TECHNICAL EVALUATION OF THE GREENHOUSE GAS EMISSION REDUCTION QUANTIFICATION FOR THE SOUTHERN CALIFORNIA ASSOCIATION OF GOVERNMENTS' SB 375 SUSTAINABLE COMMUNITIES STRATEGY

May 2012

California Environmental Protection Agency
Air Resources Board

Electronic copies of this document can be found on ARB's website at
http://www.arb.ca.gov/cc/sb375/sb375.htm.

Table of Contents

EXECUTIVE SUMMARY

The Sustainable Communities and Climate Protection Act of 2008 (SB 375) calls for the California Air Resources Board (ARB or Board) to accept or reject the determination of each metropolitan planning organization (MPO) in the State that its Sustainable Communities Strategy (SCS) would, if implemented, achieve the greenhouse gas emission reduction targets set by the Board for 2020 and 2035.

On April 4, 2012, the Regional Council of the Southern California Association of Governments or (SCAG) adopted its 2012-2035 Regional Transportation Plan (RTP) which contains the region's first SCS.

ARB staff has prepared this technical report to support the ARB's action on the SCS quantification determination for the Southern California region. The report describes the method ARB staff used to review SCAG's determination that its SCS would meet the targets established by the Board in 2010. This technical report also describes the results of ARB staff's technical evaluation of SCAG's quantification of passenger vehicle greenhouse gas emissions reductions.

ARB reviewed the draft SCS published by SCAG on December 20, 2011. Since then, the SCAG Regional Council adopted the RTP/SCS and accepted minor modifications to the plan which strengthen the ability of the SCS to exceed the 2020 target. The results of ARB staff's technical review were presented to the Board at a public meeting on March 22, 2012, and together with its review of the adopted RTP/SCS, as modified, are documented in this technical report. As this review affirms, the adopted SCS has demonstrated that, if implemented, the region will achieve a 9 percent per capita greenhouse gas reduction in 2020, and a 16 percent reduction in 2035. These reductions exceed the 2020 target of 8 percent per capita reduction and the 2035 target of 13 percent per capita reduction that the Board established.

I. LAND USE AND TRANSPORTATION PLANNING IN THE SOUTHERN CALIFORNIA REGION

The SCAG region is the most populated planning region in California and is the second most populated metropolitan area in the nation. Currently, over 18 million people, or nearly one-half of all Californians live in the region. In addition, the region is home to the seventeenth most productive economy in the world (2009 data) and represents one of the largest concentrations of business, industry, and finance in the US.

A. Southern California Association of Governments

SCAG was formed in 1965 by city and county elected officials in the region. SCAG helps fulfill responsibilities mandated by federal and State law to develop a regional approach to planning for Southern California's future. Since its inception, SCAG has become the nation's largest council of governments, functioning as the metropolitan planning organization (MPO) for the region pictured in Figure 1, which includes six counties (Imperial, Los Angeles, Orange, Riverside, San Bernardino, and Ventura), and 191 cities.

SCAG is mandated by federal and State law to develop regional plans for transportation, growth management, housing development, air quality, and other issues of regional significance. In developing the long-range regional transportation plan (RTP), SCAG operates as an umbrella planning agency for the region. As such, the RTP must consider the roles and authorities of hundreds of autonomous public agencies and jurisdictions that build and operate transportation systems and control local land use decisions within the region.

To ensure that the RTP is consistent with State and federal air quality plans, SCAG also closely coordinates with the five local air districts in the region: South Coast, Mohave Desert, Antelope Valley, Ventura County, and Imperial County. At a sub-regional level, SCAG coordinates its work with the six independent County Transportation Commissions[1] that have the primary responsibility for programming and administering transportation projects and services in their respective jurisdictions. SCAG also relies on input from its six counties and 191 city governments for projecting the level of growth and development that needs to be supported by the RTP. In addition, SCAG seeks input from 15 sub-regional associations[2] and numerous policy committees as part of its planning and policy development work.

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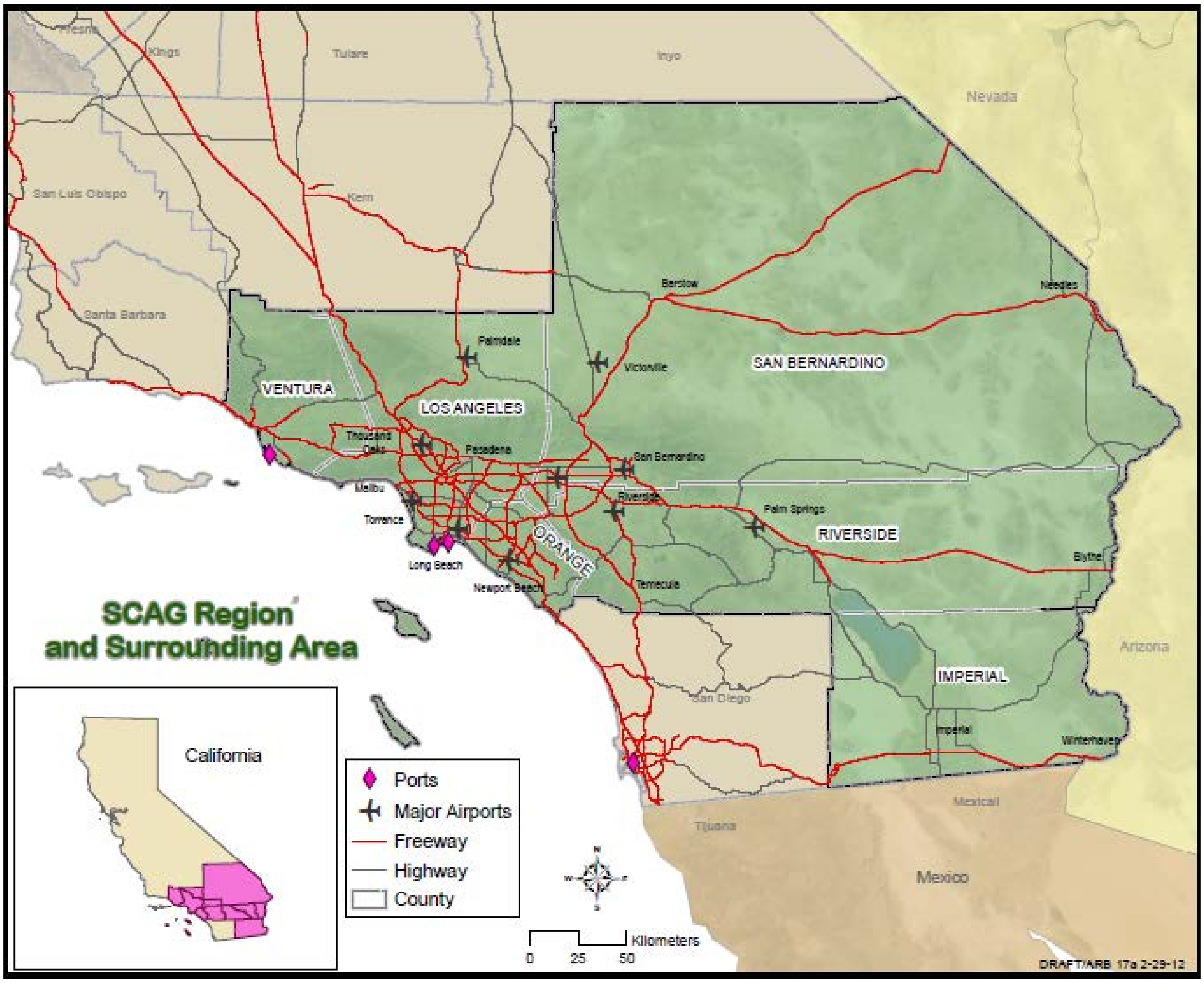
[1] Imperial Valley Association of Governments, Los Angeles Metropolitan Transportation Authority, Orange County Transportation Authority, Riverside County Transportation Commission, San Bernardino Associated Governments, and the Ventura County Transportation Commission.

[2] The sub-regions of SCAG are associations of cities and counties, created with the goal of equal service and representation for all communities in this diverse region. The sub-regions are represented on SCAG's Executive/Administration Committee and key policy committees which make decisions on transportation, economic, energy, and environmental issues.

Ultimately, it is SCAG's Regional Council, made up of 84 representatives of counties, cities, local transportation planning agencies, and tribal governments, that is responsible for overseeing the planning work of the organization and adopting a long-range RTP every four years.

Figure 1. SCAG Region



B. Meeting Regional Planning Challenges Through Collaboration

Looking ahead over the next 23 years of the planning period, SCAG has identified a number of planning goals for the region. Primary among these are ensuring the region's long-term economic competitiveness and improving quality of life for current and future generations. The changing landscape of the SCAG region's demographic profile and economy over the coming decades pose important considerations in planning towards these goals.

Although the latest 2010 U.S. Census data indicates slower regional growth in population, households, and employment than forecasted in SCAG's 2008 RTP, the region is still expected to grow by over four million new residents by 2035. The nature of this growth is expected to be quite different from today due to changing demographics, with an increasing share of the population 65 years and older, and a declining share in the working-age population (ages 16 to 64 years).

> The 2012 RTP/SCS accommodates 4 million more people as it responds to demographic shifts and addresses economic challenges.

Demographic research indicates that as baby boomers retire, the labor force will largely be replaced by immigrants and their children. The aging of the population together with an increasing number of households without children will create demand for different housing types. Decisions and preferences related to travel, housing, shopping, and other lifestyle choices by these population groups are expected to have a significant influence on for the travel characteristics of the region.

The SCAG region has consistently experienced high levels of traffic congestion. Contributing factors to the high percentage of single occupancy vehicle usage include the region's large population and geographic expanse, large and diffuse workforce, high automobile dependence, low levels of transit usage, and a maturing regional highway system with limited options for expansion. However, beginning in 2005, the region experienced a decrease in the share of travel by the drive-alone mode and an increase in alternative modes of commuting. In 2005, the region also achieved the highest transit boarding since 2000.

Recognizing the challenges ahead related to the region's economic sustainability, SCAG and its member jurisdictions and agencies are focusing efforts on making the region a more competitive and attractive place to live, work, and play. In doing so, air quality health goals, affordable housing issues, as well as inter-regional travel times and congestion are being addressed through coordinated and collaborative approaches.

Over the past decade, SCAG worked with its regional partners to develop, integrate, and implement several comprehensive plans and initiatives. These regional efforts include, among others, regular enhancements to clean air plans, a growth vision (Compass Blueprint), a Regional Comprehensive Plan, a regional economic development strategy, and now a Sustainable Communities Strategy (SCS).

As described in the examples below, SCAG has provided leadership through closer coordination and collaboration with local and regional agencies. In partnership with local jurisdictions and air quality and transportation planning agencies, the region is working to reverse air pollution trends, increase investments in alternatives to single occupancy auto use, create greater opportunities for housing, and strengthen the economy. These and other initiatives provide the backdrop to development of the region's first SCS, whose goal is to address environmental and socioeconomic challenges associated with growth through the implementation of plans, policies, and programs that substantially improve the region's livability, mobility, competitiveness, and sustainability.

Despite the significant improvements during the past two decades, the region still has some of the worst air quality in the nation. Specifically, the South Coast Air Basin has the highest concentration of ozone and particulate matter (PM 2.5) in the nation. Future air quality plans are expected to take advantage of SCAG's focus on strategies to reduce vehicle miles traveled (VMT) and number of trips, and increase non-motorized accessibility to homes, jobs, and attractions.

Since 1984, California's homeownership has averaged about 15 percent lower than that of the nation as a whole. A chief reason is the high cost of housing in California, relative to the rest of the nation. Of the four largest metropolitan planning regions in the state,[3] the SCAG region has the second lowest homeownership rate (55.2 percent), just above the San Diego region. Recent analysis done for the Urban Land Institute (2011), a research and education organization for land use and real estate development, indicates that homeownership rates are expected to continue to fall in California, and by extension, in the SCAG region. This is expected to result in increased demand for affordable rental and multi-family housing in the region.

> The four guiding principles for the SCAG region are mobility, livability, prosperity, and sustainability.

Through the Regional Housing Needs Assessment (RHNA) process, SCAG has worked with the State Department of Housing and Community Development and the local governments in the region to develop a plan for accommodating the region's housing needs. The 2012 RHNA process resulted in an allocation of affordable housing units to the region and to individual local governments, consistent with the State's determination of affordable housing need. The 2012 RTP/SCS accommodates the region's 8-year housing supply, as required by SB 375.

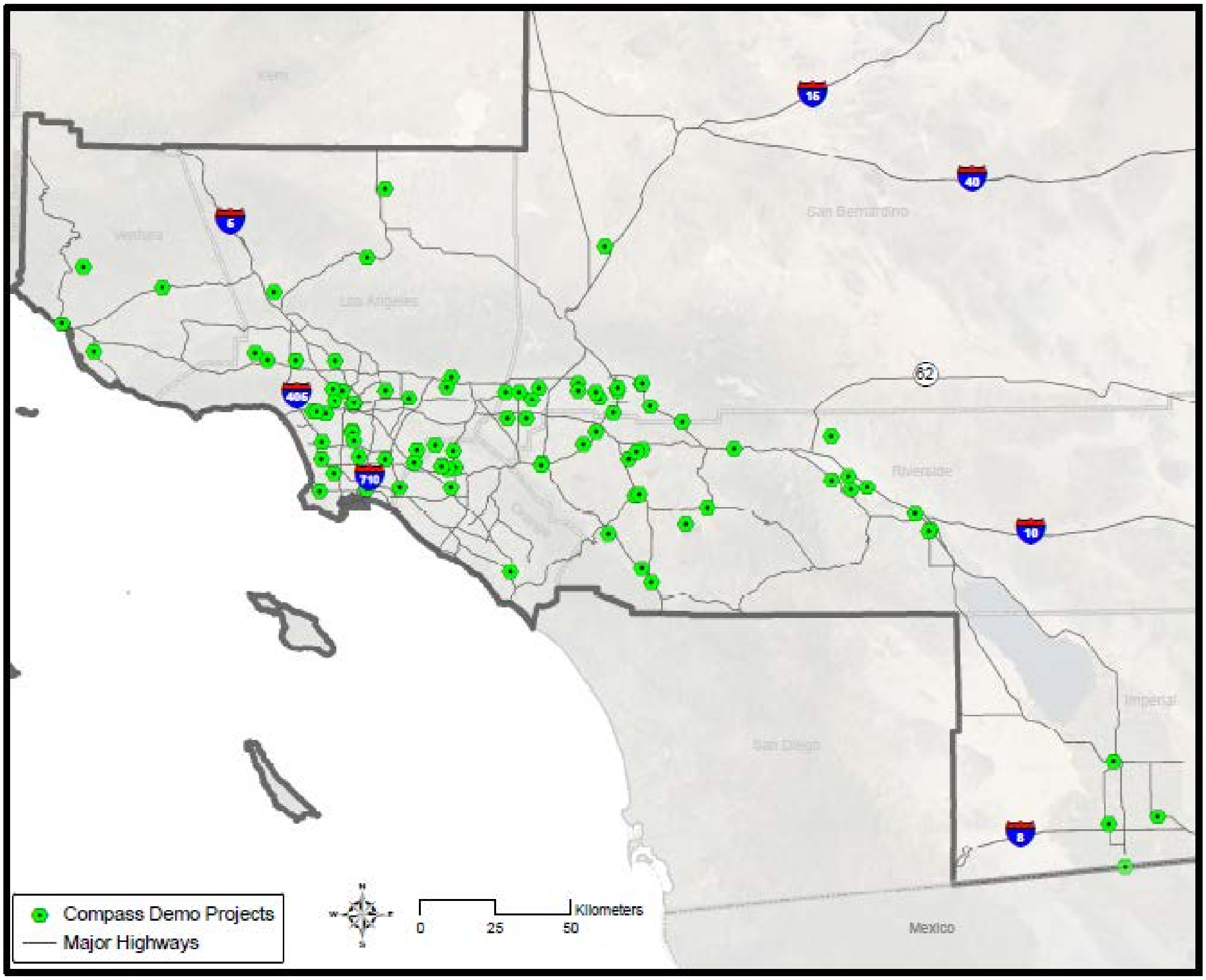
Published in 2004, SCAG's *Compass Growth Vision Report,* is driven by the principles of mobility, livability, prosperity, and sustainability. The *Compass Growth Vision Report* encourages future development and redevelopment in strategic transit corridors and urban centers to reduce congestion, produce more affordable housing, decrease the region's dependence on automobile travel and associated fossil fuels, and preserve open space.

In 2005, SCAG began offering incentive grants to local governments for sustainable planning and development projects. The demand for funding through the Compass Blueprint Demonstration Project program consistently exceeds available funds. For example, in 2010, SCAG received 60 applications totaling $9.5 million but only $2 million was available. Over the past seven years, SCAG has allocated over $10.5

[3] The four largest MPOs, by population, are SCAG, the San Diego Association of Governments, the Metropolitan Transportation Commission, and the Sacramento Area Council of Governments.

million in local incentive funds through this program to encourage sustainable development projects in accordance with the regional growth vision. An additional $3.5 million has been committed for future demonstration projects. Figure 2 shows the distribution of these projects across the six-county region, with participation in the program by urban, suburban, and rural communities.

Figure 2. Compass Blueprint Projects



SCAG's "Final 2008 Regional Comprehensive Plan (RCP)" is aimed at fostering a region that addresses future needs while recognizing the interrelationship between economic prosperity, natural resources sustainability, and quality of life. Through measured performance and tangible outcomes, the RCP serves as both an action plan for implementation of short-term strategies, and a call to action for strategic, long-term initiatives for sustaining a livable region. In short, the RCP is an integrated system-wide planning strategy to substantially improve the region's livability, mobility, competitiveness, and sustainability.

In 2010, SCAG initiated the Climate and Economic Development Project, or CEDP, bringing together a wide spectrum of stakeholders to develop a comprehensive set of policy options to meet the State's and region's climate goals. This effort, still underway, seeks to develop an inventory of the region's greenhouse gas (GHG) emissions, and to investigate effective and feasible GHG emissions reduction strategies for all sectors of the economy.

C. SCAG's Sustainable Communities Strategy

Development of a regional vision for sustainable planning and implementation was already underway in the SCAG region when California enacted the Sustainable Communities and Climate Protection Act of 2008 (SB 375). SB 375 requires RTPs in the state's metropolitan planning organizations (MPO) to consider how to reduce GHG emissions from vehicle travel that contribute to climate change. The law is significant in its aim to address VMT growth across the state, and requires each MPO to now include a SCS in its RTP. The SCS must show how land use patterns are integrated with transportation investments and Regional Housing Needs Allocations in a way that helps reduce GHG emissions from regional travel.

Consistent with the requirements of SB 375, SCAG has prepared its first SCS as part of its 2012-2035 RTP. The SCS is intended to provide a comprehensive roadmap for the SCAG region on the integration of land use development with transportation system planning. The SCS is responsive to the changing demographic and economic growth expectations for the region, achieves the region's GHG emission reduction goals, and helps to address a number of the region's other sustainability goals for economic competitiveness, livability, and social equity. The SCS is the first step in a recurring four-year planning process of moving the region towards more integrated sustainable community planning.

SCAG's SCS relies on the following key policies and strategies to achieve these multiple goals:

- Focusing new growth in existing and emerging population centers and along major transportation corridors;
- Creating significant areas of mixed use development and walkable communities;
- Targeting growth around existing and planned transit stations; and,
- Preserving existing open space and protecting established residential areas.

The following sections describe the land use and transportation assumptions that underlie SCAG's 2012-2035 RTP/SCS.

