or planned. As such, there is no singular major corridor which has increased accessibilities influencing development.

Table 1. Travel Model Inputs: Roadway Supply by Roadway Type

Rows indicating "Difference … from previous" compare value to the equivalent value in the previous run set (e.g. run set 6. Draft Plan, model year 2035 to run set 4. Final Blueprint, model year 2035).

			2. Final Blueprint		4. Final Blueprint		6. Draft Plan		7. Final Plan	
		2015	**2035**	**2050**	**2035**	**2050**	**2035**	**2050**	**2035**	**2050**
	Roadway Type	2015_TM15 2_IPA_17	2035_TM15 2_FBP_Plus _10	2050_TM15 2_FBP_Plus Crossing_1 0	2035_TM15 2_FBP_Plus _12	2050_TM15 2_FBP_Plus Crossing_1 2	2035_TM15 2_FBP_Plus _20	2050_TM15 2_FBP_Plus Crossing_2 1	2035_TM15 2_FBP_Plus _24	2050_TM15 2_FBP_Plus Crossing_2 4
Vehicle Lane Miles	Arterial/Expwy Lanes	9,746	9,733	9,685	9,733	9,685	9,778	9,760	9,779	9,807
	Collector	5,504	5,513	5,512	5,513	5,512	5,527	5,526	5,520	5,520
	Freeway GP Lanes	5,109	2,170	2,263	2,154	2,247	2,185	2,250	2,188	2,217
	Freeway HOV Lanes	467	77	73	77	73	121	126	121	126
	Freeway Tolled Lanes	44	3,638	3,666	3,654	3,682	3,611	3,675	3,609	3,664
	All Roadway Types	20,871	21,130	21,200	21,131	21,200	21,222	21,337	21,217	21,334
Difference in Vehicle Lane Miles from previous	Arterial/Expwy Lanes				0	0	45	75	1	47
	Collector				0	0	14	14	-6	-6
	Freeway GP Lanes				-16	-16	31	3	3	-33
	Freeway HOV Lanes				0	0	45	52	0	0
	Freeway Tolled Lanes				16	16	-42	-8	-3	-10
	All Roadway Types				0	0	92	136	-5	-2
Percent Difference in Vehicle Lane Miles from previous	Arterial/Expwy Lanes				0%	0%	0%	1%	0%	0%
	Collector				0%	0%	0%	0%	0%	0%
	Freeway GP Lanes				-1%	-1%	1%	0%	0%	-1%
	Freeway HOV Lanes				0%	0%	58%	71%	0%	0%
	Freeway Tolled Lanes				0%	0%	-1%	0%	0%	0%
	All Roadway Types				0%	0%	0%	1%	0%	0%

Table 2. Travel Model Inputs: Transit Supply by Transit Technology

Rows indicating "Difference … from previous" compare value to the equivalent value in the previous run set (e.g. run set 6. Draft Plan, model year 2035 to run set 4. Final Blueprint, model year 2035).

			2. Final Blueprint		4. Final Blueprint		6. Draft Plan		7. Final Plan	
		2015	2035	2050	2035	2035	2050	2050	2035	2050
	Transit Technology	2015_TM152_IPA_17	2035_TM152_FBP_Plus_10	2050_TM152_FBP_PlusCrossing_10	2035_TM152_FBP_Plus_20	2035_TM152_FBP_Plus_12	2050_TM152_FBP_PlusCrossing_12	2050_TM152_FBP_PlusCrossing_21	2035_TM152_FBP_Plus_24	2050_TM152_FBP_PlusCrossing_24
Transit Seat-Miles (thousands of seat-miles)	Local Bus	9,116	12,653	12,928	12,707	12,653	12,928	13,200	12,815	13,218
	Express Bus	1,991	3,960	4,005	4,697	4,253	4,299	4,756	4,657	4,754
	Ferry	688	2,707	2,707	2,884	2,707	2,707	2,884	2,884	2,884
	Light Rail	2,063	2,429	3,151	2,429	2,429	3,151	3,301	2,429	3,301
	Heavy Rail	12,111	21,340	21,340	21,340	21,340	21,340	21,340	21,340	21,340
	Commuter Rail	4,993	3,173	11,910	8,272	3,173	15,252	19,590	8,272	19,590
	All Transit Technologies	30,962	46,261	56,041	52,328	46,554	59,677	65,070	52,396	65,087
Difference in Transit Seat-Miles from previous (thousands of seat-miles)	Local Bus				0	0	54	272	108	19
	Express Bus				293	293	444	457	-41	-2
	Ferry				0	0	177	177	0	0
	Light Rail				0	0	0	150	0	0
	Heavy Rail				0	0	0	0	0	0
	Commuter Rail				0	3,343	5,099	4,337	0	0
	All Transit Technologies				293	3,636	5,774	5,393	68	17
Percent Difference in Transit Seat-Miles from previous	Local Bus				0%	0%	1%	3%	1%	0%
	Express Bus				15%	15%	22%	23%	-2%	0%
	Ferry				0%	0%	26%	26%	0%	0%
	Light Rail				0%	0%	0%	7%	0%	0%
	Heavy Rail				0%	0%	0%	0%	0%	0%
	Commuter Rail				0%	67%	102%	87%	0%	0%
	All Transit Technologies				1%	12%	19%	17%	0%	0%

Table 3. Travel Model Outputs: Roadway Demand by Roadway Type

Rows indicating "Difference … from previous" compare value to the equivalent value in the previous run set (e.g. run set 6. Draft Plan, model year 2035 to run set 4. Final Blueprint, model year 2035).

			2. Final Blueprint		4. Final Blueprint		6. Draft Plan		7. Final Plan	
		2015	**2035**	**2050**	**2035**	**2050**	**2035**	**2050**	**2035**	**2050**
	Roadway Type	2015_TM152_IPA_17	2035_TM152_FBP_Plus_10	2050_TM152_FBP_PlusCrossing_10	2035_TM152_FBP_Plus_12	2050_TM152_FBP_PlusCrossing_12	2035_TM152_FBP_Plus_20	2050_TM152_FBP_PlusCrossing_21	2035_TM152_FBP_Plus_24	2050_TM152_FBP_PlusCrossing_24
Vehicle Lane Miles	Arterial/Expwy Lanes	45,768	66,898	74,291	65,328	71,142	65,959	70,469	67,041	72,267
	Collector	10,406	15,645	17,626	15,324	16,884	15,178	16,488	15,432	16,867
	Freeway GP Lanes	81,571	26,646	30,997	26,278	29,521	26,996	29,474	27,494	30,067
	Freeway HOV Lanes	4,294	546	689	557	565	1,528	1,611	1,528	1,632
	Freeway Tolled Lanes	497	43,156	52,821	42,819	50,717	40,523	47,047	41,672	48,732
	All Roadway Types	142,536	152,891	176,424	150,306	168,829	150,183	165,088	153,167	169,565
Difference in Vehicle Lane Miles from previous	Arterial/Expwy Lanes				-1,570	-3,150	630	-673	1,083	1,798
	Collector				-321	-742	-146	-397	254	380
	Freeway GP Lanes				-368	-1,476	718	-47	498	593
	Freeway HOV Lanes				11	-124	970	1,046	1	22
	Freeway Tolled Lanes				-337	-2,103	-2,296	-3,670	1,149	1,685
	All Roadway Types				-2,585	-7,595	-124	-3,741	2,984	4,477
Percent Difference in Vehicle Lane Miles from previous	Arterial/Expwy Lanes				-2%	-4%	1%	-1%	2%	3%
	Collector				-2%	-4%	-1%	-2%	2%	2%
	Freeway GP Lanes				-1%	-5%	3%	0%	2%	2%
	Freeway HOV Lanes				2%	-18%	174%	185%	0%	1%
	Freeway Tolled Lanes				-1%	-4%	-5%	-7%	3%	4%
	All Roadway Types				-2%	-4%	0%	-2%	2%	3%

Table 4. Travel Model Outputs: Transit Demand by Transit Technology

Rows indicating "Difference … from previous" compare value to the equivalent value in the previous run set (e.g. run set 6. Draft Plan, model year 2035 to run set 4. Final Blueprint, model year 2035).