1. Land Use

Development of the land use strategy in the 2012-2035 RTP/SCS began by taking stock of existing land uses across the region, and of assumptions about future land uses reflected in adopted local general plans. To gather this information, SCAG staff initiated a consultation process with the cities and counties two years prior to developing the SCS. SCAG staff conducted workshops in every county, and met with staffs of 175 out of 191 cities and every county in the region to identify existing development policies and discuss local growth projections. A second round of workshops with local governments helped to confirm and verify the data that SCAG collected. Through this process, SCAG was able to develop a regional growth forecast that is consistent with the local government input and future commitments. The SCS reflects the ongoing efforts of local governments to revise and update their local general plans and specific plans. Of the 197 local jurisdictions in the region, 64 have updated 3 or more elements of their general plans since 2006, or are currently in the process of updating them. Eighteen local jurisdictions in the region have adopted, or plan to adopt, a climate action plan.

> Following demographic trends, by 2035, most new residences will be townhomes, condominiums, or apartments.

In addition to reflecting land use assumptions in adopted local land use plans, SCAG gathered information about ongoing local efforts to move towards more sustainable development during and beyond the local planning horizon. SCAG worked with local governments to develop an SCS land use scenario that reflects the potential for implementing smart growth through 2035. Table 1 identifies 495 locally initiated projects in the SCAG region that demonstrate local commitment to planning and development activities that are consistent with the land use strategies of the SCS. These projects are identified by county, and categorized as transportation projects, land use projects, or policy development activities. Transportation projects include transit, roadway, and sidewalk improvement projects. Land use projects include affordable housing, mixed use development, and transit oriented development. Plan and policy projects cover general plan amendments and similar actions that are not site-specific. While the majority of the projects are in Los Angeles County, every county in the region has participated in each type of project or planning activity. Riverside, Orange, and San Bernardino Counties each have dozens of projects. Imperial County, though its population and rate of growth may be relatively small, has 11 sustainable development projects.

Table 1. Local Sustainable Development Projects by County and Type

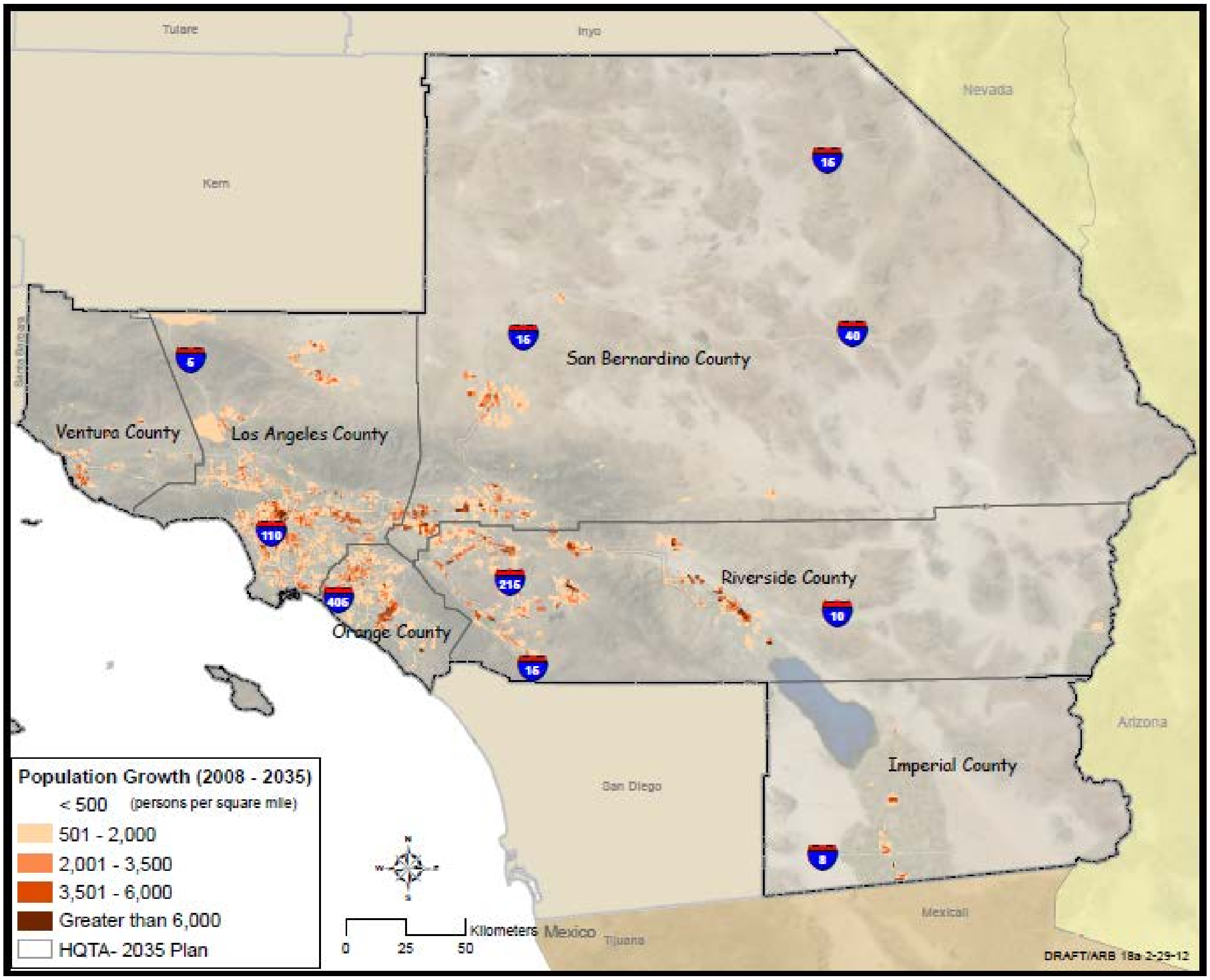
County	Transportation		Land-Use Project		Plan/Policy		Total	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Los Angeles	240	86	59	46	49	55	348	70
Riverside	12	4	22	17	13	15	47	10
Orange	9	3	22	17	12	13	43	9
San Bernardino	14	5	16	13	7	8	37	7
Imperial	2	<1	4	3	5	6	11	2
Ventura	1	<1	5	4	3	3	9	2
SCAG Region	278	56	128	26	89	18	495	100

SCAG staff worked with local governments to develop assumptions about how growth would likely occur over the planning period of the RTP/SCS. In developing the land use assumptions for the period between 2020 and 2035, SCAG staff considered a number of factors, including emerging demographic and economic trends and recent trends towards more sustainable development within city and county boundaries.

As a result of these considerations, including the assumption that the region's future housing market will need to provide for a higher proportion of multi-family housing units, SCAG's SCS takes advantage of infill and mixed use opportunities to accommodate future growth through a more compact land use pattern. In terms of land use in the region, this translates into accommodating half the region's population growth by 2035 (about two million people) on just three percent of the region's total land area (along transit corridors).

SCAG's SCS assumes a significant proportion of future growth in the region will be located in existing urban centers that have an established transit network, and where communities are planning for new compact growth. The SCS forecasts that future growth will be focused in the cities of Los Angeles, Burbank, Glendale and Pasadena (Los Angeles County), Anaheim and Irvine (Orange County), San Bernardino and Ontario (San Bernardino County), and Riverside (western Riverside County).

Figure 3. Regional Population Growth and High Quality Transit Areas



As shown in Figure 3, SCAG's SCS assumes that the majority of new housing and job growth in the region will occur in areas they have identified as High Quality Transit Areas (HQTA). An HQTA is generally defined as an area within a half mile of a transit stop with a service frequency of 15 minutes or less during peak commute hours. Focusing new growth in these areas allows the region's population to take advantage of existing and proposed transit investments, thus encouraging VMT reductions and other benefits from active transportation, more transit use, and shorter auto trips.

The SCS assumes that 51 percent of new housing and 53 percent of new employment growth between 2008 and 2035 will be within HQTAs, compared to 39 and 48 percent, respectively, in 2008. Over the plan period, the share of households within a half mile of high quality transit will more than double compared to the baseline scenario.

2. Transportation

SCAG's 2012-2035 RTP/SCS proposes to invest nearly $525 billion over the next 23 years to improve the region's multi-modal transportation system. This funding level includes approximately $305 billion from existing revenue sources, and a projected $220 billion from new revenue sources that are reasonably expected to be available over the plan period.

Table 2 breaks down the proposed transportation investments, in round numbers. About half of the total investments are for system preservation of the region's transportation network. This includes operations and maintenance for transit, highways, as well as regionally significant arterial networks. The other half of the proposed investments are split among highway toll facilities, public transit, commuter and high speed rail, active transportation such as bike and walk facilities, as well as carpooling and other transportation system management and demand management strategies. Transit investments represent about 20 percent of the total cost and about 40% of the total capital expenditures.

> Half of all new homes and jobs will be within walking distance of transit.

Table 2. 2012 RTP/SCS Transportation Investments

Component	Cost ($ Billions)	% of Total Plan Cost
Operation & Maintenance	217	41
Capital Expenditures		
Roads & Highways	86	16
Transit	107	20
Goods Movement	48	9
Active Transportation, TSM, TDM	19	4
Debt Service and Other	48	9
TOTAL	525	100

These investments are supportive of the goals of SB 375 and the region's SCS. Operations and maintenance investments help to support transit and ensure that the existing transit network continues to provide for the region's mobility needs. Proposed road and highway investments expand the region's highway toll facilities, which provide opportunities to manage growth of the region's highway system, preserve existing performance, and generate revenue that can be reinvested. The proportion of funding for transit and active transportation represent the biggest change from the previous RTP, and are intended to support the development of expanded HQTAs in the region. SCAG's SCS expands opportunities for transit oriented development by envisioning compact communities along transit corridors, with enhanced walkability and transit access to urban amenities. To bring about these changes in the urban landscape, the

SCS focuses on both expanding regional transit systems, as well as creating transit-ready development opportunities in anticipation of future transit infrastructure.

SCAG's 2012-2035 RTP/SCS also invests in expansions and extensions to the regional light rail and Metrolink/rail systems, as well as a high-speed rail connector from Palmdale to Union Station to Anaheim.

The SCS invests in construction of local street improvements that will facilitate greater transit and clean transportation readiness for the region. By removing geographic or perceived safety barriers in planned developments, and developing an extensive transportation infrastructure that can accommodate a growing zero emission motor vehicle fleet in the region, it lays the groundwork for additional high quality transit areas and clean transportation modes.

The SCS also proposes a significant increase in the amount of investment in active transportation, to create streets and neighborhoods that are safer and more attractive to biking and walking. Compared to the previous RTP, the 2012-2035 RTP/SCS dedicates more than three times the funding (or $6.7 billion) to active transportation capital investment. This investment will more than double the miles of bikeways (from 4,315 to 10,122 miles), and bring 12,000 miles of deficient sidewalks into compliance with the Americans with Disabilities Act. Additionally, the SCS proposes street safety measures to make walking and biking safer.

3. SCS Outcomes and Benefits

SCAG projects that the SCS will result in multiple benefits. Not only will the SCS support achievement of the sustainability goals of the region and the achievement of GHG emission reduction targets, it will also result in a host of significant mobility, economic, and health benefits for the region.

> The SCS will also reduce congestion, improve public health, and save open space.

With respect to the GHG emission reductions from the 2012-2035 RTP/SCS, which ARB is tasked with reviewing, the SCS demonstrated achievement of an 9 percent per capita reduction in passenger vehicle GHG emissions by 2020 and a 16 percent reduction by 2035.

In addition to helping reduce GHG emissions, SCAG's SCS highlights a number of other outcomes and benefits for the region by 2035, as summarized below:

- Savings of $5 billion in cumulative infrastructure costs to local governments
- Savings of $1.5 billion per year in health costs
- Creation of over 4 million new jobs (or about 168,000 jobs per year)
- Return on investment of $2.90 for every dollar invested in infrastructure
- Double the number of households in the region living near high-quality transit
- Reduce per capita VMT by 2035 by over 10 percent compared to 2005

- Increase telecommute and work at home mode share to almost 15 percent (from under 4 percent in 2008)
- Increase investment in public transit by 13 percent over previous RTP
- Triple the investment in active transportation, to $6 billion
- Double the number of miles of bikeways, compared to today
- Upgrade 12,000 miles of deficient sidewalks

D. Environmental Justice Analysis

As part of the RTP, SCAG prepared an environmental justice (EJ) analysis to evaluate the effects of its plan on low income and minority communities. As part of its EJ analysis, SCAG used 11 performance measures to evaluate the plan's social equity impacts and developed a toolbox of potential mitigation measures that project proponents, local governments and air districts could use to address the potential impacts to EJ communities. SCAG's analysis recognized gentrification will continue to be an issue in the region, and referenced the need for future research to monitor and analyze population trends. Their analysis also identified the need for new indicators and data at increasingly refined geographic levels to better ascertain the potential impacts on local communities.

E. Public Outreach Process

The development of SCAG's 2012 RTP/SCS involved implementation of a comprehensive and coordinated public participation plan. To achieve the broadest based consensus for its proposed RTP/SCS, SCAG established a collaborative process that involved key stakeholders, including cities and counties, County Transportation Commissions, federal and State agencies, the business and development community, and public health and environmental justice advocacy groups. SCAG's outreach process has been ongoing for the past two years and has consisted of informational workshops throughout the region to familiarize the public with the planning process and discuss potential alternative land use scenarios. Attended by over 2,000 stakeholders, these public meetings attempted to provide the public with a user-friendly picture of how the region would grow over the next 25 years and a vision of alternative land use patterns. Input received through this process was used to shape the RTP. Next, a series of workshops and public hearings were held to discuss the selection of a preferred scenario from among alternatives. This culminated in the selection of the preferred scenario by the Regional Council in November 2011 and release of the draft 2012 RTP/SCS in early December 2011. Starting in January 2012, SCAG held a series of public workshops for elected officials, as well as public hearings throughout the region, to explain the components of the proposed RTP/SCS and to receive public comments.

SCAG responded to public comments on the draft 2012-2035 RTP/SCS and the draft Programmatic Environmental Impact Report and made responsive modifications to both documents. The proposed final RTP/SCS was presented to the public at a public meeting of the Joint Regional Council and Policy Committees meeting on March 21,

2012. On April 4, 2012, the Regional Council conducted a final public meeting at which it adopted the final RTP/SCS by unanimous vote.

II. ARB STAFF REVIEW

A. Overview

The Sustainable Communities and Climate Protection Act of 2008 calls for ARB's "acceptance or rejection of the MPO's determination that the Sustainable Communities Strategy (SCS) would, if implemented, achieve the greenhouse gas emission reduction targets" in 2020 and 2035. ARB staff prepared this technical report to support ARB's action to either accept or reject SCAG's quantification determination. This report describes the method ARB staff used to review SCAG's determination that its SCS would meet its targets, and reports the results of staff's technical evaluation of SCAG's quantification of passenger vehicle GHG emissions reductions.

SCAG's quantification of GHG emissions reductions in the SCS is central to its determination that the SCS would meet the targets established by ARB in September 2010. Government Code section 65080(b)(2)(J)(i) requires the MPO to submit a description to ARB of the technical methodology it intends to use to estimate GHG emissions from its SCS.. SCAG's technical methodology identifies its transportation modeling system, including the regional travel demand model,[4] its inputs, performance indicators, land use projections, growth forecast, 4D model,[5] and sensitivity analyses as the technical foundation for its quantification.

SCAG estimated that the SCS would achieve an 9 percent per capita reduction in GHG emissions from passenger vehicles by 2020, and a 16 percent per capita reduction by 2035. ARB staff's evaluation of SCAG's SCS and its technical documentation indicates that if implemented, the SCS would meet or exceed the GHG emissions reduction targets set by the Board.

This chapter presents the results of ARB staff's analysis of the SCS, including, minor modifications to the draft SCS at the time the Regional Council adopted the final plan. These modifications reflect small adjustments to socioeconomic data from local jurisdictions and the addition of minor transportation projects to the RTP. Neither of these modifications was sufficient to change the conclusion that the targets would be met. The modifications resulted in a slight benefit by increasing the amount of GHG reductions in 2020, from SCAG's original estimate of 8 percent per capita to 9 percent. The final SCS retained the estimate from the draft SCS that a 16 percent reduction would be achieved by 2035.

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[4] The travel demand model consists of four major modeling steps: trip generation, trip distribution, mode choice, and trip assignment.

[5] The 4D model is a land use model that is used in the SCS process to measure changes to GHG emissions from land use changes associated with Density (population and employment density), Diversity (jobs and housing diversity in the region), Destination (access to other activity centers) and Design (improved walk/bike environment).

SCAG's regional travel demand and 4D model followed the current state of the practice and used reasonable model inputs and assumptions. The sensitivity analysis of the model has demonstrated adequate sensitivity to transportation strategies. ARB staff's evaluation of the performance indicators supports the estimation of GHG reductions resulting from the SCS.

Application of ARB Staff Review Methodology

Review of SCAG's SCS focused on the technical aspects of regional modeling that underlie the quantification of GHG reductions, and is structured to examine SCAG's modeling tools, model inputs, application of the model, and modeling results. The general method was described in ARB's July 2011 document entitled "Description of Methodology for ARB Staff Review of Greenhouse Gas Reductions from Sustainable Communities Strategies Pursuant to SB 375" to review SCAG's quantification of GHG emissions reductions described in their SCS. To address the unique characteristics of the SCAG region and modeling system, ARB's methodology was tailored to and expanded for the evaluation of SCAG's SCS.

ARB staff evaluated how SCAG's models for estimating travel demand, land use impacts, and future growth operate and perform, and how well they provide for quantification of GHG emissions reductions associated with the SCS. In evaluating whether or not SCAG's models are reasonably sensitive for this purpose, ARB staff examined issues such as:

- How does the growth forecast reflect the economic recession?
- What is the basis for allocation of land use changes?
- How well does SCAG's travel demand model replicate observed results?
- Are cost assumptions (fuel price and vehicle operation cost) used in the model reasonable?
- How sensitive is SCAG's model to changes in key land use and transportation variables as compared with the empirical literature?

To help answer these and other questions, ARB staff used publicly available information in SCAG's SCS, and accompanying documentation including the RTP technical appendices and the model validation and peer review report. SCAG also provided additional clarifying information, sensitivity analyses, and data tables, as listed in Appendix B.

Four central components of SCAG's GHG quantification methodology and supporting analyses were reviewed for technical soundness and general accuracy:

- Modeling Tools
- Data Inputs and Assumptions for Modeling Tools
- Model Sensitivity Analyses
- Performance Indicators

The following technical data and analysis reflect the information available to ARB staff during its review of the SCS, including the supporting data provided by SCAG as shown in Appendix B.

Modeling Tools

SCAG's model validation report and the associated information SCAG presented to a peer-review panel in June 2011 were reviewed. ARB staff also assessed how well SCAG's travel demand model replicates observed results based on both the latest inputs (socioeconomic, land use, and travel data) and assumptions used to model the SCS. SCAG's 4D model documentation and results were reviewed to assess whether appropriate methodology was used to quantify the expected reduction in GHG emissions from its SCS. SCAG's modeling practices were also reviewed in light of the California Transportation Commission's (CTC) "2010 California Regional Transportation Plan Guidelines," the Federal Highway Administration's (FHWA) "Model Validation and Reasonableness Checking Manual," and other key modeling guidance and documents.

Data Inputs and Assumptions for Modeling Tools

SCAG's key model inputs and assumptions were evaluated to confirm that SCAG's model inputs represent current and reliable data, and were appropriately used in their model. Specifically, a subset of the most relevant model inputs were reviewed, including: 1) regional socioeconomic characteristics, 2) the region's transportation network, 3) travel inputs, and 4) cost assumptions. In evaluating these four input types, model inputs were compared with underlying data sources and reviewed the assumptions SCAG used to forecast growth and VMT. This involved using publicly available, authoritative sources of information, such as national and statewide survey data on socioeconomic and travel factors. The documentation of region-specific forecasting processes and approaches were also evaluated, where applicable, to the evaluation of a region's land use forecast assumptions.