			2. Final Blueprint		4. Final Blueprint		6. Draft Plan		7. Final Plan	
		2015	2035	2050	2035	2050	2035	2050	2035	2050
	Transit Technology	2015_TM152_IPA_17	2035_TM152_FBP_Plus_10	2050_TM152_FBP_PlusCrossing_10	2035_TM152_FBP_Plus_12	2050_TM152_FBP_PlusCrossing_12	2035_TM152_FBP_Plus_20	2050_TM152_FBP_PlusCrossing_21	2035_TM152_FBP_Plus_24	2050_TM152_FBP_PlusCrossing_24
Transit Seat-Miles (thousands of seat-miles)	Local Bus	879	2,052	2,118	1,837	1,943	1,690	1,945	1,742	1,993
	Express Bus	49	178	187	159	140	172	156	179	163
	Ferry	12	74	70	59	41	56	45	58	47
	Light Rail	237	521	834	478	630	414	621	430	647
	Heavy Rail	487	1,047	1,064	925	950	828	863	875	913
	Commuter Rail	61	412	504	377	431	349	386	372	418
	All Transit Technologies	1,725	4,284	4,777	3,835	4,136	3,509	4,015	3,656	4,181
Difference in Transit Seat-Miles from previous (thousands of seat-miles)	Local Bus				-215	-175	-147	2	52	48
	Express Bus				-19	-47	13	16	7	7
	Ferry				-15	-29	-3	3	2	3
	Light Rail				-43	-203	-63	-10	15	26
	Heavy Rail				-123	-114	-97	-87	47	51
	Commuter Rail				-35	-73	-28	-45	23	32
	All Transit Technologies				-450	-641	-326	-121	147	166
Percent Difference in Transit Seat-Miles from previous	Local Bus				-10%	-2%	-2%	0%	1%	1%
	Express Bus				-1%	-2%	1%	1%	0%	0%
	Ferry				-2%	-4%	0%	1%	0%	0%
	Light Rail				-2%	-10%	-3%	0%	1%	1%
	Heavy Rail				-1%	-1%	-1%	-1%	0%	0%
	Commuter Rail				-1%	-1%	-1%	-1%	0%	1%
	All Transit Technologies				-1%	-2%	-1%	0%	0%	1%

ATTACHMENT E: AUTO OPERATING COST (AOC) CALCULATIONS FOR PLAN BAY AREA 2050

Fall 2020

CARB staff reviewed the following approach for calculating auto operating costs (AOC) and indicated via email on October 14, 2020 that staff "believes there are no aspects of the draft AOC methodology that would yield inaccurate estimates of SB 375 GHG emissions." The methodology show below is based on the approach developed by the four large MPOs for the previous SCS cycle (see Appendix 1).

Methodology

The AOC calculation quantifies the average per mile cost to operate a passenger vehicle. The AOC calculation incorporates three inputs, Fuel Cost, Non-Fuel Cost, and Fuel Efficiency, using the following formula:

$$AOC_{year} = \frac{fuel\ cost_{year}}{fuel\ efficiency_{year}} + non\ fuel\ cost_{year}$$

where:
AOC $_{year}$ *= calculated auto operating cost by year ($/mile)*
Fuel cost $_{year}$ *= average fuel cost weighted across all fuel types ($/gasoline gallon equivalent)*
Non-fuel cost $_{year}$ *= average non-fuel operating (maintenance, repair, and tire) costs weighted across all fuel types ($/mile)*
Fuel efficiency $_{year}$ *= average fuel efficiency weighted across all fuel types (miles/gallon)*

The approach for developing the AOC assumption for Plan Bay Area 2050 (which will serve as the region's third SCS – SCS3) builds off of the multi-agency methodology developed by the 4 largest MPOs for the second round of SCS (SCS2) in an effort to establish consistent growth assumptions for forecasting changes in passenger vehicle operating costs. Cost assumptions were developed for modeling years 2005 and 2015 through 2050 in five-year increments.

Fuel Cost Assumptions

The approach to estimate fuel costs uses a methodology similar to the second SCS but relies on the CARB Auto Operating Cost Calculator[64] fuel cost estimates and more recent EIA Annual Energy Outlook estimates to forecast fuel prices to update the fuel price growth ratio.

For modeling years 2005 to 2030, fuel prices for each fuel type were drawn directly from the CARB AOC Calculator. In the CARB AOC Calculator, historical gasoline and diesel fuel prices for years 2000 through for years 2018 through 2030, and hydrogen fuel and electricity prices from 2015 through 2030 were supplied by the California Energy Commission (CEC).[65] The average fuel price weighted by VMT of each

[64] California Air Resources Board. SCS Evaluation Resources, Draft Auto Operating Cost Calculator. Accessed 4/13/2020: https://ww2.arb.ca.gov/resources/documents/scs-evaluation-resources
[65] California Energy Commission. Revised Transportation Energy Demand Forecast, 2018-2030. Publication Number: CEC-200-2018-003. February 2018. Available at: https://efiling.energy.ca.gov/getdocument.aspx?tn=223241

fuel type was calculated for each of these years.[66]e[67] and recent gas taxes were added to base fuel costs using the following steps:

- The High Oil Price and Low Oil Price for all years 2030-2050 were collected from EIA 2018 Annual Energy Outlook, Petroleum and Other Liquids Prices Table.
- The midpoint between the high and low oil forecast values was calculated for each year.
- The fuel price ratios of each future year price relative to the year 2030 price was calculated.
- The fuel price ratios were multiplied by the year 2030 CEC fuel price assumptions to estimate post-2030 gasoline and diesel prices; prices after 2030 for hydrogen and electricity were held at 2030 CEC levels, as assumed in the CARB AOC Calculator, because of a lack of reliable forecast data for those fuels.
- Per-gallon tax rates were also added to the base gas prices for every year after 2017,[68] to reflect the statewide SB1 excise tax applied beginning that year ($0.12/gallon gasoline, $0.20/gallon diesel) and raised in 2019 ($0.176/gallon gasoline).[69]
- To calculate an overall average fuel cost for a given year, the price for each fuel type was weighted by the VMT of each fuel type.

Non-Fuel Cost Assumptions

Ongoing non-fuel operating costs, such as tires and other ongoing maintenance costs, are added to the overall auto operating cost for each year. The non-fuel costs are based on data from the American Automobile Association (AAA) and growth ratios developed by the 4 large MPOs for the second SCS (Appendix 1). This approach was used by MTC in the second SCS and is applied again in this methodology for estimating non-fuel costs.

For modeling years through 2017, non-fuel costs for each fuel type vehicle were drawn directly from the CARB AOC Calculator. The non-fuel costs provided in the calculator were collected from AAA's *Your Driving Cost* reports.[70] MTC calculated an overall average non-fuel cost weighted by VMT of each fuel type for each of these years.

To estimate non-fuel costs of gasoline and diesel vehicles for years after 2017, growth ratios developed using AAA data by the four large MPOs for the SCS2 (see Table 1 and Appendix 1) were used to calculate future year gasoline and diesel vehicle non-fuel operating costs. The growth ratios were multiplied by the 2005 gasoline and diesel non-fuel costs. For non-fuel costs of electric and hydrogen vehicles after

[66] VMT data by fuel type used for weighting is from: California Air Resources Board. SCS Evaluation Resources, Draft Auto Operating Cost Calculator. Accessed 4/13/2020: https://ww2.arb.ca.gov/resources/documents/scs-evaluation-resources
[67] US Energy Information Administration. Annual Energy Outlook 2018, Petroleum and Other Liquids Prices. Accessed 10/21/2019: https://www.eia.gov/outlooks/aeo/data/browser/#/?id=12-AEO2018&cases=ref2018~highprice~lowprice&sourcekey=0
[68] It is assumed that the prices supplied by the CEC include other taxes applied to fuels before 2017, as indicated in the CEC Energy Demand Forecast Report: "Historical tax rates are included in historical retail prices, so only changes from past tax rates need to be added to forecast years." California Energy Commission. Revised Transportation Energy Demand Forecast, 2018-2030. Publication Number: CEC-200-2018-003. February 2018. Available at: https://efiling.energy.ca.gov/getdocument.aspx?tn=223241
[69] California Department of Tax and Fee Administration. Sales Tax Rates for Fuels. Accessed 4/10/2020: https://www.cdtfa.ca.gov/taxes-and-fees/sales-tax-rates-for-fuels.htm
[70] American Automobile Association. Your Driving Cost: How much are you really paying to drive? 2017 Edition. Available at: https://exchange.aaa.com/automotive/driving-costs/#.XpZ3bchKiCg

2017, values were drawn from the CARB AOC Calculator. An overall average non-fuel cost was calculated, weighted by fuel type VMT, for each modeling year.

Table 5: *Forecast Year Non-Fuel Cost Ratios*[71]

Year	Ratio to 2005
2005	1.00
2020	1.38
2035	1.75
2050	2.12

Fuel Efficiency Assumptions

Fuel efficiency estimates for each fuel type vehicle and for all years were drawn from the CARB AOC Calculator. CARB used VMT and fuel usage data from EMFAC2017 and Vision 2.1 Scenario Modeling System to calculate fuel efficiency (in miles per gasoline gallon equivalents) for each fuel type for each year. For each modeling year, MTC calculated an overall average fuel efficiency weighted by fuel type VMT.

Calculated Auto Operating Costs

Using the AOC formula described earlier and the average fuel costs, non-fuel costs, and fuel efficiencies documented above, the AOC was calculated for each modeling year.

Table 6: Auto Operating Costs (2017$)

Year	Average Fuel Cost ($/gal)	Average Non-Fuel Cost ($/mile)	Fuel Efficiency (mi/gal)	AOC ($/mile)	SCS2 AOC ($/mile)
2005	3.11	0.0762	20.67	0.2268	0.2306
2020	3.67	0.1044	27.14	0.2397	0.2798
2035	4.57	0.1294	40.67	0.2417	0.2540
2050	4.91	0.1551	44.23	0.2661	N/A

[71] From MTC, SCAG, SACOG, and SANDAG Memorandum dated October 13, 2014, Re: Automobile Operating Cost for the Second Round of Sustainable Communities Strategies, Table 5: Forecast Year Non-Fuel-Related Operating Costs Ratios

Memorandum

To: Ken Kirkey, MTC; Huasha Liu, SCAG; Gordan Garry, SACOG; Muggs Stoll, SANDAG

From: David Ory, MTC; Guoxiong Huang, SCAG; Bruce Griesenbeck, SACOG; Clint Daniels, SANDAG

Re: Automobile Operating Cost for the Second Round of Sustainable Communities Strategies

Date: October 13, 2014

This memorandum summarizes our collective thinking regarding fuel price assumptions for the second round of sustainable communities strategies (SCSs)[1].