Model Sensitivity Analysis

Sensitivity testing is often used to assess whether a model is reasonably responsive to changes in key inputs, including changes to land use and transportation factors. These tests often involve systematically changing model input variables and measuring variations in output variables. They can also be performed by examining variations in independent and dependent variables across a dataset, and evaluating the correlations between the variables. SCAG conducted sensitivity tests of its travel model to support its GHG emissions quantification analyses as part of its SCS.

The results of SCAG's sensitivity tests were compared to those found in the available empirical literature. As part of the sensitivity analysis review, responsiveness of SCAG's travel demand model to changes in the following input variables were examined:

- Fuel pricing
- Transit capacity, Bus
- Transit capacity, Rail
- Freeway capacity (increase/decrease in freeway capacity, for selected segments)
- Land use (using the 4D model to test individual land use variables)
- Auto operating costs
- Transit capacity (bus, rail, BRT, etc. combined)
- Telecommute
- Income distribution

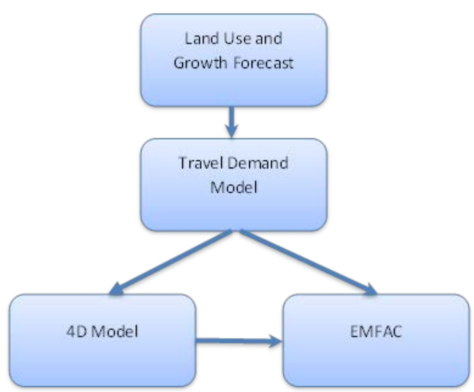
Regional Performance Indicators

Performance indicators help explain changes in VMT and related GHG emissions that are expected to occur, whether through changes in travel modes, vehicle trip distances, or through some other means. SCAG developed several performance indicators to evaluate the effect of implementation of the 2012 RTP/SCS on changes in VMT and GHG emissions. These performance indicators include land consumption, jobs/housing balance, distance of housing and employment from transit stations, passenger VMT, mode share, speed changes, vehicle delay, travel time distribution, and number of non-motorized trips. A qualitative evaluation was done to determine if increases or decreases in these individual indicators are directionally consistent with SCAG's modeled GHG emissions reductions.

B. SCAG's Modeling Tools

SCAG uses several models to quantify GHG emissions that would result from implementation of the 2012 RTP/SCS (Figure 4). SCAG's travel demand model employs a computer software package (TransCAD)[6] to calculate changes in travel demand based on a number of different modeling inputs, such as base year population, employment, and planning assumptions about future year land use, housing, and the transportation network. Based on these and other inputs, the travel demand model produces

Figure 4. SCAG's Modeling Tools



[6] TransCAD is a computer software package specifically designed for transportation planning and analysis.

vehicle activity outputs (performance indicators) such as VMT, vehicle hours traveled, number of vehicle trips, and average speed. SCAG employs a 4D model to account for additional VMT and GHG emissions reductions related to land use and transportation strategies to which the travel demand model is not responsive.

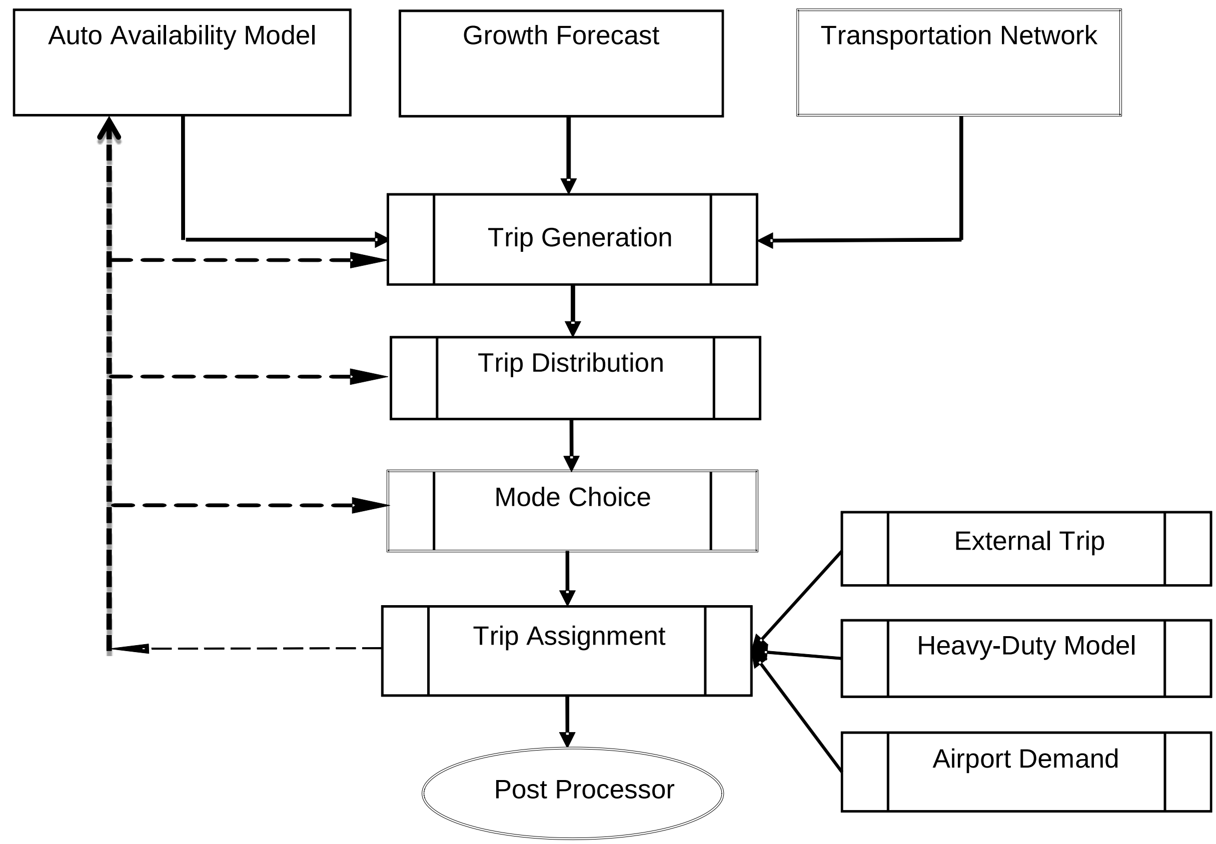
Using the VMT outputs from its travel demand and 4D models, SCAG then estimates the reduction in GHG emissions from implementation of its SCS for 2020 and 2035. SCAG converted VMT outputs to GHG emissions by running ARB's vehicle emissions model, EMFAC 2007. For the 2012 RTP/SCS, SCAG used EMFAC 2007 because it is the latest version of EMFAC approved by the U.S. EPA. The section below describes the various models used to develop the 2012 RTP/SCS in greater detail as well as planned model improvements that SCAG is developing for its next RTP update in 2016.

1. Travel Demand Model

The travel demand model SCAG used for its 2012 RTP/SCS is an aggregation of different sub-models (Figure 5). This section reviews key components of the regional travel demand model: auto availability model, trip generation, trip distribution, mode choice, and trip assignment.

This section also discusses the model validation process that SCAG performed to establish the credibility of the forecasts as an output of the model. SCAG used the travel demand model to assess the need for long-term transportation system such as roadways, transit planning, and goods movement. SCAG also used the travel demand model to perform federally required air quality conformity analysis and the technical analysis for determining if GHG emissions reduction targets will be achieved through implementation of the 2012 RTP/SCS.

Figure 5. SCAG's Regional Travel Demand Model



a) Auto Availability Model

The SCAG regional travel demand model uses an auto availability model to determine the number of motor vehicles available for use by household members. SCAG explicitly models auto availability at the household level using variables such as household size, income, number of workers, types of housing units, residential and employment density, and access to transit and non-motorized transport. SCAG used its "Year 2000 Post-Census Regional Travel Survey" (2000 household travel survey) to develop and calibrate the model. The output of the auto availability model becomes an input to the trip generation and mode choice steps.

The auto availability model was evaluated based on the structure and variables used in the model as well as whether the model followed the state of the practice.[7] The model captures the relationship between household characteristics and auto availability, and shows that the number of vehicles available per household decreased as the walk and transit access to employment increased, as observed from the model validation and peer review report. These relationships indicate SCAG has followed the current state of

[7] The state of the practice indicates the methods used by most MPOs in developing the travel demand models.

the practice in modeling auto availability as described in the Federal Highway Administration's "Model Validation and Reasonableness Checking Manual." (FHWA 2010).

The CTC's "2010 California Regional Transportation Plan Guidelines" recommends that a travel demand model be sensitive to land use and transit accessibility. The signs (±) and coefficients of density, accessibility to transit, and non-motorized transport in the auto availability model indicate that SCAG's model has addressed this recommendation.

b) Trip Generation

Trip generation in SCAG's travel demand model estimates the number of person-trips for each activity, such as traveling to and from work, school, shops, the airport, and social/recreational events. The trip generation model consists of two sub-models: trip production and trip attraction. Trip production refers to the starting location of the trip, which is most commonly home-based. The attraction end of the trip is the location where the activity occurs, such as the workplace, school, or shopping area.

SCAG estimated the number of trips produced in the region by applying the trip rates to the household demographics by trip purpose (calculated based on SCAG's 2000 Household Travel Survey) using a cross-classification model. A cross-classification model is similar to a look-up table, and develops average household trip rates by purpose, based on household demographics. For example, the variables SCAG used for home-based work (HBW) trip production are the number of workers, age of head of household, and household income. SCAG further divided HBW trips into direct trips (from home directly to work), and strategic trips (intermediate stops between home and work, e.g., to drop off a child at school, or for other reasons). The purpose of this subdivision is to capture the extended trip lengths of HBW trips. Different trip rates were used for direct trips and strategic trips. SCAG estimated home-based school (HBSC) and home-based college and university (HBCU) trip production rates using the number of children between 5 and 17 years old and college–age persons in the household, respectively. In addition, HBCU trip production rates included household income and group quarters population. Home-based non-work trips, such as shopping, recreation, and social activities were based on auto availability, household size, and household income.

To estimate trip attractions SCAG used a linear regression model. A regression model develops a relationship between the independent variables (e.g., income, employment, household size, car ownership) and the number of trips attracted to a zone. Once the total number of trip attractions for each trip purpose was estimated at the Transportation Analysis Zone (TAZ)[8] level, it was allocated to households based on income and auto availability. For home-based shopping, SCAG estimated trip attractions by applying

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[8] TAZs are the most commonly used geographic units in the travel demand model. TAZs split the entire study area at the major boundaries and freeways.

zonal retail employment trip rates. For HBSC and HBCU trips, SCAG matched trip attractions at the school district and the university enrollment levels, respectively. SCAG then assigned a group quarters population to a college location. The model was calibrated based on SCAG's 2000 household travel survey and the "2009 National Household Travel Survey" (NHTS). HBW trips were validated against the Census Transportation Planning Package (CTPP) 2000 survey and the American Community Survey's (ACS) three-year workflow tables. Table 3 summarizes the percent of trips shared by purpose from the SCAG model, compared to those provided in the "NCHRP Report 365: Travel Estimation Techniques for Urban Planning." [9]

Table 3. Percent of Trips by Purpose

Trip Purpose	SCAG's Model	NCHRP Report 365 (Urban Area with Population > 1 million)	Difference
Home-based work	24%	21%	3%
Home-based other	52%	56%	-4%
Non-home-based	24%	23%	1%
Total	100%	100%	0%

As part of the evaluation of the trip generation step, the parameters used in the trip production and attraction models, and their association to trip rates were reviewed. The responsiveness of trip rates to key parameters in the model were reviewed and compared to those found in independent data sources.

The analysis of SCAG's model indicates that trip rates tend to increase as income and auto ownership increases. Trip rates among different socioeconomic strata (e.g., low income, medium income, high income, and very high income) and auto ownership rates from SCAG's model validation report were compared. HBW trip rates increased with an increase in income and the number of workers per household. Home-based other (HBO) trip rates increased as auto availability and household size increased. Overall, SCAG's trip generation model followed the process for estimating trip generation outlined in "NCHRP Synthesis 358."

c) Trip Distribution

SCAG used the trip distribution step in its model to estimate the number of trips from one zone to each of the other zones. Trip distribution models were developed using data from SCAG's 2000 household travel survey. SCAG used an advanced method, a destination choice model, to estimate the trip distribution for all purposes except HBSC

[9] The "NCHRP Report 365" describes travel demand modeling theory and techniques, and their common applications by transportation planning agencies, and observed data for key modeling parameters at the national level.

and HBCU trips. A destination choice model predicts the probability of a person choosing a certain destination for a particular trip based on the travel time and operating cost, as well as land use and socioeconomic characteristics. SCAG used a gravity model to distribute the HBSC and HBCU trips. A gravity model matches the trip production and attractions based on cost and time. Home-based work direct trips and home-based work strategic trips were estimated using variables such as distance between zones, auto availability, mix density,[10] household income, employment, and access to different modes of travel. Further, HBW trips are constrained by zonal employment at the attraction zones. Home-based non-work destination choice models also use similar variables to those of the HBW trip.

To allocate the trips, SCAG calculated the shortest path between zones in a highway network taking into account the duration of the trip and operating cost. To incorporate the duration of the trip into the calculation, the value of travel time is estimated to be proportional to household income, while operating cost is valued at $0.17 to $0.24 per mile. SCAG also calculated the shortest path between pairs of transit access points taking into account the fare price, walk time, wait time, the number of transfers, and in-vehicle time. The model used travel times that are internally consistent with those used in later stages of the model. The trip distribution model was calibrated until the trip length and trip matrices matched the observed 2000 household travel survey and CTPP data. Further, the model was calibrated at the county level using the NHTS 2009 and ACS county-level data.

In evaluating the trip distribution step of the SCAG regional travel demand model, model outputs, including the trip length frequency distribution, the number of intra-zonal trips, and area-to-area flows were evaluated. The trip length frequency distribution is the most common measure used to evaluate trip distribution models. A statistical measure called the coincidence ratio to evaluate the distributions between the observed and modeled estimations. The coincidence ratio for HBW trips was greater than 0.91 and for other trip purposes it was greater than 0.89. This implies that the modeled and observed distributions match about 90% of the time. SCAG estimated the intra-zonal trips to fall within 1.5 percent to 8 percent of total trips for different trip purposes. This falls within the FHWA guidelines, which indicate that for large metropolitan areas, intra-zonal trips should be less than 10 percent of the total trips (FHWA, 2010). As mix density increased, the number of intra-zonal trips increased consistently. The area-to-area flow in the model reasonably replicated the 2000 household travel survey results as shown in SCAG's model validation report.

d) Mode Choice

Mode choice allocates trips per person into the different modes of transportation. The mode choice step uses output from the trip distribution step by purpose and assigns trips to different modes based on available transportation modes, travel time, travel

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[10] Mix density refers to different land uses, such as residential, commercial, and institutional, that are in close proximity to each other.

cost, and socioeconomic characteristics. SCAG used a nested logit modeling structure to estimate the mode shares for five time periods for each trip purpose. The mode choice model predicts the probability of selecting a mode for each trip based on the socioeconomic characteristics of the trip maker and the travel cost.

SCAG's mode choice model used three sets of mode choices including auto, transit, and non-motorized transportation. These choices were further divided into 12 sub-modes. To allocate trips between auto and transit SCAG used travel time and cost in the mode choice model. Three types of costs were considered in estimating the travel cost for auto modes: auto-operating cost, value of time, and tolls. SCAG used auto operating cost ranging from $0.17 to $0.24 per mile in 1999 dollars, while the value of time was estimated as proportional to the household income, and toll costs ranged from $0.11-$0.35 per mile. In addition, the mode choice model also considered household income and auto ownership information in allocating the trips between modes. Trip allocation to non-motorized transportation is constrained by maximum travel distance of up to 3 miles for walking and 12 miles for bicycling.

SCAG's transit options range from local bus service to high-speed rail. To allocate transit trips, SCAG used variables such as in-vehicle travel time, walk time, drive time, first wait time, second wait time, cost, access to primary mode, and access to secondary mode. SCAG also explicitly modeled the station choices for all rail modes.

In evaluating the mode choice step of the regional travel demand model, ARB staff reviewed model structure, and both observed and surveyed data that SCAG used to develop and calibrate the model, model parameters, and auto-occupancy rates by purpose. Estimated mode share by trip purpose was also compared against the observed data, including transit ridership.

The mode choice model was calibrated using the data from SCAG's 2001 Household Travel Survey, an on-board transit survey, and CTPP worker flow data. SCAG calibrated the mode choice model for the number of trips by time period, trip purpose, and mode. For transit modes, SCAG calibrated against the district-to-district transit flow by purpose, time period, and sub-modes.

The methods used in developing the mode choice model in the SCAG travel demand model are consistent with the approaches used nationwide as cited in NCHRP Report 535. The coefficients and constants used in the mode choice model had reasonable sign and magnitude by trip purpose, as recommended in the FHWA guidelines. In Table 4, mode shares by trip purpose were compared against the observed data. The differences were less than 2 percent by trip purpose. Transit boardings by mode (commuter rail, urban rail, metro bus) predicted by SCAG's travel demand model were compared to the observed data from the on-board survey (Table 5). The differences range widely, from 9 percent to 31 percent, which SCAG believes is due to under reporting by some transit operators in transit ridership surveys. The SCAG region has more than 80 carriers, and many small operators do not provide the ridership information. Overall, mode choice model results are consistent with observed data.

Table 4. Comparison of Mode Shares by Trip Purpose

Modes	Estimated (Peak Period)				Observed (Peak period)			
	HBW	HBNW	HBSC	NHB	HBW	HBNW	HBSC	NHB
Drive alone	78.6%	29.8%	7.9%	47.6%	79.2%	30.4%	7.9%	47.0%
Shared ride 2	6.9%	25.4%	19.8%	12.7%	6.7%	24.7%	19.4%	12.5%
Shared ride 3	3.4%	16.9%	16.8%	14.3%	3.3%	16.4%	16.6%	14.3%
Shared ride 4+	1.6%	16.0%	16.1%	17.6%	1.6%	15.1%	15.9%	17.4%
Transit	6.7%	1.7%	2.8%	0.9%	6.3%	1.7%	2.5%	1.0%
Non-motorized transportation	2.8%	10.2%	26.9%	6.9%	2.9%	11.8%	28%	7.9%
School Bus	0.0%	0.0%	9.8%	0.0%	0.0%	0.0%	10.1%	0.0%

HBW – Home-based work

HBNW – Home-based non-work

HBSC – Home-based school

NHB – Non home-based

Table 5. Comparison of Transit Boardings by Mode

Transit Mode	Model Estimated Boarding	Observed Boarding	Difference (%)
Commuter Rail	56,379	48,417	16
Urban Rail	251,823	276,084	-9
Metro Bus	1,378,183	1,554,723	-11
Other transits	1,175,563	899,907	31
Total Boarding	2,861,949	2,802,133	2

Auto-occupancy[11] is another critical factor in forecasting the travel demand for the region. This factor is used to convert the person-trips into auto-trips for use in the traffic assignment step. The SCAG region's average auto-occupancy by trip purpose is lower than that reported in the NCHRP Report 365 (Table 6). This might be due to an increase in observed auto ownership over the past decade.

[11] Auto-occupancy indicates the number of people including driver in a vehicle at a given time.