Background

The Regional Targets Advisory Committee (or RTAC) formed by the California Air Resources Board (ARB) recommended that MPOs use "consistent long-range planning assumptions statewide, to the degree practicable, including … existing and forecasted fuel prices and automobile operating costs."[2] For the first round of sustainable communities strategies, we agreed to use the following sets of assumptions:

- Base Year Fuel Price: Region-specific, set during model calibration
- Year 2020 Fuel Price: $4.74 (Year 2009 dollars, $2009);
- Year 2035 Fuel Price: $5.24 ($2009);
- Effective Fleet-wide Fuel Efficiency: Region-specific, derived from ARB's Emission Factor (EMFAC) software;
- Year 2020 Non-fuel-related Operating Cost (if included in region-specific automobile operating cost calculations): $0.09 ($2009);
- Year 2035 Non-fuel-related Operating Cost (if included in region-specific automobile operating cost calculation): $0.11 ($2009).

This set of assumptions were used to compute the assumed perceived automobile operating cost for each MPO. The resulting values are shown in Table 1.

[1] The first round beginning with SANDAG's 2011 RTP/SCS; the second round beginning with SANDAG's 2015 RTP/SCS.

[2] See page 10 of *Recommendations of the Regional Targets Advisory Committee Pursuant to Senate Bill 375: A Report to the California Air Resources Board*.

Table 1: Assumed Perceived Automobile Operating Costs ($2009) for First Round of SCSs

MPO	Base Year Cost (year)	Year 2020 Cost	Year 2035 Cost	Avg Annual Growth (Base to 2035)
SCAG	$0.23 (2005)	$0.32	$0.32	1.1%
MTC	$0.18 (2010)	$0.28	$0.28	1.8%
SACOG	$0.21 (2008)	$0.27	$0.29	1.2%
SANDAG	$0.19 (2008)	$0.22	$0.21	0.4%

Using the above assumptions, we achieved consistency in forecast year fuel price as well as the approach to computing perceived automobile operating cost. Unfortunately, we were not able to achieve consistency in base year assumptions. Achieving consistency across MPOs for base year input is more difficult than achieving consistency across forecast year input because base year input is part of the expensive and time consuming model development process.

The result of using consistent forecast year assumptions and inconsistent base year assumptions were uneven changes in the assumed increase in perceived automobile operating cost across MPOs. For example, between 2010 and 2035, MTC assumes a 1.8 percent average annual increase in perceived automobile operating cost; between 2008 and 2035, SANDAG assumes a 0.4 percent average annual increase. It is worth noting that the base year differences may reflect actual base year differences (i.e., fuel prices changing from 2005 to 2010) and do reflect regional differences in the assumed average fleet-wide fuel efficiency. In any case, the differences in growth rates make it difficult to claim that the perceived automobile operating costs were handled in a consistent manner.

Proposed Approach

Our proposed remedy for the above-described problem is *not* to try and achieve consistent base year assumptions. The model calibration process is difficult enough without adding the constraint of a single perceived automobile operating cost introduced at an unknown time in the model development cycle. Rather, we propose using a consistent growth in fuel price between the SB 375 base year of 2005 and the forecast years used in the SCS, specifically the target years 2020, and 2035. In addition, we propose using a consistent non-fuel-related operating cost as well as consistent data sources for effective fleet-wide fuel efficiency and base year gas price.

The following subsections outline the approach. Note that the below assumptions do not account for potential increases in fuel costs from California's Cap-and-Trade program.

Fuel Price Assumptions

The Department of Energy issues an annual forecast of motor vehicle gasoline prices. The 2013 forecast[3] is paired with historical information from 2005 to compute a consistent fuel price ratio that will be used by each MPO. The target value for the calculation is not the midpoint between the low and high forecast,

[3] The data can be found here: http://www.eia.gov/forecasts/archive/aeo13/source_oil.cfm.

but rather three-quarters of the way between the low and high forecasts, plus 32 cents ($2010) – the 32 cents accounts for gasoline generally being more expensive in California than the rest of the nation. These calculations are shown in Table 2.

Table 2: Department of Energy Forecasts and Resulting Growth Ratio (Prices in Year 2010 Dollars)

Year	Low	High	Low plus 75% Diff + 32 cents	Ratio to 2005
2005	---	---	$2.82*	---
2015	$2.70	$3.77	$3.82	1.35
2020	$2.54	$4.17	$4.08	1.45
2025	$2.53	$4.39	$4.25	1.51
2030	$2.52	$4.77	$4.53	1.61
2035	$2.53	$5.18	$4.84	1.72
2040	$2.57	$5.70	$5.24	1.86

* – Historical price taken from http://www.eia.gov/dnav/pet/pet_pri_gnd_a_epm0_pte_dpgal_a.htm, and converted to year 2010 dollars.

To compute an MPO-specific forecast year fuel price, the growth ratios in Table 2 are paired with base year prices. We propose using base year prices from a consistent source, specifically the retail gasoline price data from the Oil Price Information Service (OPIS); these prices will be introduced during our next round of model development activities. The assumed base year prices are shown in Table 3 for each of the MPO areas for years 2005 through 2012. These prices will be used in subsequent model development activities[4].

Table 3: Historical Gas Prices per OPIS (All prices in Year 2010 dollars)

Year*	MTC	SCAG	SACOG	SANDAG
2005	$2.83	$2.85	$2.74	$2.84
2008	$3.68	$3.53	$3.53	$3.35
2010	$3.17	n/a	$3.09	$2.92
2012	$3.87	$3.90	$3.85	$3.64

* - The base year prices are only shown (and, in some cases, only purchased) for 2005 and potential model calibration years. For example, SCAG intends to use a 2012 calibration year, and, as such, did not purchase the year 2010 prices from OPIS.

[4] Some MPOs will be recalibrating their models and generating a "new" "forecasts" (or "backcasts") of year 2005. Others will not. Those generating new forecasts will use the fuel prices listed in Table 3; those not generating new forecasts will leave their prices as they were set in their model development processes.

Non-Fuel-Related Operating Costs

As noted above, the calculation of perceived automobile operating cost is assumed to have two components: fuel costs and non-fuel-related costs. Similar to the base year fuel price, we propose using base year non-fuel-related operating costs from a consistent source, specifically the American Automobile Association (AAA). The assumed non-fuel-related base year prices are shown in Table 4; these are national estimates that we'll assume apply to each of the MPO areas. These prices will be used in subsequent model development activities.

Table 4: Non-Fuel-Related Operating Costs (Prices in Year 2010 dollars per mile)

Year	Maintenance	Tires	Maint. + Tires
2005	$0.0437	$0.0062	$0.05
2006	$0.0453	$0.0065	$0.05
2007	$0.0437	$0.0069	$0.05
2008	$0.0452	$0.0076	$0.05
2009	$0.0447	$0.0082	$0.05
2010	$0.0444	$0.0096	$0.05
2011	$0.0461	$0.0103	$0.06
2012	$0.0524	$0.0105	$0.06

The above data can be used to estimate forecast-year non-fuel-related costs. Using a simple linear regression and extrapolation, the forecast year values shown in Table 5 can be computed. Similar to the gasoline price, the MPOs will use the computed ratio to calculate the forecast year values from whatever values were or are assumed for year 2005.

Table 5: Forecast Year Non-Fuel-Related Operating Costs Ratios (Prices in Year 2010 dollars)

Year	Estimate	Ratio to 2005
2005	$0.050	---
2012	$0.063	1.26
2015	$0.062	1.25
2020	$0.069	1.38
2025	$0.075	1.50
2030	$0.081	1.62

2035	$0.087	1.75
2040	$0.093	1.87

Effective Fleet-wide Fuel Efficiency

The computation of perceived automobile operating cost requires an assumption be made about the effective passenger-vehicle[5] fuel efficiency. ARB's EMFAC software provides two estimates of carbon dioxide (CO_2) emissions. The first estimate is for a hypothetical future in which fuel and vehicle regulations are not enacted; this hypothetical future is used only for computing emissions for SB 375 purposes (method A). The second estimate is for the expected future in which fuel and vehicle regulations are enacted (method B). This future is assumed for all non-SB 375 purposes, including federally-mandated conformity analyses. Unfortunately, the EMFAC software only provides a fuel consumption result for the first set (method A) of CO_2 emissions. The effective fleet-wide fuel efficiency needs to be calculated from the second estimate. Each MPO will use the following equation to compute the effective fleet-wide fuel efficiency:

$$FE = \frac{VMT}{\frac{(CO_2)_B \cdot FLCFS}{(CO_2)_A} \cdot FC_A}$$

where VMT is passenger-vehicle miles traveled, $(CO_2)_A$ is the passenger-vehicle CO_2 estimate from method A, $(CO_2)_B$ is the passenger-vehicle CO_2 estimate from method B, and FC_A is the passenger-vehicle fuel consumption from method A. FLCFS is an adjustment factor to account for Low Carbon Fuel Standards (LCFS) CO_2 reduction factors assumed in EMFAC 2011. LCFS is a fuel standard that requires a reduction of at least 10 percent in the carbon intensity of California's transportation fuels by 2020 (see Table 5-2, http://www.arb.ca.gov/msei/emfac2011-technical-documentation-final-updated-0712-v03.pdf). FLCFS is set at 1.11 to offset this reduction factor in the fuel efficiency calculations as the reduction from LCFS is related to carbon content rather than fuel consumption. The calculation assumes a linear relationship between CO_2 emissions and fuel consumption.