Table 6. Comparison of average auto-occupancy by trip purposes

Trip Purpose	Auto Occupancy	
	SCAG	NCHRP 365*
HBW	1.09	1.11
HBNW	1.64	1.66
NHB	1.39	1.64
HBSC	2.04	NA

* Based on 1998 data

e) Trip Assignment

The last step in SCAG's travel demand model is trip assignment, which incorporates inputs of the transportation network and trip tables by mode. This includes both highway and transit assignment of vehicle trips. This step of the travel demand model estimates traffic volume and travel time for each link of the network for a specific time period from all trips. SCAG's trip assignment model performs five feedback iterations into the auto availability, trip generation, trip distribution, and mode choice steps to identify the shortest routes between trip origins and destinations.

The trip assignment step uses a modified Bureau of Public Roads link performance function to estimate the congested travel time in the network. Congested travel time in each link is calculated as a function of volume-to-capacity ratio. Link performance functions were developed based on field studies and Performance Measurement System (PeMS)[12] traffic data. The same assignment procedure is used for different facility types with designated capacity and modified coefficients based on posted speed and area types. A user equilibrium approach is used to identify the shortest route between each origin and destination by performing several iterations to estimate network link flows considering capacity restraints and travel times. The convergence criteria used in the SCAG model is 0.001 relative gap[13], or a maximum internal iteration of 200.

In evaluating the trip assignment step, the assignment function used in the model and the associated coefficients were reviewed. Estimated and observed volume counts by facility type, were also compared with VMT in the region. SCAG's travel demand model used a capacity sensitive assignment function as required by CTC's "2010 California RTP Guidelines" to estimate the link volumes and speeds. The coefficients used in the assignment function were consistent with FHWA guidelines. A comparison of estimated

[12] PeMS measures the performance of the California highway network in real time using the data from vehicle detection stations.
[13] Relative gap measures the relative difference of traffic flow between current iteration and the previous iterations.

and observed traffic counts at the screenline[14] locations by facility type (Table 7) shows that all the facility types fall within the acceptable range of FHWA guidelines. Further, the observed and modeled volume counts at screenline locations had a strong correlation of 0.94, indicating that the model closely followed the observed data.

Table 7. Comparison of Estimated and Observed Traffic Counts

Facility type	Model	Observed	Difference (%)	FHWA Guidelines (%)
Freeway	12,352,747	12,079,101	2	±7
Major Arterials	5,276,288	4,872,997	8	±10
Minor arterials	2,851,476	2,722,576	5	±15
Collector and local	421,046	459,655	-8	±20

The estimated VMT from the model and the observed data from the Highway Performance Monitoring System (HPMS)[15] were compared at the county level. Differences ranged between 4 and 20 percent. The wide range might be due to the variations in the geographical area covered by HPMS and model estimates, and poor quality of HPMS measurement process. Generally, it is recommended that HPMS data be physically measured every three years, but it is not a requirement. Roads that were not directly measured were estimated by using sampling techniques and growth factors to adjust the volumes from the last time the road was measured.

SCAG's travel demand model partially addresses induced demand through a feedback mechanism that inputs congested travel time into the auto availability model, to account for travelers who change their travel routes and modes in response to changed travel times. SCAG also addresses the induced demand from new investments as part of growth projections. SCAG is developing an integrated land use and transportation model which will have a full feedback mechanism to account for induced demand. FHWA also acknowledges that the current travel demand models are not sensitive to changes in travel behavior resulting from highway improvements.

f) Model Validation and Peer Review

Model validation, a critical step in the development of any regional travel demand model, establishes the credibility of the model to predict future travel behavior. Base year validation is called static validation and is performed by comparing model results to observed data. Testing the predictive capabilities of the model is called dynamic validation and it is tested by changing the input data for future year forecasts. SCAG also performed a reasonableness check at the each step of the model.

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[14] The screenline is an imaginary line used to split the study area into different parts. Along these lines, traffic counts are collected to compare against the model estimates.
[15] Highway Performance Monitoring System is a federally mandated program to collect roadway usage statistics for essentially all public roads in the US.

SCAG uses a state-of-practice regional travel demand model

In performing model validation, SCAG employed recognized data sources such as the California Household Travel Survey, the National Household Travel Survey, the Census Transportation Planning Products, Info USA, California Department of Finance, and the American Community Survey at different geographic levels. SCAG also conducted a trend analysis of socioeconomic data that included population, employment, and number of households. SCAG compared model outputs to observed data as a check on the reasonableness of modeling results. Overall, SCAG's travel demand model was developed in accordance with the CTC's 2010 RTP and FHWA guidelines. The CTC's "2010 California RTP Guidelines," provide both requirements and recommendations for large MPOs, like SCAG, to enhance the modeling capabilities and validation procedures, as listed in Appendix A.

SCAG conducted a peer review meeting in June 2011, consisting of nine expert practitioners in the field. These experts reviewed each of the major model components, and provided suggestions on short- and long-term model enhancements to SCAG's existing regional travel demand model. From their review, the panel concluded that the SCAG travel demand model:

> *"is an advanced 4-step model that meets and in many cases exceeds the state of the practice--with the exception of the lack of zero-vehicle ownership sensitivity in the destination and mode choice models. With this one change properly addressed, the model is suitable for use in preparing 2012 RTP, conformity analysis and SCS."* (SCAG 2008 Model Validation and Peer Review Report)

The panel also suggested short-term changes or enhancements that called for:

- Zero-vehicle ownership sensitivity in the trip distribution and mode choice models;
- Averaging traffic counts over 3 years instead of using single year counts;
- Matching observed travel time and speeds on links as part of model validation.

All these suggestions were incorporated into the regional travel demand model that was used for the 2012 RTP/SCS and for estimating the GHG emissions. As already discussed, SCAG has addressed the sensitivity of zero-vehicle ownership in the trip distribution and mode choice steps. SCAG also revisited the traffic count data along the screenline locations and adjusted them, as recommended. Link level travel time and speed validation results will be incorporated in the final model validation report to be released by March 2012.

2. 4D Model

SCAG used a 4D model to improve the modeling system's response to changes in GHG emissions from land use changes. It worked in conjunction with the travel demand model that accounted for changes in density, mixed use, and access to transit. The 4D model was used to capture the additional GHG benefits of land use and transportation strategies to which the regional travel demand model was not adequately sensitive.

SCAG contracted with Fehr & Peers and Renaissance Planning to determine the benefits of a 4D model and the extent of additional GHG emissions reductions that could be modeled beyond the travel demand model's capability. SCAG's travel demand model is already sensitive to some land use related factors, such as type of housing (single-family and multi-family), transit accessibility to employment, a composite measure of household, employment and intersection density, and walk accessibility to employment. However, the model could not directly respond to other factors, such as the effects of mixed use development or changes to community design that improved bike/walk options. Additionally, SCAG did not have prior test data to determine if the model's sensitivity to density and design were consistent with the empirical literature for either local or national data.

SCAG's 4D model uses the 2009 National Household Travel Survey (NHTS) data and transportation network characteristics. Overall, the 4D model follows a similar structure to that of the regional travel demand model in that it:

- Determines the number of vehicles owned by each household, similar to the auto availability model;
- Predicts whether a given household has made a trip or not, based on socio-demographic variables and output from the previous step (number of vehicles owned by each household);
- Estimates the number of trips made by each household on any given day;
- Determines the mode share for trips made by households;
- Estimates VMT using variables such as household density, bus stop density, and regional accessibility.

The 4D model produced reasonable results in responding to changes in variables such as mix density, destination accessibility, and walkable design. By using the 4D model, SCAG estimated that approximately 0.41 pounds of carbon dioxide (CO_2) per capita could be reduced by 2035 that could not otherwise be obtained from the travel demand model runs. These emissions reductions account for approximately 2 percent of the GHG reductions by 2035.

3. EMFAC Model

The EMission FACtors (EMFAC 2007)[16] model developed by ARB, is a California specific computer model that calculates daily emissions of air pollutants from all on-road motor vehicles including passenger cars, trucks, and buses for calendar years 1970 to 2035. The model estimates exhaust and evaporative hydrocarbons, carbon monoxide,

[16] EMFAC 2007 can be downloaded from the ARB website at (http://www.arb.ca.gov/msei/documentation.htm)

oxides of nitrogen, particulate matter, oxides of sulfur, methane, and CO_2 emissions. It uses vehicle activity provided by regional transportation planning agencies, and emission rates developed from testing of in-use vehicles. In addition to statewide emissions, the model can also estimate emissions at the county, air district, and air basin levels.

ARB maintains and periodically updates the EMFAC model. EMFAC undergoes an extensive validation process, which includes comparing the model outputs with those from independent data sources, reconciling fuel consumption estimates with fuel sales data, and comparing modeled to ambient emission ratios. Currently EMFAC 2007 is approved by U.S. EPA. ARB has released an updated version of the model, EMFAC 2011, which ARB has submitted to U.S. EPA for approval.

4. Planned Modeling Improvements

This section describes the planned modeling improvements undertaken at SCAG for the next RTP due in 2016. SCAG is developing these model improvements to enhance the quality of analytical tools used to inform regional decision makers. SCAG is currently developing their next generation models and tools, which consist of an activity-based model (ABM), a land use modeling, and local sustainability tools.

The ABM uses an integrated framework to address the complex interactions between travel activity and behavior. When final testing is completed, SCAG's ABM should be able to model the activity-travel patterns of workers as well as non-workers in a household. SCAG's ABM is being designed to take various inputs like land use, socioeconomic characteristics, and the transportation system, and provide as outputs the complete daily activity travel patterns for each individual in the household. When ready, this model will replace the trip generation, trip distribution, and mode choice steps in the current travel demand model at a more detailed temporal and spatial resolution.

SCAG is also in the process of developing an enhanced land use model under the Production Exchange and Consumption Allocation System (PECAS) model framework. This model is intended to predict economic activity associated with land uses as a result of changes in transportation investments and policies. The PECAS model will be integrated with the ABM, and the effects of transportation and land use policy changes will be evaluated through interactions between variables and a feedback mechanism.

SCAG is developing a GIS based mapping tool that can be integrated with spreadsheet programs for use by sub-regions and local governments in SCS development. This tool can provide an easy way to estimate VMT and GHG emissions reductions from selected land use strategies, and can be scaled to various geographic zones.

C. SCAG's Data Inputs and Assumptions for Modeling Tools

SCAG's SCS is based upon on a number of significant inputs and assumptions, which influence many of the strategies relevant to GHG emissions reductions. These inputs and assumptions provide the foundation for SCAG's modeling approach, and are used by SCAG's travel model to project changes in the land use and transportation systems. Inputs and assumptions include land use, socioeconomic and transportation network characteristics, and travel costs. ARB staff evaluated the appropriateness of the data on which these inputs and assumptions are based, and how well the model responds to changes in these inputs and assumptions, as demonstrated by SCAG's sensitivity analyses.

1. SCAG's Approach to Growth Forecasting and Visioning of Future Land Use

Before any evaluations of policies or assessment of future impacts could be conducted, one of the first steps SCAG undertook in the development of the 2012 RTP/SCS, was the estimation of future population, employment, and housing, often called an MPO's growth forecast. SCAG's growth forecast sets the assumptions of how many people will live in the region, how many households they will form, the number and types of jobs those people will have, and where they will live.

Once the socioeconomic forecasts were developed, SCAG produced its forecast of future land use patterns. The land use forecast estimates three major development characteristics of the region: how much, where, and at what intensity the development will occur. The land use forecast was then integrated with existing, planned, and potential transportation facilities. This integration of land use forecasting and transportation infrastructure is what SCAG used to develop a land use alternative that addresses the goals of SB 375, while accommodating the forecasted population, housing, and employment levels. The forecasted land use pattern must also satisfy major regional policy objectives, such as accommodating the region's Regional Housing Needs Allocation (RHNA), regional mobility goals, and sustainability goals.

Taken together, the growth and land use forecasts determine the future demand for travel. Greater attention to forecasting of land use lets SCAG develop a clearer picture of future travel demand, and from that demand, the kinds of transportation infrastructure that is needed to serve the region's future population.

SCAG's Growth Forecast

Process

SCAG's Integrated Growth Forecast was prepared in accordance with the 2012 RTP growth forecast update process for the 2012 RTP/SCS and the related Environment Impact Report and RHNA. The process began in the fall of 2008 with a series of sub-regional workshops followed by one-on-one meetings with local jurisdictions or sub-regions. These workshops and meetings enabled SCAG to verify the accuracy of the socioeconomic data regarding land use and existing general plans. SCAG staff then developed an initial range of regional growth forecasts in early 2009.

SCAG faced several unique challenges in preparing the 2012 Integrated Growth Forecast: the growth forecasts were being developed in the midst of an unprecedented national recession; there were significant differences between the data prepared by the U.S. Census and California Department of Finance (DOF); and Census and DOF forecasts were prepared prior to the recession, calling into question how reasonable the numbers were. As a result, SCAG modified its growth forecast framework from one of focusing purely on a long-term perspective to one that looked at three scenarios consisting of low, medium, and high job growth forecasts.

As part of this process, SCAG convened a panel of fifteen experts in the fields of national economics and demographics to review these initial ranges of growth forecasts and their underlying assumptions. The first meeting of the panel took place in spring of 2009. SCAG staff modified their initial forecasts based on the input from the panel of experts. Between the summer of 2009 and early 2010, SCAG held a second round of workshops and one-on-one meetings to get input on these initial forecasts and to add socioeconomic data at the local jurisdiction/census tract/TAZ level. SCAG staff found that the local input overestimated employment and underestimated population in 2035 compared to SCAG's own forecast.

A second panel of experts met in the spring of 2010 to look at the local data in conjunction with U.S. Bureau of Labor Statistics and Census projections. This panel recommended that SCAG reduce the employment projections forecast to a level more consistent with the population. SCAG staff revised the employment forecasts between December 2010 and March 2011 based on these recommendations. SCAG convened the third and final panel of experts in May 2011. This panel provided updated perspectives on the short-term economic forecasts. SCAG staff continued to update and revise the growth forecasts through 2011, and released the Integrated Growth Forecast in December 2011. The December 2011 Growth Forecast, as adjusted in 2012 prior to adoption, was used as the basis for the 2012 RTP/SCS.

Methodology

SCAG's forecasting relied on the use of the latest demographic and economic assumptions, which included the recommendations of the previously described expert review panel, as well as consultant assistance from Dr. Stephen Levy of the Center for the Continuing Study of the California Economy. The preliminary regional and county level growth forecast for both population and households was developed by multiplying the city-level share of growth change from the 2008 RTP by the city's share of the county-level growth change in the forecast period. The preliminary employment forecasts use a constant share method, meaning that each city's share of jobs by sector is held constant over the forecast period.

This approach to forecasting assumes that employment growth is the driving force behind regional population and household growth. The approach also assumes that labor demand and labor supply are balanced through domestic migration (i.e. migration from other areas of the United States), which is constantly fluctuating. Household growth is based on population growth and household formation rates. SCAG's overall framework for relating population, households, and jobs is the same as that used by major national forecasting firms and California's other three largest MPOs. Both the California Department of Housing and Community Development and Caltrans support this framework as part of an overall effort to promote common methods for projection and forecasting statewide.

SCAG uses the shift-share model for forecasting employment which looks at how specific industries in the region relate to the national share of that industry. The key inputs in forecasting employment are the pool of job opportunities and the share of those opportunities (nationally) which locate in the region. Industry-specific projections from the Bureau of Labor Statistics formed the basis for the regional projections by industrial sector. The labor supply was calculated based on labor force participation rates for specific age, ethnic, and gender groups following Bureau of Labor Statistics projection trends. Generally the labor force participation rate for the SCAG region was assumed to continue to decline. Unemployment and the rate of "double jobbing" (number of jobs per worker) were also factored in. The unemployment rates were assumed to be 10%, 7% and 5% in 2010, 2020, and 2035 respectively, while the double jobbing rate was assumed to be 1.05 jobs per worker.

The methodology SCAG used to model population growth and other characteristics was to age the current population using birth and death rate assumptions using Census and DOF analyses. Fertility rates were generally assumed to decline, and survival rates to increase. Life expectancy at birth was presumed to continue to improve at the same rate as determined by the U.S. Census Bureau's 2008 projection. Foreign immigration was based on historical trends and expert panel review. SCAG has found, however, that recent trends of immigration do not match historical trends and have revised assumptions to reflect the recent trends.

Household formation rates were projected by age, ethnicity and gender. These rates were benchmarked to 2010 Census households. Forecasts were based on household formation (headship) rates. The headship rates by age, gender, and race/ethnicity were kept constant from 2010 rates.

Demographic inputs and assumptions SCAG used in establishing its growth forecast describe a number of key characteristics of the people living and working in the Southern California region. These data inputs and assumptions were developed through SCAG's regional growth forecast process, which was described in detail above. ARB staff focused its review on the population, household, and employment inputs to the model.

Population

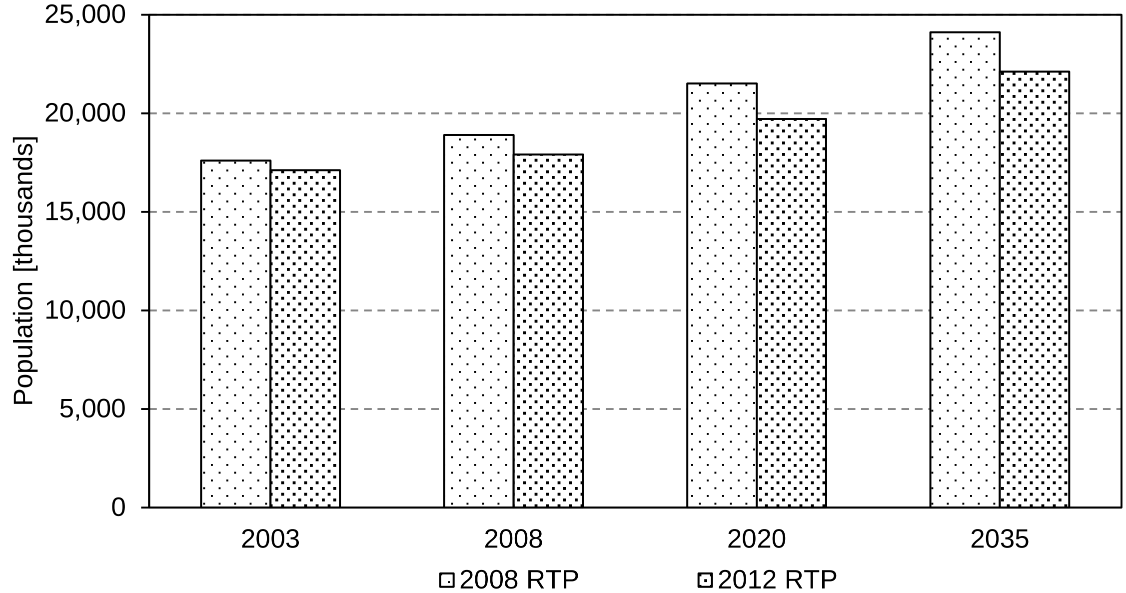
Population is a basic component of how present and future demand for transportation is estimated, since regional travel patterns are closely linked to population growth over time. The 2010 U.S. Census reports the SCAG region's population in 2010 as 18,051,534. SCAG projected population using a variety of data inputs: 2010 Census and Bureau of Labor Statistics projections, DOF projections, local jurisdiction inputs, expert panel review and a consultant-provided set of economic assumptions (Steven Levy – Center for the Continuing Study of the California Economy).

Nearly half of all Californians (49 percent) live within the SCAG region. SCAG projected that the region's population will grow by 23.8 percent between 2008 and 2035, from almost 18 million in 2008, to just under 20 million by 2020, to just over 22 million by 2035. Figure 6 illustrates SCAG's population projections.