Using the effective fuel efficiency derived from EMFAC presents a "chicken or egg" problem, as one cannot generate the fuel-efficiency estimate unless an input assumption about operating cost is made, but the operating cost assumption requires a fuel-efficiency estimate. In practice, each MPO will select a representative fuel efficiency estimate during the SCS development process that will be carried through SCS adoption.

Region-Specific Calculations

Detailed calculations are provided below for each of the MPO regions. The regions differ as to whether they will update the year 2005 simulation results using the prices presented in Table 3 and Table 4; either way, consistent ratios for fuel prices (presented in Table 2) and non-fuel-related prices (Table 5) are applied to either the updated or non-updated 2005 assumptions.

[5] Defined as EMFAC vehicle types LDA, LDT1, LDT2, and MDV.

MTC: Assuming updated Year 2005 Simulation Results

Using the above information, MTC will compute the year 2005, 2020, and 2035 perceived automobile operating cost estimates using the approach detailed in Table 6.

Table 6: MTC Region Example Calculations Assuming Updated 2005 Results (Prices in Year 2010 dollars)

Year	Quantity	Value
2005	Region-specific fuel price (Table 3, dollars per mile)	$2.83
	Non-fuel-related price (Table 4, dollars per mile)	$0.05
	Effective passenger vehicle fuel efficiency (EMFAC, miles per gallon)	20.09
	Perceived automobile operating cost (cents per mile)	19.1¢
2020	Consistent fuel price ratio (Table 2)	1.45
	Region-specific fuel price (Ratio x 2005 price)	$4.09
	Consistent non-fuel-related price ratio (Table 5)	1.38
	Region-specific non-fuel-related price	$0.07
	Effective passenger vehicle fuel efficiency (EMFAC, miles per gallon)	25.15[†]
	Perceived automobile operating cost (cents per mile)	23.1¢
2035	Consistent fuel price ratio (Table 2)	1.72
	Region-specific fuel price (Ratio x 2005 price)	$4.85
	Consistent non-fuel-related price ratio (Table 5)	1.75
	Region-specific non-fuel-related price	$0.09
	Effective passenger vehicle fuel efficiency (EMFAC, miles per gallon)	28.85[†]
	Perceived automobile operating cost (cents per mile)	25.6¢

[†] - Value may change during the planning process.

SCAG: Assuming Updated Year 2005 Simulation Results

Using the information contained in this memorandum, SCAG will compute the year 2020 and 2035 perceived automobile operating cost estimates using the approach detailed in Table 8.

Table 7: SCAG Region Example Calculations (Prices in Year 2010 dollars)

Year	Quantity	Value
2005	Region-specific fuel price (Table 3, dollars per gallon)	$2.85
	Non-fuel-related price (Table 4, dollars per mile)	$0.05
	Effective passenger vehicle fuel efficiency (EMFAC, miles per gallon)	18.63
	Perceived automobile operating cost (cents per mile)	20.3¢
2020	Consistent fuel price ratio (Table 2)	1.45
	Region-specific fuel price (Ratio x 2005 price)	$4.12
	Consistent non-fuel-related price ratio (Table 5)	1.38
	Region-specific non-fuel-related price	$0.07
	Effective passenger vehicle fuel efficiency (EMFAC, miles per gallon)	23.63†
	Perceived automobile operating cost (cents per mile)	24.3¢
2035	Consistent fuel price ratio (Table 2)	1.72
	Region-specific fuel price (Ratio x 2005 price)	$4.89
	Consistent non-fuel-related price ratio (Table 5)	1.75
	Region-specific non-fuel-related price	$0.09
	Effective passenger vehicle fuel efficiency (EMFAC, miles per gallon)	26.40†
	Perceived automobile operating cost (cents per mile)	27.3¢

† - Value may change during the planning process.

SACOG: Assuming Static Year 2005 Simulation Results

Using the information contained in this memorandum, SACOG will compute the year 2020 and 2035 perceived automobile operating cost estimates using the approach detailed in Table 8.