Figure 6. SCAG Region Population Projection

SCAG's original population projections from July 2010 – which were based on the California Department of Finance (DOF) projections - were almost 1 million higher than the numbers released by the U.S. Census for 2010. The DOF projections, which were published before the recession, have not been revised since the release of the 2010 census data. DOF will not be releasing its updated growth projections until 2013. Figure 7 illustrates the differences between SCAG's growth projections from the 2008 RTP and the 2012 RTP.

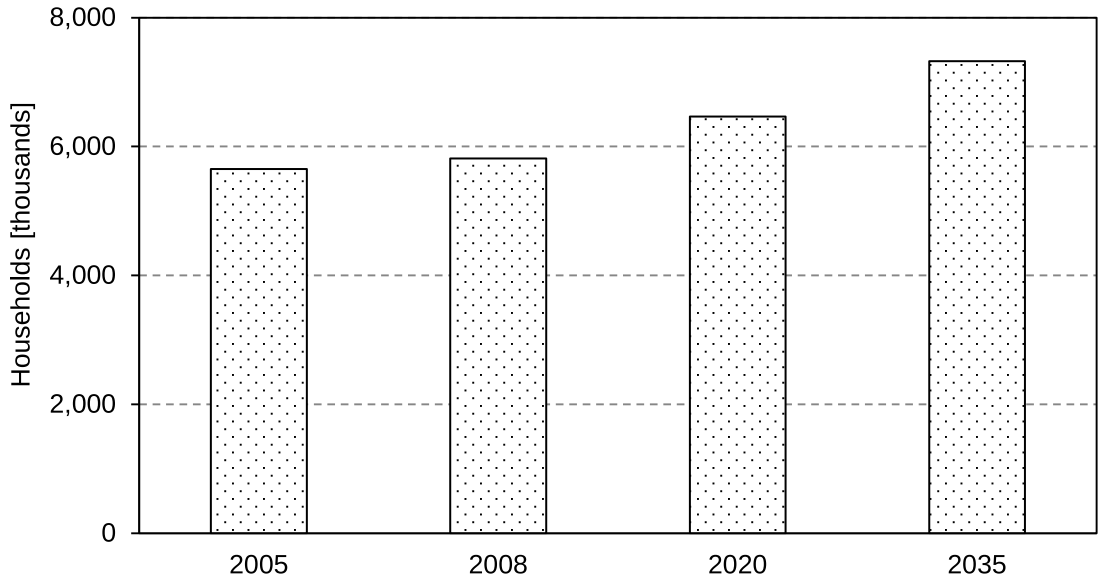
Figure 7. SCAG Region Population: 2008 vs. 2012 RTP



Housing

A household consists of a group of people occupying one housing unit, and can include both family and non-family members. The number of households is an important assumption in travel models because it is a primary input in determining the number of trips that occur in the region. SCAG's calculation of the number of households was done at the "minimum planning unit" (MPU) level, which correlates with parcel and 2000 Census block split. Household information and the number of planning units from the 2000 Census blocks were assigned to MPUs based on land use information from SCAG and was then reviewed by local jurisdictions. New residential construction information was added by using digital map products to include growth from 2000 to 2008. SCAG also calculated the number of households with the 2010 Census PL-94 block data to convert the number of housing units and households in 2010 to the 2000 Census block boundaries. SCAG then disaggregated these data into MPUs based on available land use information. The final step in the calculation was to adjust the 2010 numbers back to the 2008 level to get the base year number of households. The household formation level for 2020 and 2035 was calculated from the projected population. These rates vary based on age, gender, and ethnicity, and will change over time.

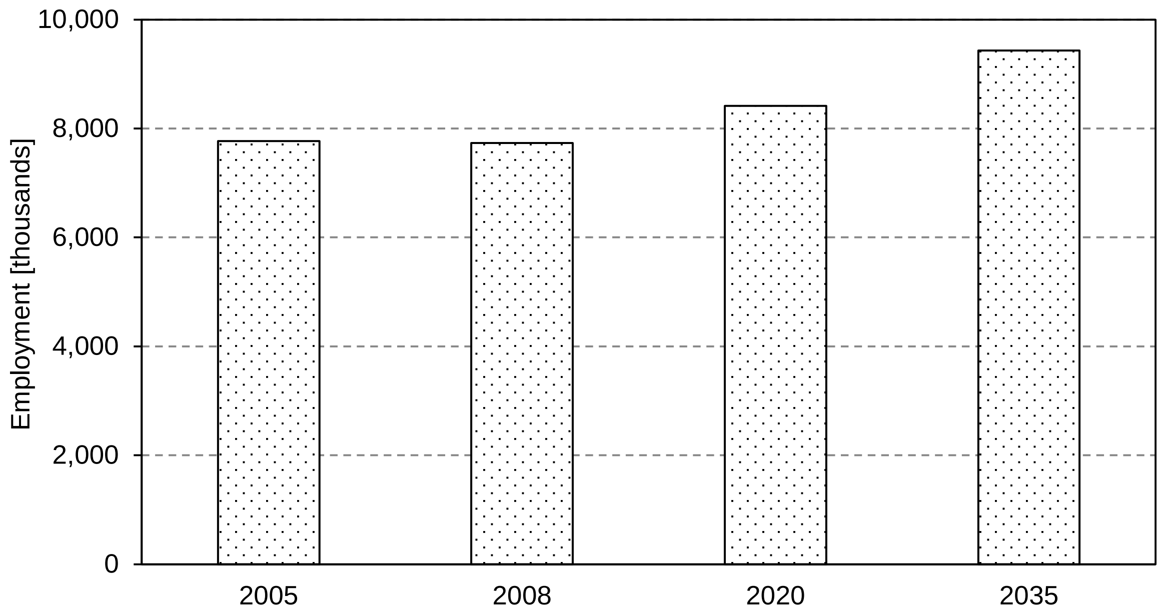
Figure 8. SCAG Region Households Projection



Employment

Employment describes the total number of workers in a region, which in turn, influences the number of commute trips generated. SCAG used several recognized and accepted sources of data in developing employment forecasts. These sources fall into two primary categories: household surveys and employer-based reports. Sources in the household survey category include the Current Population Survey, the American Community Survey (ACS), the U.S. Census SF3, and Public Use Microdata Sample data. Sources in the employer-based report category include the Census Transportation Planning Package (CTPP), the Current Employment Statistics, Labor Market Information Benchmark, ES202 (Bureau of Labor Statistics Employment and Wage Reports), Quarterly Census of Employment and Wages, County Business Patterns, Regional Economic Information System, and InfoUSA data. SCAG further revised its regional employment forecasts in April 2011 based on the latest 2010 job information from the California State Employment Development Department (EDD). SCAG's employment forecast were compared with EDD forecasts, as well as Input-Output Analysis: Foundations and Extensions, which is a widely used textbook and reference for modeling national and regional economies. As Figure 9 illustrates, SCAG expects that employment will grow from 7.7 million in 2008, to 8.4 million by 2020, and to 9.4 million by 2035. This change over the 27 year period represents a 22 percent increase. The data follow a similar trend to data provided by EDD of increasing employment. In 2035, the difference between SCAG and EDD employment projections is 1.5 percent. SCAG's employment forecasts are based on EDD numbers and use a shift-share model to develop more detailed job growth forecasts by jurisdiction and by industry.

Figure 9. SCAG Region Employment Projection



Growth Forecast - Summary

SCAG's growth forecasts for population, housing, and employment use state of the practice methodology for MPO forecasting. SCAG relied not only on standard federal and State sources, such as the Census, DOF, and projections, but also convened a local expert panel as part of its growth forecast process. Population and household numbers were benchmarked to the decennial census numbers. In addition, SCAG staff produced region-specific methodologies for refining estimates for migration flows, ethnic-specific headship rates, and industry-specific employment forecasts. SCAG's forecasts provide an additional degree of detail at the jurisdiction level from what is provided by the Census, DOF, and EDD.

SCAG's Future Land Use

In developing the future land use forecast, SCAG implemented a public outreach process to assess the range of policy options to be tested in the alternatives. SCAG used this public input to determine the associated parameters, policies, and controls to be tested. Using this public input, together with a sketch planning model, the alternatives were further refined and discussed at SCAG's Plans and Programs Technical Advisory Committee.

SCAG staff performed further analysis with the alternatives and recommended to its Regional Council that Alternative B be selected as the preferred alternative. This land use scenario addresses the goals of SB 375 through integrated land use and transportation planning. The preferred alternative focuses growth almost exclusively in or near High Quality Transit Areas (HQTA). An HQTA is defined by SCAG as a walkable transit village or corridor and is within a half mile of a transit stop with 15 minute or less service frequency during work commute hours.

Some other features of the preferred alternative are:

- Fifty-one percent of new housing growth occurs in HQTAs, up from 39 percent in the 2008 RTP.
- Fifty-three percent of new job growth occurs in HQTAs, up from 48 percent in the 2008 RTP
- Total land consumed in the preferred alternative is roughly half of the land that would be consumed if current trends and policies continued in the future (the no project alternative).

Process for Developing the Land Use Forecast

SCAG's process for developing its future land use followed four major steps: First, SCAG staff used developed and evaluated a series of land use themes generated by a sketch planning model. SCAG evaluated these land use themes in terms of six criteria.

Once these themes were developed, SCAG conducted a series of 18 public workshops in the summer of 2011 to gather pubic feedback on the land use themes and land use priorities. SCAG used the information from public outreach, local governments, stakeholders and county Transportation Commissions to develop four detailed alternatives.

SCAG then evaluated potential alternatives to assess ability to achieve policy goals for the 2012 RTP/SCS,

Finally, SCAG staff recommended the preferred alternative to the Regional Council. The Regional Council selected the preferred alternative and directed SCAG staff to develop the 2012 RTP/SCS using that land use forecast.

Data collection: Development and evaluation of land use themes

SCAG began the process of land use forecast development in 2011 with a series of planning sessions with local governments to gather all relevant land use and transportation policies, plans, and data required to formulate the SCS. Using survey instruments, one-on-one discussions, and geographical information system (GIS) software, local governments provided information on growth opportunities, local land use plans and measures, transportation demand and transportation system measures (TDM/TSM), and other local transportation information. The six County Transportation Commissions (CTC) also participated extensively so their respective county priorities would be kept in focus throughout the process.

Using the information from local governments and the CTCs, SCAG used a sketch planning model to develop land use themes. SCAG developed these land use themes as a way to explore two aspects of future growth: where in the six-county region growth will occur and how the region will grow in terms of the shape and style of neighborhoods and transportation systems that will define the region's future growth. Each of the land use themes were developed by varying the following parameters.

- Distribution of jobs and households across the region
- Housing profile— the mix of single family and multi-family housing
- Transit network, from planned to enhanced, including location of HQTAs
- General plans—Local general plans were used to varying degrees across the alternatives

SCAG evaluated the land use themes using a sketch planning model in terms of six criteria:

- Land consumed
- Greenhouse gas emissions (from all sources)
- Potential for generating air pollution
- Fuel use (from all sectors of the economy)
- Building energy use and cost
- Fiscal impacts

Each of the above criteria was examined for each of the land use themes. From this analysis, a clear progression was noted across the criteria evaluated. For example, one theme may consume three times more undeveloped land than another, or overall greenhouse gas emissions could be reduced by one, compared to another, theme. SCAG staff began to develop the alternative analysis framework during this phase. Work on the framework continued throughout the process until an alternative was selected.

<u>Public outreach and development of alternatives</u>

At the end of the land use theme evaluation process, four themes were taken to a series of 18 public outreach workshops held throughout the SCAG region during the summer of 2011. Through presentations and handouts used during these interactive workshops, nearly 700 members of the public learned how development location, neighborhood design, housing options and mix, and transportation investments compared among the themes, and how each of these themes resulted in varying impacts for the region. Participants discussed the intrinsic tradeoffs in each land use theme as well as how these tradeoffs related to objectives and priorities for SCAG's 2012 RTP/SCS. SCAG collected input from participants through discussions and anonymous polling. Workshop participants were able to view poll results in real time.

The resulting overall top priorities from workshop participants were the economy, environment, and transportation. Discussions focused on mobility, modes of travel, environmental and community impacts, and funding issues. Workshop participants voiced a desire for future housing and employment to be located in mixed use areas, more travel mode choice, and future transportation investment to be spread across all modes of travel.

SCAG staff combined the feedback from the public outreach sessions described above, with input from local governments, stakeholders, and County Transportation Commissions to develop three detailed alternatives for further analysis, and an analysis of the impact of a rapid increase in fuel prices. Selected policies were tested in each alternative through variation across each of the alternatives. These policies were:

- Growth pattern: focusing growth into more compact, walkable, mixed use development patterns.
- Transit access: improving regional transportation efficiency by focusing growth around transit facilities.
- Housing profile: better matching future housing market demand through land use changes.
- Jobs-housing balance: better integrating housing and employment to reduce the amount of regional auto travel and improve quality of life.

<u>Evaluation of alternatives and selection of the preferred alternative</u>

SCAG staff evaluated the three alternatives based on public input and feedback from its member jurisdictions. SCAG staff's evaluation considered how well each alternative met the policy goals and objectives as set out in the beginning of the process.

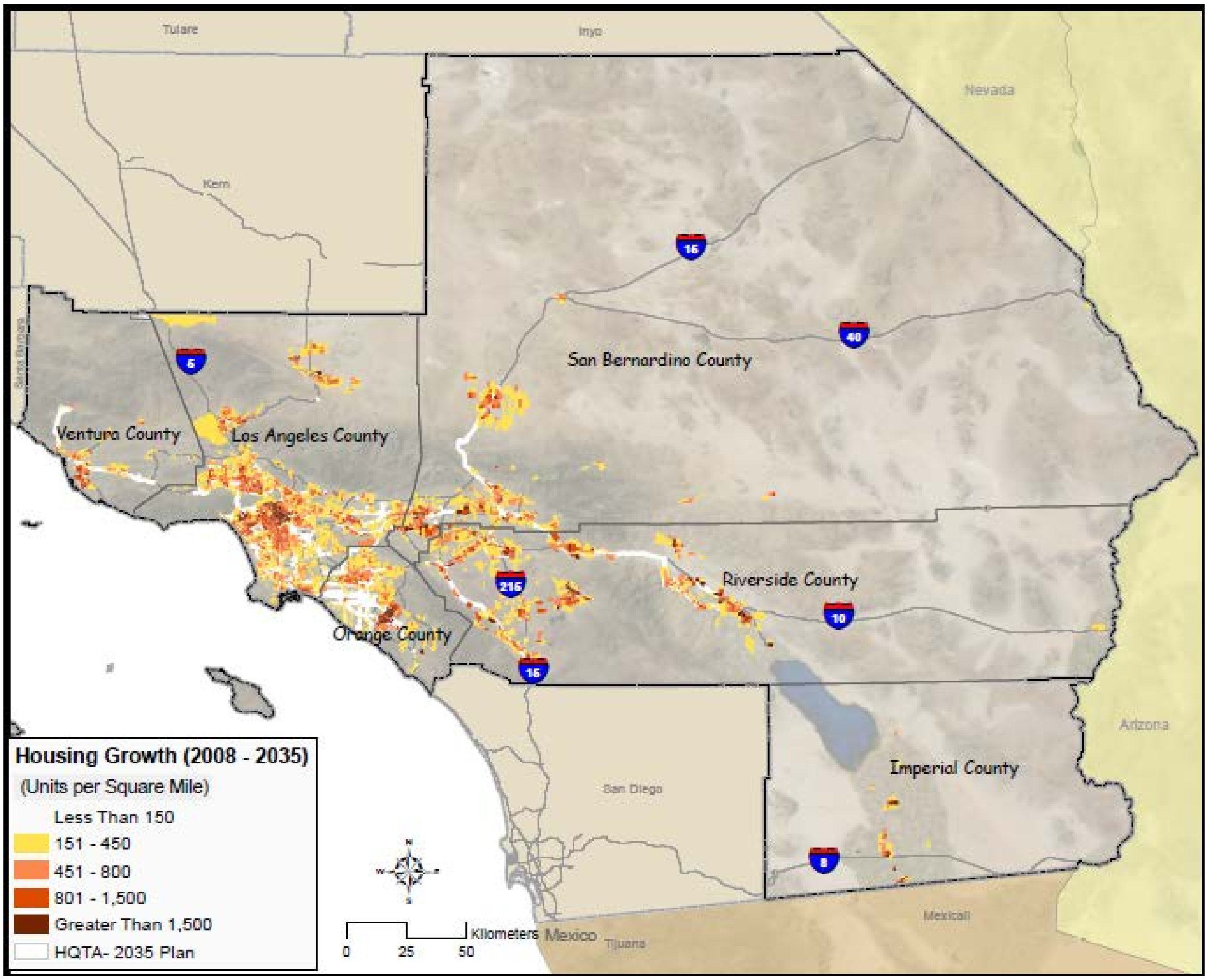
On November 3, 2011, SCAG staff recommended a preferred alternative (Alternative B) to its Regional Council at a publicly-noticed joint meeting of the SCAG Regional Council, the Community, Economic and Human Development Committee, the Energy and Environment Committee, and the Transportation Committee. SCAG staff's recommendation was based on their conclusion that Alternative B met SCAG's RTP/SCS policy objectives including: 1) meeting the SB 375 greenhouse gas targets, 2) meeting the requirements of the federal Clean Air Act related to transportation conformity, and 3) ensuring consistency of the land use forecast with local general plans and local government concurrence with the predicted future patterns of local growth. The Regional Council accepted staff's recommendation and directed SCAG staff to develop the 2012 RTP/SCS using Alternative B.

Two major policy objectives drive this alternative: a greater focus on regional growth around High Quality Transit Areas (HQTA), and accommodating future housing market demand. In contrast to keeping forecast housing and employment totals in agreement at the TAZ level as in Alternative A, SCAG maintained housing and employment totals in agreement at the city-level in this alternative. SCAG shifted future housing growth within city boundaries to focus more of future growth in a more compact way around HQTAs. These adjustments were made with the assumption that many of the recent development trends, in which cities locate growth nearer to current or future transit hubs, will continue. In some cases, jurisdictions have agreed to increase or decrease their projected household growth to reflect the adequacy of infrastructure expected to accommodate this new growth. This shift in housing capacity to a more dense, compact form reflects SCAG's expectation that future housing market demand is shifting to small lot single-family homes, townhomes, and multi-family housing.

In 2035, the resulting land use pattern will intensify both residential and employment development in HQTAs, within jurisdictions with such areas, while keeping the jurisdictional growth totals consistent with local general plans. It will move the region towards a more walkable, mixed use development pattern which can lead to reduced vehicle miles traveled (VMT), and other benefits that come from a higher walk/bike mode share, more transit use, and shorter auto trips. The preferred alternative is believed to meet demand for a broader range of housing types, with new housing and land use focused on the development of smaller lot single-family homes, townhomes, and multi-family condominiums and apartments.

Figure 10 illustrate the preferred alternative's focus on growth in and around transit and shows the resulting housing growth, in units per square mile, in the SCAG region in 2035. Comparing this pattern with the pattern of HQTAs anticipated by 2035 shows that most new development is projected to occur in and around transit-intensive areas.

Figure 10. Housing Unit Growth in Units per Square Mile in 2035



After selection of the preferred alternative for development of the 2012 RTP/SCS, SCAG staff created community types, or categories to summarize the regional land use pattern more succinctly. Table 8 summarizes these community types.