Table 8: SACOG Region Example Calculations (Prices in Year 2010 dollars)

Year	Quantity	Value
2005	Region-specific fuel price (Table 3, dollars per gallon)	$2.74
	Non-fuel-related price (Table 4, dollars per mile)	$0.05
	Effective passenger vehicle fuel efficiency (EMFAC, miles per gallon)	19.50
	Perceived automobile operating cost (cents per mile)	19.1¢
2020	Consistent fuel price ratio (Table 2)	1.45
	Region-specific fuel price (Ratio x 2005 price)	$3.96
	Consistent non-fuel-related price ratio (Table 5)	1.38
	Region-specific non-fuel-related price	$0.07
	Effective passenger vehicle fuel efficiency (EMFAC, miles per gallon)	24.92†
	Perceived automobile operating cost (cents per mile)	22.8¢
2035	Consistent fuel price ratio (Table 2)	1.72
	Region-specific fuel price (Ratio x 2005 price)	$4.70
	Consistent non-fuel-related price ratio (Table 5)	1.75
	Region-specific non-fuel-related price	$0.09
	Effective passenger vehicle fuel efficiency (EMFAC, miles per gallon)	28.30†
	Perceived automobile operating cost (cents per mile)	25.4¢

† - Value may change during the planning process.

SANDAG: Assuming Static Year 2005 Simulation Results

Using the information contained in this memorandum, SANDAG will compute the year 2020 and 2035 perceived automobile operating cost estimates using the approach detailed in Table 9.

Table 9: SANDAG Region Example Calculations (Prices in Year 2010 dollars)

Year	Quantity	Value
2005	Region-specific fuel price (Table 3, dollars per gallon)	$2.84
	Non-fuel-related price (Table 4, dollars per mile)	$0.05
	Effective passenger vehicle fuel efficiency (EMFAC, miles per gallon)	18.89
	Perceived automobile operating cost (cents per mile)	20.0¢
2020	Consistent fuel price ratio (Table 2)	1.45
	Region-specific fuel price (Ratio x 2005 price)	$4.11
	Consistent non-fuel-related price ratio (Table 5)	1.38
	Region-specific non-fuel-related price	$0.07
	Effective passenger vehicle fuel efficiency (EMFAC, miles per gallon)	23.98†
	Perceived automobile operating cost (cents per mile)	24.0¢
2035	Consistent fuel price ratio (Table 2)	1.72
	Region-specific fuel price (Ratio x 2005 price)	$4.87
	Consistent non-fuel-related price ratio (Table 5)	1.75
	Region-specific non-fuel-related price	$0.09
	Effective passenger vehicle fuel efficiency (EMFAC, miles per gallon)	27.20†
	Perceived automobile operating cost (cents per mile)	26.7¢

† - Value may change during the planning process.

Comparisons across SCS Rounds

Table 10 compares the fuel price and resulting automobile operating cost results across SCS rounds for each MPO *assuming* the effective fleet-wide fuel efficiency number remains unchanged from the first to second round – this number will change during the planning process.

Table 10: Fuel Price and Automobile Operating Cost Comparison across SCS Rounds (Prices in Year 2010 Dollars)

Year	Quantity	MTC		SCAG		SANDAG		SACOG	
		Rnd 1	Rnd 2	Rnd 1	Rnd 2	Rnd 1	Rnd 2	Rnd 1	Rnd 2
2005	Fuel price	$2.79	$2.83	$2.83	$2.85	$2.68	$2.84	$2.70	$2.74
	Auto. Oper. Cost	21.2¢	19.1¢	23.8¢	20.3¢	19.2¢	18.9¢	19.7¢	19.1¢
2020	Fuel price	$4.74	$4.09	$4.74	$4.12	$4.74	$4.11	$4.74	$3.96
	Auto. Oper. cost	28.7¢	23.1¢	31.9¢	24.3¢	22.6¢	24.0¢	27.0¢	22.8¢
2035	Fuel price	$5.24	$4.85	$5.24	$4.89	$5.24	$4.87	$5.24	$4.70
	Auto. Oper. cost	28.6¢	25.6¢	32.3¢	27.3¢	21.7¢	26.7¢	28.9¢	25.4¢
Ratios	2020 to 2005	1.34	1.21	1.34	1.20	1.18	1.20	1.37	1.20
	2035 to 2005	1.33	1.34	1.36	1.34	1.13	1.33	1.47	1.33

Next Steps

This memorandum proposes a consistent approach for computing fuel price for each of our MPOs for the second round of sustainable community strategies. After collecting your feedback and modifying our approach accordingly, we will share this approach with ARB and the other MPOs across the state.

m:\application\regionalcooperation\automobileoperatingcost_working\2014 08 27 draft second round scs automobile operating cost.docx