Table 8. Summary of SCAG's Community Types

Community Type	Description
Urban	Highest intensity. Centrally located districts with significant amounts of employment and corresponding residential uses and retail, typically located in a dense cluster of multi-story buildings and high-rise buildings. Typically located at the convergence of a number of high capacity transit facilities complemented by non-auto infrastructure that provides access and connectivity.
City	On average one-half the intensity of the Urban community type. Contains significant employment centers and a mix of medium- and high-density housing, supported by retail and daily services. One to two high capacity transit facilities, a number of bus routes, and non-auto infrastructure provide access and connectivity to a range of activities and locations.
Town	Low- to medium-density housing opportunities that are located close to local-serving retail and daily services. Characterized by an employment core or an independent job center in low- to mid-rise structures. Sidewalks and bike facilities are adequate and the areas benefit from one high capacity transit facility and local buses.
Suburban	Contain a mix of uses, but often have one predominant use, such as residential or office. Residential areas are typically low-density with larger lots and are separated from retail and other daily service uses. Predominantly served by automobiles; bus service and commuter rail may also operate in certain neighborhoods.
Rural	Housing is characterized by acreage lots and ranches, and is often far from commercial and employment activities, which occur in isolated nodes located on rural cross-roads and highway services zones. Transit and non-auto facilities rarely serve these areas, making automobile use the most frequent mode of travel.

Tables 9 - 10 and Figures 11 - 12 below summarize some of the features of the preferred alternative. SCAG's 2012 RTP/SCS incorporates the final RHNA target for the region and describes a land use pattern that accommodates the future housing growth. Table 9 summarizes the forecasted housing growth by community type and Table 10 summarizes the forecasted job growth by community type.

Table 9. SCAG SCS Forecasted Housing Units 2020 and 2035

Community Type	Existing Housing Units (2008)	Total Forecasted Housing Units (2020)	Total Forecasted Housing Units (2035)
Urban	139,000	180,000	226,000
City	685,000	755,000	948,000
Town	2,496,000	2,760,000	3,159,000
Suburban	2,333,000	2,556,000	2,750,000
Rural	162,000	212,000	241,000
Total	5,815,000	6,462,000	7,324,000

Figure 11 compares the housing unit increase from 2008 to 2020 and 2021 to 2035 by community type. Because it will take time for the housing demand to shift more toward multi-family housing unit options, housing growth between 2008 and 2020 is projected to be fairly consistent with housing growth patterns of the recent past. Concentrated growth in urban areas is consistent with the preferred alternative that places housing and jobs in HQTAs. By 2035 the shift of new housing to Urban, City, and Town communities is more apparent, while housing in Suburban and Rural areas increase by less. This is consistent with anticipated housing demand preferences for multi-family units near transit options.

Figure 11. Forecasted Housing Unit Increase

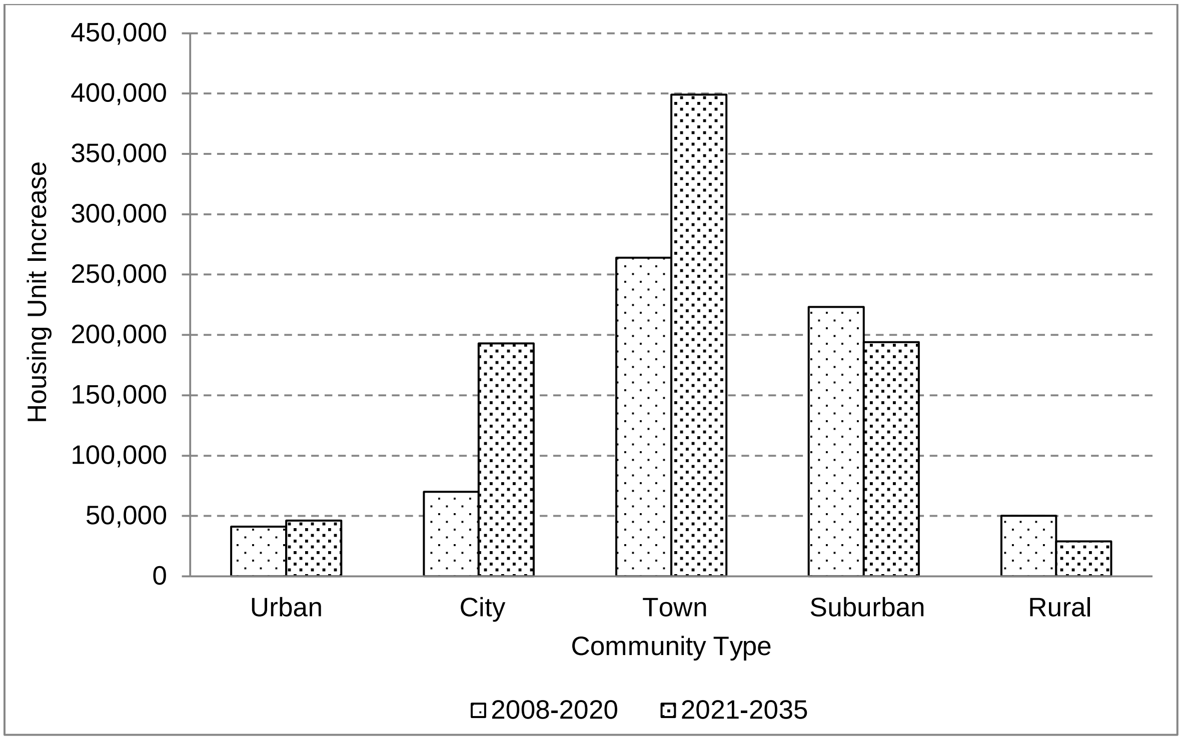
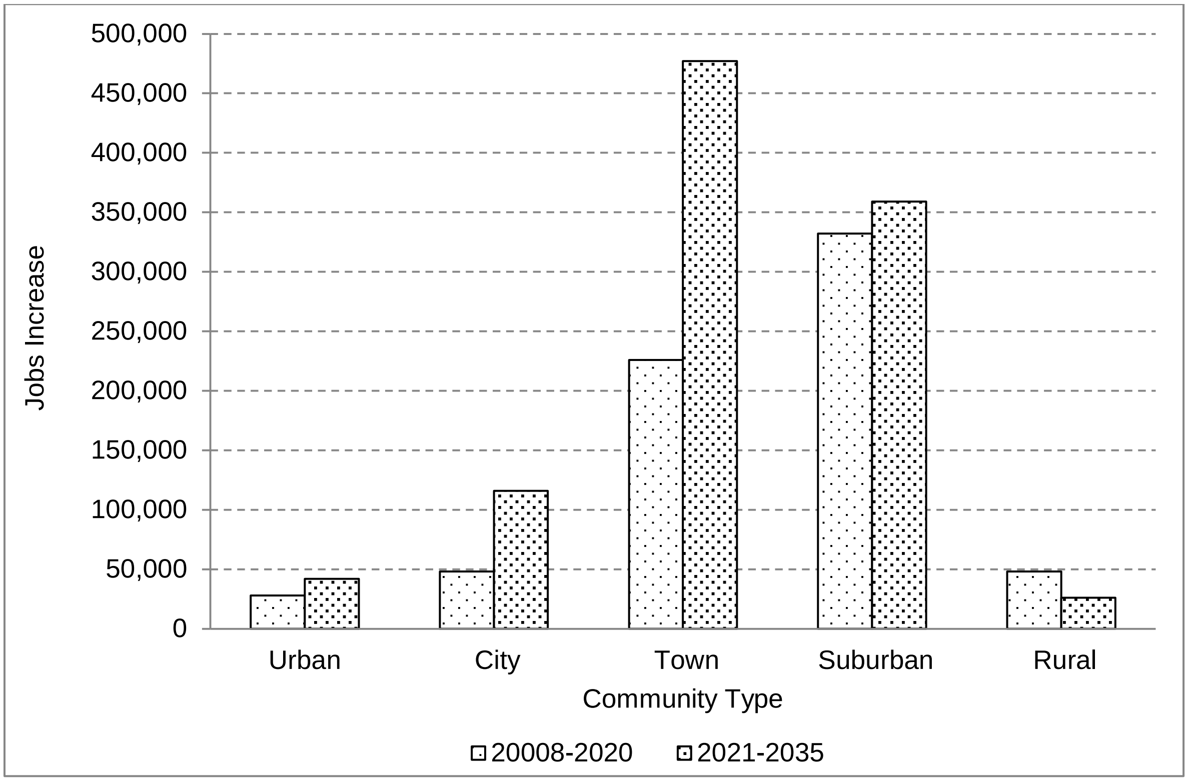


Table 10. Summary of Jobs Forecasted in 2020 and 2035

Community Type	Existing Jobs (2008)	Total Forecasted Jobs (2020)	Total Forecasted Jobs (2035)
Urban	503,000	531,000	573,000
City	1,029,000	1,077,000	1,193,000
Town	2,872,000	3,098,000	3,575,000
Suburban	3,183,000	3,515,000	3,874,000
Rural	147,000	195,000	221,000
Total	7,734,000	8,416,000	9,436,000

Figure 12 compares the jobs increase from 2008 to 2020 and 2021 to 2035 in jobs by community type. This is different from housing growth by community type and reflects a move toward a jobs/housing balance. For both 2020 and 2035, SCAG shows a higher job increase by percent in Rural communities. Rural areas tend to have low jobs-to-housing ratios compared to Urban and City areas which tend to have much higher jobs-to-housing ratios. Town and Suburban communities, which usually have more housing than jobs, will see a more dramatic jobs increase by 2035. The strategic placement of housing and jobs by community type may reduce daily commute trips and therefore an overall reduction in VMT. The balance between jobs and housing is discussed in greater detail in the Performance Indicators section.

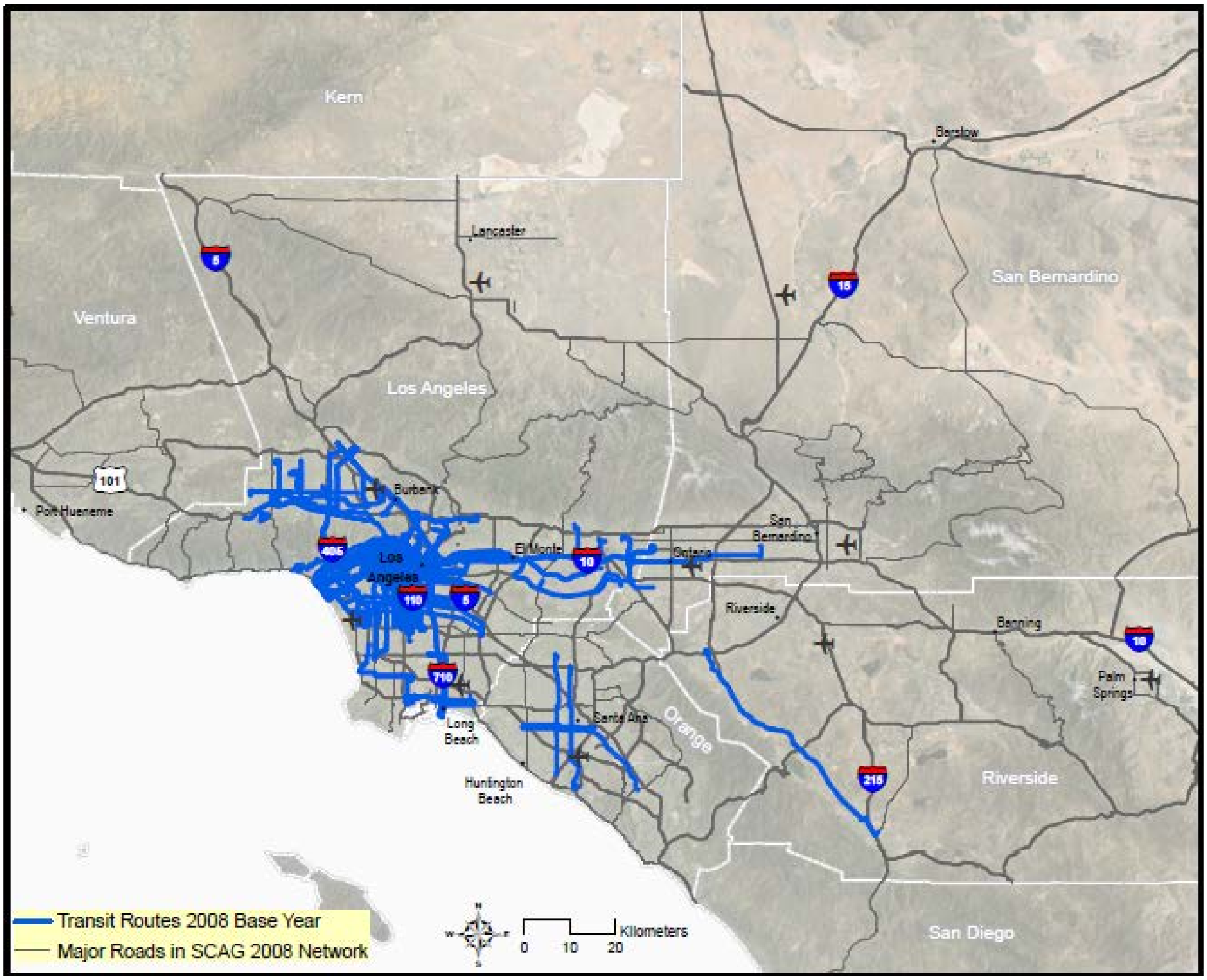
Figure 12: Forecasted Jobs Increase



2. Transportation Network Inputs and Assumptions

The transportation network is a map-based representation of the transportation system serving the SCAG region. One part of that transportation network is the highway network, which is used to develop an inventory of the existing road system, estimate the highway travel times and distances, simulate automobile travel, and estimate associated impacts such as pollution, energy use, and accidents. The other part of that transportation network is the transit network, which is used to model the impacts of transit and land use strategies on travel patterns throughout the region. Figure 13 presents the base year transportation network in the SCAG region. ARB staff reviewed the SCAG regional highway and transit networks, link capacity, and free-flow speed assumptions used in the 2008 SCAG regional travel demand model. The methodologies SCAG used to develop the transportation network and travel model input assumptions is consistent with guidelines given in the NCHRP Report 365. SCAG performed sensitivity test runs to examine the travel demand model's responsiveness to link capacity and transit service frequency. A summary of the sensitivity test results is presented in the Model Sensitivity Analysis section of this report.

Figure 13. Highway and Transit Network in SCAG Region



a) Highway Network

A highway network is a representation of the automobile roadway system, which includes elements such as streets, roads, arterials, and freeways in the region. The SCAG regional highway network includes over 16,000 centerline miles for all freeways, arterials, urban major collectors, of which 11,000 lane miles are on freeways. Additionally, the highway network contains over 65,000 street segments and 30,000 intersections. The 2008 lane miles by type of roadway in the SCAG region are summarized in Table 11. The highway network map was based on three commercial area types: core, central business district, and urban business district, and four residential area types: urban, suburban, rural, and mountain, to reflect land use intensity, primarily population and employment density. SCAG staff developed separate networks for an AM peak period from 6:00 am to 9:00 am, a midday period from 9:00 am to 3:00 pm, a PM peak period from 3:00 pm to 7:00 pm, an evening period from 7:00 pm to 9:00 pm, and a night period from 9:00 pm to 6:00 am to simulate roadside parking restrictions during the day.

Table 11. Summary of SCAG's Highway Network Inventory in 2008

Roadway Type	Base Year Lane (Miles)
Freeway general purpose lanes (e.g. mixed flow, auxiliary)	10,919
Freeway managed lanes (e.g. HOV, HOT, Toll)	1,205
Major Arterial/Expressway	16,203
Minor Arterial	21,218
Collectors	12,221
Locals	5,117

SCAG staff used two methods to develop their regional highway network. First, SCAG staff used the existing regional highway network inventory from the 2008 RTP, and local input from sub-regional and regional agencies to create a GIS-based network inventory. Second, SCAG staff and County Transportation Commissions and Caltrans districts reviewed the inventory for accuracy using aerial photos, and performed model sensitivity runs to ensure proper flow and connectivity.

The SCAG highway network has geo-coded primary and secondary network attributes. Geocoding is a process of assigning geographical information to network attributes so that they can be placed as points on the highway network and analyzed with other spatial data. Transportation models need basic attributes such as distance, speed and capacity to determine impedance for the appropriate assignment of trips to the network. There are primary and secondary attributes in the SCAG model. Primary attributes such as speed limits, number of lanes by time period, intersection control at model nodes, median type, and a distinctness between one-way versus two-way streets were applied to the model. Secondary attributes, which include the locations of features such as shoulder type, controlled intersections, parking, were delivered as GIS inputs.

The description of the SCAG highway network development was compared with the National Cooperative Highway Research Program (NCHRP) Report 365. The NCHRP Report 365 describes travel demand modeling theory and techniques, and their common applications by transportation planning agencies, and observed data for key modeling parameters at the national level. SCAG followed acceptable practice, consistent with the NCHRP 365 report. In addition, the facility type definitions used in the SCAG highway network are consistent with FHWA's "Federal Functional Highway Classification system.

b) Link Capacity

Link capacity is defined as the number of vehicles that can pass a point of roadway at free-flow speed in an hour. One important reason for using link capacity as an input to the travel demand model is for congestion impact, which can be estimated as the additional vehicle-hours of delay traveling below free-flow speed. Procedures to estimate link capacity are described in the Transportation Research Board's "Highway Capacity Manual 2000" (HCM). For instance, according to the HCM, a travel model should be able to reflect the change in demand due to new transportation policy or project such as congestion pricing or roadway expansion.

In the SCAG travel demand model, link capacity is classified by the number of lanes, area type, and facility type. The link capacity varies by the facility types used in the modeling of the SCAG regional highway network as summarized in Table 12. SCAG staff validated roadway capacity inputs with field data and studies conducted by their consultants. The link capacities used in the SCAG highway network are within reasonable limits because the maximum capacities are less than or equal to the suggested maximum link capacities in the HCM.

Table 12. Link Capacity of the 2008 SCAG Highway Network

Roadways	SCAG Link Capacity Range (vehicles/hour/lane)	HCM 2000 Maximum Capacity Range (vehicles/hour/lane)
Arterial/Expressway (Signal Spacing < 2 miles)	375 - 975	1,900-2,200
Arterial/Expressway (Signal Spacing > 2 miles)	1,400 - 1,900	
Freeway/HOV	1,900 - 2,100	2,100-2,400
Freeway-Freeway Connector	1,400 - 1,900	1,800-2,200
Auxiliary Lane	1,000	N/A

c) Free-Flow Speed

Free-flow speed is used to calculate the shortest travel time between two points in the highway network. Factors such as the prevailing traffic volume on the link, posted speed limits, adjacent land use activity, functional classification of the street, type of intersection control, and spacing of intersection controls can affect link speed. Both peak period travel speeds and off-peak travel speeds were considered in the estimation of free-flow speed. The SCAG region's reported posted speeds by facility type are listed in Table 13. SCAG staff validated free-flow speed with field data and studies conducted by their consultants. The SCAG SCS model peer review panel recommended SCAG assume free-flow speeds of arterials/expressways and freeways at five miles per hour (mph) beyond the posted speed limits for these facility types.

Table 13. Free-Flow Speed by Facility Type

Facility Type	Posted Speed (mph)	Free-Flow Speed (mph)
Arterial/Expressway	45-60	Posted Speed +5
Freeway/HOV	55-70	Posted Speed +5
Freeway-Freeway Connector	40-60	45-55
Auxiliary Lane	N/A	15-35

The methodology used in estimating highway free-flow speeds in the SCAG region was reviewed. SCAG's estimation of free-flow speed based on the posted speed is consistent with the recommended practice indicated in the NCHRP Report 365.

d) Transit Network

Besides the highway network, transit network is the second part of a region's transportation network. Based on the United States Department of Transportation – Federal Highway Administration's (USDOT-FHWA) "Model Validation and Reasonableness Checking Manual," the purposes for the development of a transit network are verification of access links and transfer points, performance of system level checks on frequency and proximity between home and transit station/stop, and relating transit speeds to highway (auto) speeds.

The SCAG regional transit network was built directly off the completed regional highway network, which included 40 different transit carriers, 130 operators, more than 1,000 lines, and 2.7 million daily boardings. The 2008 transit system operation coverage in the SCAG region is summarized in Table 14.

Table 14. The SCAG Regional Transit System in 2008

Transit System	Operation Miles in 2008
Regular transit bus	644,555
Bus rapid transit bus	6,089
Express bus	103,923
Transit rail	32,431

For the base year transit network in the SCAG region, regional transit services were grouped into seven transit modes. An additional mode, High Speed Rail, was added to future year transit networks. Table 15 summarizes the base year roadway route miles in SCAG's transit network, by mode and time-of-day. Transit routes in the transit network were characterized by attributes such as transit operators, transit modes, identification number, route name, distance, direction, and fares. The transit network also included detailed frequency, and schedule during each of the five time periods.

Table 15. The SCAG Regional Transit Network Roadway Route Miles in 2008

Transit Mode	Roadway Route Miles for Transit	
	Peak	Off Peak
Commuter Rail	2,864	2,495
Local Rail	206	184
Express Bus	3,756	2,601
Rapid Bus	1,230	1,025
Local Bus	22,077	18,811
Transit way	1,704	1,121
Bus Rapid Transit	28	28
Total	31,866	26,266

SCAG's development of the regional transit network is consistent with the procedures discussed in the "NCHRP Report 365" and USDOT's "Model Validation and Reasonableness Checking Manual." For example, in the SCAG network, the route name is designated, the transit line is coded, and transit line attributes are included in the network, per the procedures outlined by the "NCHRP Report 365" and "Model Validation and Reasonableness Checking Manual."

3. Travel Demand Model Inputs and Assumptions

The number of trips associated with various land uses, and the time and length of those trips based on trip destinations can influence the amount of travel within a study region. Key model inputs for each step of the travel model (e.g. number of trips produced per household by purpose) were reviewed and compared to those from independent data sources using the methods described in the "Description of Methodology for ARB Staff Review of Greenhouse Gas Reductions from Sustainable Communities Strategies (SCS) Pursuant to SB 375." This review allowed ARB to understand the variables used in the model, the assumed values of the variables, and the sources of the model input.

a) Trip Generation Rates

Trip generation is the average of the daily person trips for each trip type in a planning region. Important factors that can influence the amount of travel in a region include but are not limited to automobile ownership, income, household size, density and type of employment, the availability of public transportation, and the quality of the transportation system. SCAG used the regional travel demand model as described in an earlier section of this report to estimate production trips and attraction trips based on the SCAG 2000 household travel survey data.

SCAG's model included trip classifications such as home-based work direct (HBWD), home-based work strategic trips (HBWS), home-based school (HBSC), home-based shopping (HBSH), work-based other (WBO), and other-based other (OBO), which follows the standards provided in the "NCHRP Report 365." The trip purposes were collapsed during evaluation into home-based work (HBW), home-based other (HBO), and non-home-based (NHB) trips so that the results can be compared to independent source data. The total number of trips by purpose in the SCAG region in 2008 was converted to average daily person trips per household for comparison purposes. Table 16 shows the comparison between the SCAG modeled trip rates by trip purpose and those from the "NCHRP Report 365." The weighted averages of percent average daily person trips by purpose from the "NCHRP Report 365" are based on an urban area with a population greater than one million.

Table 16. Trip generation rates by purpose

Trip Purpose	Average Daily Person Trips Per Household		Percent Difference
	SCAG's Model	NCHRP Report 365	
HBW	1.8	1.8	2%
HBO	4.6	4.8	-3%
NHB	2.8	2.0	44%
Total	9.3	8.5	9.0%

SCAG's trip rates match closely with the results from the "NCHRP Report 365" except for non-home-based trips. Non-home based trips tend to be underreported in household surveys because respondents frequently leave out short trips and trips with relatively unimportant purposes; non-home-based trips are expected to have the greatest deviations from the reference. The trip rates for all purposes estimated from the 2000 SCAG household travel survey are reasonable to be used as inputs to the 2008 SCAG travel demand model.

b) Trip Time and Distance Distribution

In the trip distribution step of travel modeling for the SCAG region, trip time and distance estimated using the highway network, are used as inputs to quantify travel impedances between zones. The SCAG trip distribution modeling step uses a gravity model for HBSC and HBCU trips and a destination choice model for the other trip purposes. These models were calibrated using the SCAG 2000 household travel survey. To understand the reasonableness of the SCAG trip time and distance inputs, these data were compared with those from independent data sources such as the 2008 American Community Survey (ACS) and the 2009 National Household Travel Survey (NHTS).

The trip time and distance data reported by SCAG are presented in Tables 17 and 18, respectively. SCAG's trip time input for auto trips is similar to those reported in the 2008 ACS and the 2009 NHTS however, SCAG's trip time inputs for non-motorized and transit trips are greater than the reference sources'. Similarly, SCAG's trip distance for each mode is greater than those reported in the 2009 NHTS. Some possible reasons for the differences between the SCAG's and reference trip distance and time inputs are that the original studies for the ACS and NHTS are at a nationwide level, and they were conducted a different time . Also, the differences could be attributed to the fact that the SCAG region has nearly 50 percent of the population in California, and it is one of the most congested areas in the nation, whereas the other sources focus on nationwide average.

Table 17. Average Trip Time by Mode

Mode	Average Trip Time (minutes)		
	2008 SCAG Model	2008 ACS	2009 NHTS
Auto	25	24.0* 28.3**	22.85
Walk	30	N/A	16.15
Bike	24	N/A	N/A
Transit	71	48.3	52.98

*Drive alone.

**Carpool.

Table 18. Average Trip Distance by Mode

Mode	Average Trip Distance (miles)	
	2008 SCAG Model	2009 NHTS
Auto	14.5	12.09
Walk	1.5	0.98
Bike	4	N/A
Transit	13.9	10.18

4. Cost Inputs and Assumptions

Travel cost is one of the major factors determining the mode of transportation for a trip. Several basic travel cost components used as inputs in the SCAG travel model were reviewed: vehicle operation cost, fuel cost, transit fare cost, and parking cost. Sensitivity tests, such as those for gasoline price, transit frequency, and transit fare, were also evaluated to examine how responsive the SCAG model is to VMT. The results of the sensitivity tests are presented in the model sensitivity analysis section of this report.

a) *Vehicle Operating Cost*

Vehicle operating cost is a key parameter used in the mode choice step of the SCAG model. SCAG defines vehicle operating cost as an out-of-pocket expense consisting of fuel (primarily gasoline) cost and other costs, including repair, maintenance, tires, and accessories. The assumed year 2008 vehicle operating cost in the SCAG model expressed in year 1999 dollar is 19.93 cents per mile, which includes a fuel cost of 13.5 cents per mile and other costs of 6.43 cents per mile.

Fuel price is an important factor that influences per capita VMT. The price of fuel is the amount consumers pay at the pump for regular grade gasoline (in dollars/gallon). When gasoline prices go up, drivers are expected to decrease their frequency of driving, reduce their travel distance, increase their use of public transit, and/or switch to more fuel efficient cars. Lower gas prices would be expected to have the opposite effects on VMT.

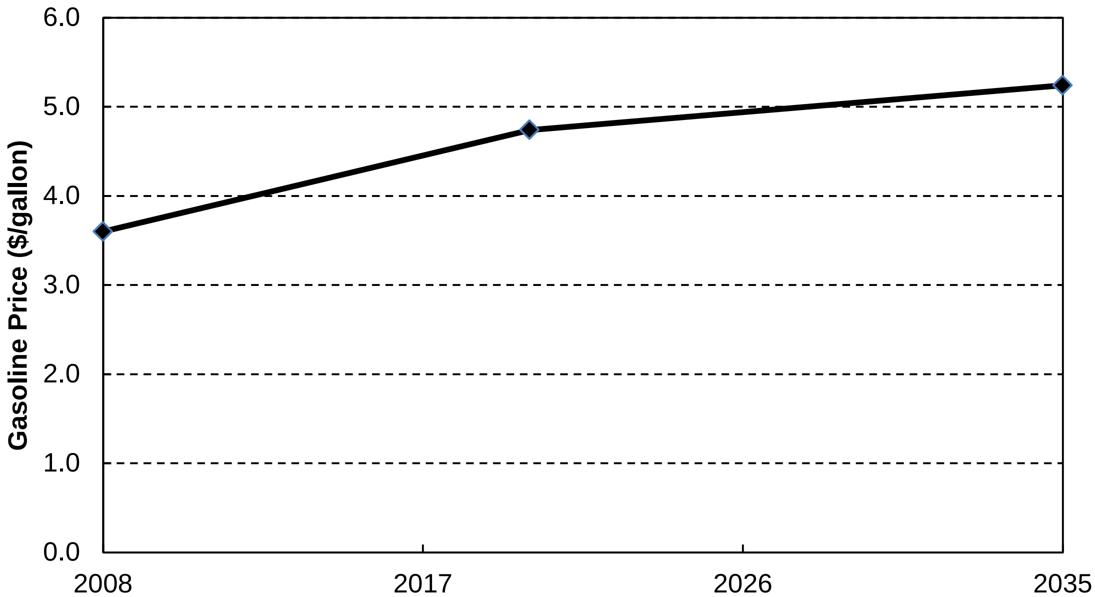
SCAG staff forecasted fuel prices following the methodology agreed upon by major California MPOs. SCAG staff used the high and low gasoline price forecasts from the United States Department of Energy's (USDOE) "Energy Outlook with Projections to 2035," starting with 75% of the difference between the high value and the low value, then added this to the low value, and then added $0.25 to account for the higher cost of California gasoline, relative to the national average. Forecasted gasoline prices for the years 2008 to 2035 are summarized in Table 19 and Figure 14. The forecasted gasoline prices used as inputs for the SCAG model were compared to those forecasted by the California Energy Commission (CEC) and USDOE.

Table 19. Fuel Price (in Year 2009 dollars)

Year	SCAG ($/gal)	Difference from Baseline (%)	USDOE ($/gal)	Difference from USDOE (%)	CEC* ($/gal)	Difference from CEC (%)
2008	3.60	0%	3.26	10%	N/A	N/A
2020	4.74	32%	4.03	18%	4.46	6%
2035	5.24	46%	5.85	-10%	N/A	N/A

*High price, converted to 2009 dollars

Figure 14. SCAG's Gasoline Price Forecast (in 2009 Dollars Per Gallon)



The differences between the SCAG model's forecasted gasoline prices and USDOE's range from 9% to 11%; the difference is 6% when comparing the SCAG model's forecasted value to CEC's value. The difference between the forecasted gasoline price from the SCAG model and the other sources is acceptable because gasoline price in California is higher than the national average. Also, SCAG is one of the major metropolitan areas in California; it is reasonable that gasoline price in SCAG is higher than the average value forecasted by CEC. Moreover, SCAG's forecast of gasoline price matches that estimated by the other three major MPOs in California.

b) Transit Fare

SCAG's year 2008 transit network includes three types of transit fares: base boarding fares, zone fares, and transfer fares; and two types of fare factors: a base fare factor and a transfer fare factor. Fare values were collected through the Transit Level of Service Data Collection program and are represented in 2008 dollars. Considering the complex fare structure for most carriers, SCAG staff used only published, full cash fares for initial boarding and transfers to represent the base fare and transfer fare. To account for the revenue composition of different fare types such as one-way walkup fares, daily/weekly/monthly passes, Senior/Student/Disabled fares, and other special fares, base fare factors and transfer fare factors are estimated from the boarding and revenue data provided by transit operators. By applying fare factors to the published, full cash fare, the resulting fares represent actual fares paid by an average passenger. Finally, all boarding fares (base fare and transfer fare) were converted from 1999 dollars using a CPI adjustment factor derived from the CPI factor published by the US Department of Labor for the Los Angeles-Riverside-Orange County metropolitan area.

The fare structure varies significantly by operator and by service for the same operator. For example, the Los Angeles County Metropolitan Transportation Authority (LACMTA) has both local and express bus service. For a local bus, the general fare is a flat rate of $1.25. For an express bus, there is a surcharge of $0.60 for each zone in addition to the $1.25 fare. However, the Orange County Transportation Authority (OCTA), another major operator in the region, charges a general fare of $1.50 for local buses. For express buses, the fare is a flat rate of $3.00 or $4.50, depending on the route. To accommodate variations in the fares for different routes, the year 2008 transit network codes general flat fares (i.e., base fares, transfer fares) at the route level, while the fare factors are calculated at the carrier level.

Two other major operators, Metrolink and Amtrak, follow a zone-based fare structure. For example, Metrolink fares are calculated with a distance-based formula using the shortest driving distance between stations, with an 80-mile maximum charge. To capture the published cash fare between two station pairs, a fare matrix was developed for Metrolink and Amtrak. Similarly, the LACMTA Express bus and Los Angeles Department of Transportation (LADOT) Commuter Express bus that have zone-based fares are also included in a zone-to-zone fare matrix.

c) Parking Cost

Parking cost is used as a parameter in the mode choice step of the SCAG model to determine the proportion of auto and transit trips. When parking cost increases, travelers may reduce their driving trips and/or switch to public transportation to save travel costs. Parking cost assumptions used in the SCAG model were reviewed. TJKM Transportation Consultants performed the parking cost modeling for SCAG. The parking cost modeling was based on the existing SCAG regional socioeconomic data, land use data, and the 2000-2001 SCAG parking survey. The hourly and daily minimum and maximum parking costs in the SCAG region were identified at the TAZ level by area type. Parking cost varies within a TAZ, and the actual cost varies from the posted prices because some employees receive parking subsidies. Parking cost results provided by SCAG were compared to the typical national average daily parking cost estimated by the Victoria Transport Policy Institute (VTPI). In “Transportation Cost and Benefit Analysis Techniques, Estimates and Implications,” VTPI estimates the cost of different types of parking spaces based on the parking cost associated with some major cities in the U.S. Table 20 summarizes the average daily parking cost associated with each area type defined in the SCAG region.

Table 20. Average Parking Cost in the SCAG Region in 2009 Dollar

Area Type	Average Cost in SCAG (dollars/day)	Typical Range of Parking Cost (dollars/day)
Core Area	18.05	9.55 to 11.71
Central Business District	10.35	
Urban Business District	9.73	3.91 to 9.61
Urban Area	8.43	
Suburban Area	12.68	1.96 to 2.58
Rural Area	7.60	
Mountain Area	6.94	

Compared to the typical ranges of parking cost, SCAG's estimates by area type follow the general trend of cost level: cost associated with a central business district is the most expensive, followed by the parking cost in urban areas, then the parking cost in suburban areas. In general, average daily parking cost in the SCAG region is higher than the upper bound of the typical range. Geographic location of the SCAG region might be the main contributor to this difference in parking cost, because metropolitan areas such as Los Angeles are ranked as having the highest land prices in the US.

D. Model Sensitivity Analysis

As they relate to an MPO travel demand model, the use of sensitivity analyses is intended to provide an indication of how the model actually behaves (compared to how it is expected to behave) and whether the model is capable of producing forecasts that could reasonably be expected to result from the data inputs and assumptions used. Sensitivity analyses are not intended to quantify model inputs or outputs or provide an analysis of actual modeled data. They are simply intended to assess the performance of the model itself.

Conducting a sensitivity analysis consists of a process of changing one single model input variable at a time (such as increased transit frequency, fuel price, or residential density) to see if and to what extent certain model outputs, such as VMT, react (or are sensitive) to such changes. Travel modelers will typically rate models as being sensitive as long as changes in model outputs result from changes in model inputs. ARB's analysis goes further by asking whether or not the results of the SCS sensitivity analysis demonstrate that the model is showing output changes that are within the range of values published in relevant empirical literature. In those cases where SCAG's sensitivity analysis findings could not be corroborated by the empirical literature, ARB staff indicated that the findings were sensitive, meaning that changes in model inputs resulted in changes to model outputs. In those instances where the findings were corroborated by the empirical literature, the findings were referred to as either sensitive directionally, meaning that the direction of change was consistent with findings in the empirical literature, or sensitive in magnitude, meaning that the amount of change predicted was consistent with the literature.

ARB requested that SCAG conduct a series of sensitivity analyses for its model using the following variables:

- Fuel pricing
- Transit capacity, Bus
- Transit capacity, Rail
- Freeway capacity (increase/decrease in freeway capacity, for selected segments)
- Land use (using the 4D model to test individual land use variables)
- Auto operating costs
- Transit capacity (bus, rail, bus rapid transit, etc. combined)
- Telecommute rates
- Income distribution

SCAG's sensitivity analyses were evaluated to understand how the model outputs changed as the inputs changed. Changes in model outputs were also compared with expected changes indicated in the empirical literature. In those cases where the range of elasticities[17] was available in the literature, ARB applied them to changes in model inputs that were used in SCAG's sensitivity analyses. This information provided a better understanding of the travel demand model's capacity to effectively capture the GHG emissions impacts of SCAG's SCS on key model outputs such as VMT, trips, and mode share.

This section provides a summary of the evaluation. We note that neither the sensitivity analyses, nor pertinent findings in the empirical literature, are in all cases definitive. The integration of sustainable community strategies into transportation modeling is still relatively new, resulting in analytical knowledge gaps that experience and new research will overcome over time. Nevertheless, the results of SCAG's sensitivity analyses are sound and generally consistent with available empirical research.

Based on both SCAG's specific sensitivity analyses, and examination of the relevant empirical literature, ARB staff's evaluation shows that SCAG's analysis of model output changes is sound, and that the model is generally sensitive for the variables tested. SCAG's analysis reflected changes to model outputs from changes in inputs. For many of the variables, SCAG's results were consistent with the empirical literature. In some cases, no comparable empirical studies were available which examined the same inputs and outputs as SCAG's analysis. Such a comparison is important to ensure that staff's analysis is technically sound. In four instances, SCAG's results were slightly outside the lower range of expected impacts based on the literature. These instances are

[17] An elasticity is defined as the percent change in one variable divided by the percent change in another variable.

explained in more detail in the following sections with explanations of factors that may have affected the sensitivity test results.

1. Fuel Pricing Sensitivity Test

Fuel price is a major component of auto operating cost, which influences per capita VMT. When fuel prices go up, drivers are expected to decrease their frequency of driving. Conversely, when fuel prices go down, drivers are expected to travel more by auto.

Since fuel price is a significant component of the cost of operating a vehicle (i.e. auto operating costs), SCAG staff ran two sensitivity tests focused on fuel price to determine whether the model responds appropriately to fuel price changes. For the tests, fuel prices in the model were changed to 50 percent and 150 percent of the 2008 baseline fuel price of $3.60 per gallon (in 2009 dollars).

As shown in Table 21, when fuel prices dropped to 50 percent of the base case cost, VMT increased 10 percent. Conversely, when these prices rose to 50 percent above the base case, VMT decreased by 7.8 percent.

Table 21. Fuel Pricing - Sensitivity Results

Test	Modeled VMT (thousands)	Expected Short-Run VMT range* (thousands)	Expected Long-Run VMT range** (thousands)
50 percent of base case cost	457,185	419,800 – 446,817	438,504 – 486,303
Base Case	414,694	--	--
150 percent of base case cost	383,234	411,488 – 384,471	392,784 – 344,985

*Calculated based on short-run elasticities of -0.02 to -0.15

**Calculated based on long-run elasticities of -0.11 to -0.34

The empirical literature includes a range of elasticities for changes in vehicle travel over the short-run (less than five years) relative to fuel price, including -0.02 to -0.09 (Small and Van Dender, 2007) and -0.15 (Agras and Chapman, 1999). The long-run elasticities (greater than five years) from these studies are -0.11 to -0.34 (Small and Van Dender, 2007) and -0.32 (Agras and Chapman, 1999). SCAG's modeled VMT changes in response to changes in the fuel price component of auto operating costs are directionally consistent with the trends noted in the empirical literature for long-run elasticities. The long-term behavioral changes in travel from increases or decreases in auto operating costs are relevant for the SCS.

2. Transit Capacity, Bus Frequency Sensitivity Test

Bus service frequency influences bus transit ridership. When bus transit service becomes more frequent, the bus ridership is expected to increase. Conversely, as bus service becomes less frequent, bus ridership is expected to decrease.

SCAG ran two sensitivity tests to determine the model's responsiveness to changes in bus transit service frequency. The tests included a model run that decreased service frequency by 50 percent and one that increased service frequency by 100 percent. As shown in Table 22, increases in transit frequency resulted in increased ridership, while decreases in transit frequency resulted in decreased ridership.

Information from "Policy Brief on the Impacts of Transit Service Strategies Based on a Review of the Empirical Literature" (Boarnet and Handy, 2010) indicates that for every one percent increase in bus service frequency in an urban area, a corresponding increase in ridership should fall somewhere within a range of 0.3 percent to 0.5 percent. The modeled results SCAG performed for bus ridership fall within the expected range of changes in ridership for the 50% of base case scenario based on the UCD-UCI research. For the 100% increase from base case scenario, the modeled results fall below the range expected based on the empirical literature. In this case, the result is within 10% of the expected level of ridership. The SCAG model is conservative in predicting the anticipated ridership increase from increased bus transit service frequency, but SCAG staff explains that this is due to the relatively limited extent of transit coverage in the region, as well as the unique aspects of the market for transit in the SCAG region.

Table 22. Transit Capacity, Bus - Sensitivity Results

Test	Modeled Ridership (trips)	Expected Ridership* (trips)
50 percent decrease from base case for bus frequency	594,437	612,106 – 540,094
Base case	716,573	--
100 percent increase from base case for bus frequency	856,179	936,163 – 1,080,188

*Expected transit ridership calculated based on elasticities of 0.3 to 0.5 percent increase in ridership for every 1 percent increase in bus transit service frequency.

3. Transit Capacity, Rail Frequency Sensitivity Test

Rail transit trips make up 10 percent of the total number of transit trips in the SCAG region. Service improvement to fixed rail systems are, for the most part, restricted to service scheduling and frequency changes. When rail transit service becomes more frequent, the rail ridership is expected to increase. Conversely, as service becomes less frequent, rail ridership is expected to decrease. SCAG conducted two sensitivity tests to examine the model's responsiveness with respect to the variation in rail transit service frequency. The two tests were a 50 percent decrease and a 100 percent increase in rail transit service frequency from the base case. The results of the sensitivity tests were compared to the expected range of rail transit ridership based on the elasticity of ridership to the change of rail transit frequency reported in the Transit Cooperative Research Program (TCRP) "Report 95: Traveler Response to Transportation System Changes." The TCRP "Report 95" states the range of elasticity of rail transit ridership with respect to service frequency is between 0.3 and 0.7. In other words, for every 1 percent change in rail transit service frequency, the corresponding ridership will change by 0.3 to 0.7 percent. Table 23 summarizes the modeled and expected rail transit ridership (in trips) with respect to change in rail transit service frequency.

Table 23. Transit Capacity, Rail – Sensitivity Results

Test on Transit Rail Frequency	Modeled Ridership (trips)	Expected Ridership (trips)
50 percent of base case	133,595	89,816 - 117,452
Base case	138,179	--
100 percent increase from base case	140,985	179,633 - 234,904

* Expected rail transit ridership calculated based on elasticities of 0.3 to 0.7 percent increase in ridership for 1 percent increase in rail transit service frequency.

Based on the results presented in Table 23, the modeled ridership of trips for the two cases changes in the same direction as the reference case; however, the values are outside the expected ranges found in empirical literature. One possible explanation for this difference is that the elasticity value indicated in the TCRP Report 95 is an arc elasticity, which only applies to calculation of the responded rail transit ridership given a certain range change in transit rail service frequency. However, the change of rail transit frequency in the sensitivity test is at least 50 percent of the base case, which could be wider than the reference range of change of rail transit frequency. As a result, the expected rail transit ridership could be overestimated.

4. Freeway Capacity Sensitivity Test

Roadway capacity represents the maximum number of vehicles at free-flow speed that can pass a certain point on a road in one hour. Changes in roadway capacity affects travel speeds in the region. When roadway capacity increases, total VMT in the region is expected to increase. The opposite happens when roadway capacity decreases.

SCAG conducted two sensitivity tests examining the model's responsiveness to changes in freeway capacity: increasing freeway capacity by 20 percent, and decreasing freeway capacity by 20 percent. Modeled results were compared to those based on recent empirical literature. The expected short-term and long-term elasticity of VMT with respect to the change in roadway capacity is from 0.1 to 0.56

(Cervero and Hansen, 2002) and from 0.39 to 0.84 (Cervero, 2003), respectively. Table 24 summarizes the modeled results, and the expected number of trips based on the empirical literature.

Table 24. Freeway Capacity - Sensitivity Results

Test on Freeway Capacity	Modeled Ridership (thousand trips)	Expected Ridership (thousand trips)	
		Short Run*	Long Run*
20 percent decrease from base case	406,843	368,248 - 406,400	345,025 - 382,348
Base case	414,694	--	
20 percent increase from base case	421,077	422,988 - 461,140	447,040 - 484,363

*Calculated, based on short-run elasticities of -0.1 to -0.56.

**Calculated, based on long-run elasticities of -0.39 to 0.84.

Based on results presented in Table 24, the modeled change of VMT moves in the same direction as expected; however, the magnitude of change does not fall into the expected ranges. The difference in the magnitude of change can be explained by differences in study locations and time of study.

5. Land Use Sensitivity Tests

SCAG used a 4D model to conduct the sensitivity analyses of the following land use variables: residential density, employment density, job mix, walkability, jobs/housing balance, auto accessibility, regional local bus accessibility, high quality local bus density. A detailed description of the 4D model is presented in the modeling tools section of this report.

SCAG's 4D model documentation report explains how the SCAG region-specific elasticities differ from those reported in the empirical literature. SCAG's walkability and local bus accessibility elasticities, for instance, are below the elasticities cited in the empirical literature. These are partially offset by the slightly higher sensitivity to auto accessibility. The region's overall lower sensitivity to job mix is somewhat offset by its higher sensitivity to jobs/housing balance.

Nevertheless, while showing slightly more sensitivity to certain built environment factors and less sensitivity to other factors, the 4D model overall produces reasonable results. The comparison between the 4D model and the regional travel demand model shows an additional 2.4 percent reduction in VMT per household that can be attributed to the built environment factors included in the 4D model. SCAG concluded that using a 2 percent reduction adjustment would be appropriate. Table 25 shows the comparison of elasticities between 4D model and the empirical literature.[18]

Table 25. Comparison of Elasticities between 4D and Regional Travel Demand Models

Test on 4D Variables	SCAG Elasticities*	Empirical Literature Elasticities*
Residential Density	-0.068 to -0.072	-0.05 to -0.12
Employment Density	-0.004 to 0.005	N/A
Job Mix	-0.016 to -0.017	-0.02 to -0.11
Walkability/Connectivity	-0.035 to -0.036	-0.06 to -0.12
Jobs/Housing Balance	-0.079 to -0.083	0 to -0.35
Auto Accessibility	-0.27	-0.05 to -0.25
Local Bus Accessibility	-0.042 to -0.044	-0.05 to -5.8
High Quality Local Bus Density	-0.007 to -0.009	N/A

*****An elasticity is the percent change in VMT per 1 percent change in the variables.

6. Auto Operating Costs Sensitivity Test

Auto operating costs consist of two major components: fuel prices (which are discussed in a previous section of this document) and other costs that include regular maintenance, repairs, tires, and other accessories. SCAG staff ran two sensitivity tests for auto operating costs (i.e. the sum of fuel and the “other” costs) to determine whether the model responds appropriately to changes in overall auto operating costs. Since the fuel component of auto operating costs makes up the biggest amount of these costs, the results of this analysis were compared to the available empirical literature on changes in fuel costs. For the tests, auto operating costs in the model were changed to 50 percent and 150 percent of the 2008 baseline auto operating cost of 20.63 cents per mile (in 2009 dollars).

As shown in Table 26, when operating costs dropped to 50 percent of the base case cost, VMT increased 17 percent. Conversely, when these costs rose to 50 percent above the base case, VMT decreased by 11 percent.

The empirical literature includes a range of elasticities for changes in vehicle travel over the short-run (less than five years) relative to fuel price, of -0.02 to -0.09 (Small and Van Dender, 2007) and -0.15 (Agras and Chapman, 1999). The long-run elasticities (greater

[18] Empirical literature elasticities were taken from a series of empirical literature reviews commissioned by ARB. These reviews can be accessed on ARB’s website at: http://arb.ca.gov/cc/sb375/policies/policies.htm

than five years) from these studies are -0.11 to -0.34 (Small and Van Dender, 2007) and -0.32 (Agras and Chapman, 1999). In other words, VMT changes in response to changes in the fuel price component of auto operating costs, and VMT changes are directionally consistent with the trends noted in pertinent empirical literature for long-run elasticities. The long-term behavioral changes in travel from increases or decreases in auto operating costs are most relevant for the SCS.

Table 26. Auto Operating Costs - Sensitivity Results

Test	Modeled VMT (thousands)	Expected Short-Run VMT range* (thousands)	Expected Long-Run VMT range** (thousands)
50 percent decrease from base case cost	484,132	418,841 – 445,796	437,502 - 485,192
Base Case (2008)	414,694	--	--
150 percent increase from base case cost	370,993	383,592 – 410,547	344,196 – 391,886

*Calculated based on short-run elasticities of -0.02 to -0.15

**Calculated based on long-run elasticities of -0.11 to -0.34

7. Transit Capacity, Bus and Rail, Combined Sensitivity Test

Transit service frequency is a key to the effectiveness of regional transit service. SCAG staff conducted two sensitivity tests on a combined mode of transit frequency (e.g. bus, rail, bus rapid transit) to determine the responsiveness of the model. The two tests were a 50 percent decrease and a 100 percent increase from the base case. The modeled results provided by SCAG were compared to expected values based on existing literature. The TCRP Report 95 states the average elasticity of combined transit ridership with respect to service frequency is 0.5. In other words, for 1 percent increase in combined service frequency, transit ridership will increase by 0.5 percent. Table 27 summarizes the modeled results, and the expected number of trips based on the empirical literature.

Table 27. Transit Capacity, Bus and Rail, Combined - Sensitivity Results

Test on Transit (combined) Frequency	Modeled Ridership (trips)	Expected Ridership* (trips)	Difference (%)
50 percent of base case	579,024	537,430	8%
Base case	716,573	--	
100 percent increase from base case	874,903	1,074,860	-19%

*Calculated based on an average elasticity of 0.5

The difference between the modeled number of trips and the reference value is within 20 percent. The magnitude of the difference may arise from the reference elasticity being derived from studies based on regions different from SCAG.

8. Telecommute Sensitivity Test

Telecommuting is a work arrangement that offers employees a flexible work schedule including variable work locations. Choosing to work from home or from a telecommute center can indirectly lower VMT and GHG emissions. The extent of telecommute impacts on GHG reductions depends largely on the assumed number of telecommuters, the commute frequency, and circumstances of the day of telecommute. Other factors such as commuter behavior (mode choice) or seasonal changes are also influential and can contribute to lower VMT and GHG emissions.

SCAG conducted a sensitivity analysis to test the effects of a changing telecommute environment within their SCS. The test scenario was modeled by assuming a 10 percent increase or decrease from HBW trips to telecommuting, and comparing the results to the base year condition in 2035. It is expected that an increase in daily telecommuting should cause a decrease in HBW trips and ultimately result in reduced daily VMT. Conversely, a decrease in the number of telecommuters should lead to an increase in HBW commuters using cars or public transportation. The modeled results of the test scenarios are summarized in Table 28.

Table 28. Telecommute - Sensitivity Results

Mode Share*		10% Increase in Telecommute from Base Case	Base Case2035	10% Decrease in Telecommute from Base Case
HBW	SOV - Trips	8,350,661	9,462,212	10,574,335
	SOV - VMT	95,247,639	99,353,226	102,835,408
	HOV - Trips	1,363,662	1,554,647	1,732,008
	HOV - VMT	15,553,929	16,323,794	16,843,778
	Transit - Trips	791,218	887,399	1,004,427
	Transit - VMT	11,319,165	11,891,147	12,680,891
	Total - VMT	122,019,183	127,568,166	132,124,260
non-HBW	SOV - Trips	21,926,648	21,916,035	21,975,128
	SOV - VMT	131,481,482	137,186,921	142,778,940
	HOV - Trips	30,934,650	30,951,856	30,856,945
	HOV - VMT	185,497,282	193,748,086	200,486,745
	Transit - Trips	938,735	1,013,446	932,550
	Transit - VMT	5,629,053	6,343,827	6,059,055
	Total - VMT	322,607,817	337,278,834	349,324,740
HBW & non-HBW	Total - VMT	444,627,000	464,847,000	481,449,000

*Total VMT (HBW and non-HBW) and Trips are SCAG model output; SOV, HOV and Transit VMT are estimated

The model seems to respond appropriately. However, relevant empirical literature refers to daily and not total HBW VMT. Separating and estimating with any precision daily HBW VMT per mode share after a 10 percent commuter switch is difficult since trip distribution and VMT are not directly correlated. Furthermore, changes to HBW mode share have a significant influence on the non-HBW mode share, trip distribution, and VMT. Choosing whether to make the daily work commute by SOV, HOV, or public transportation involves human behavior that cannot easily be predicted. Although the number of each HBW trip mode for a 10 percent commuter switch can be estimated, corresponding VMT’s cannot be derived, just estimated.

Available empirical literature suggests potential VMT reductions due to telecommuting ranges from 62 percent to 90 percent for commute HBW (Henderson & Mokhtarian 1996). These ranges however, are based on travel demand studies conducted during the 1990’s and may not be representative today. Instead, the study results can be used as general guidelines to predict trends in VMT.

The switch of 10 percent HBW commuters to telecommuting reduced the total VMT by approximately 20,220,000 miles to 444,627,000 VMT. The total VMT is increased by approximately 16,602,000 miles to 481,449,000 VMT when 10 percent of all telecommuters switch to a HBW mode. These results suggest the model is sensitive to both telecommuting scenarios including the modeled base case year.

9. Income Distribution Sensitivity Test

SCAG's income distribution sensitivity test focused on worker/job income distribution and the related household income level/distribution. The test simulated changes in the distribution of incomes among households in the region, and predicted changes in the travel behavior and mode choice for households within the SCAG region.

The determining factor in selecting different transportation modes of travel depends largely on the available income per household. According to the U.S. Energy Information Administration, higher income correlates to higher VMT per household. On average, lower income households own fewer or no cars, drive fewer miles, and tend to use public transportation more often than higher income cohort groups. Studies have shown that as household incomes decrease, transit commute mode shares often increase and VMT decreases. Similarly, VMT rises and transit commute mode share declines for households that fall into the higher income categories.

Table 29 illustrates that SCAG's model is directionally sensitive to income shifts. However, directly relevant empirical literature that describes income in a similar manner to determine if the model appropriately reflects the magnitude of changes observed from this variable could not be identified.

Table 29. Income Distribution – Sensitivity Results

	Income Shift High (+10%)	Base Year 2035	Income Shift Low (-10%)
VMT	468,087,000	464,847,000	459,649,000

E. SCS Performance Indicators

ARB staff evaluated changes in a subset of key indicators that describe SCS performance. These indicators are examined to determine if they can provide qualitative evidence that the SCS could meet its GHG targets if implemented. The directional consistency of the indicators with SCAG's modeled GHG emissions reductions, as well as the general relationships between those indicators and GHG emissions identified in the empirical literature were evaluated. The indicators include: passenger VMT, commute trip mode share, residential density, jobs/housing balance, housing type changes, travel time distribution, and vehicle delay by mode. The assessment relies on key empirical studies for each indicator that illustrate qualitatively how changes can increase or decrease VMT and/or GHG emissions. Below is a summary of the evaluation for the land use and transportation-related performance indicators.

Provides qualitative evidence of GHG reductions

1. Land Use Indicators

In order to determine the benefits of the development pattern in the SCS on GHG emissions from passenger vehicles, the evaluation focused on performance indicators related to land use: changes in residential density, jobs/housing balance, changes in the mix of housing types, and housing/employment in High Quality Transit Areas (HQTAs).

a) Residential Density

Residential density is a measure of the average number of dwelling units per acre of developed land. Travel characteristics in the region are expected to change as the housing market shifts from single unit homes on larger lots, to single unit homes on smaller lots, townhomes, and multifamily housing. These changes in travel behavior include reductions in average trip length, and could eventually result in decreased regional VMT.

A review of relevant empirical literature reveals this is likely to be the case. Brownstone and Golob analyzed National Household Travel Survey (NHTS) data and observed that denser housing development significantly reduces annual vehicle mileage and fuel consumption, which directly results in the reduction in GHG emissions. They also reported that households in areas with 1,000 or more units per square mile drive 1,171 fewer miles and consume 64.7 fewer gallons of fuel than households in less dense areas. Boarnet and Handy (2010) reported that doubling residential density reduces VMT an average of 5 to 12 percent. Litman (2010) reported that increased population density leads to a 0.2 to 1.45 percent decrease in the demand for car travel.

SCAG's land use forecast in the 2012 RTP/SCS projects that between 2008 and 2020 the region's residential density will increase by a little over 10 percent, and over 23 percent between 2008 and 2035 (Table 30).

Table 30. Average Residential Density in Dwelling Units per Acre in the SCAG Region

2008	2020 (Plan)	2035 (Plan)
6.09	6.74	7.54

These increases in density are consistent with the empirical literature and indicate the likelihood of reductions in VMT and auto trip length, shifts in travel mode away from single occupant vehicles, and reductions in GHG emissions.

b) Jobs-Housing Balance

Jobs/housing balance refers to the approximate distribution of employment opportunities and workforce population across a geographic area. It is usually measured in terms of the proportion of jobs per household. For example, a jobs/housing balance of 1.25 means there are 5 jobs for every 4 households. The aim of jobs/housing balance is to provide local employment opportunities that may reduce overall commuting distance among residents, and also the reverse – to provide homes near workplaces. The literature reports that a jobs/housing balance is sensitive to the area of analysis. In one study, an area defined as a "commute shed" is an area of about 14 miles in radius around an employment center, and a jobs/housing ratio between 1.0 and 1.3 is considered "balanced" (Armstrong 2001). As the area of analysis expands, the jobs/housing ratio becomes less informative. For example, a jobs/housing ratio considered balanced for a "commute shed" area is not necessarily balanced for larger areas such as the SCAG region. Generally, a jobs/housing ratio near 1.3 is accepted as "balanced" considering that California's households have an average of 1.3 workers (Kroll 2008). SCAG's Regional Comprehensive Plan (2008) identifies a goal of adding one housing unit for 1.5 full time equivalent jobs.

Although using a regional jobs/housing statistic in a region such as SCAG may not be as useful as a statistic at a smaller scale, evaluating the trend over time of a regional jobs/housing ratio can be useful to gauge the projected impact of land use policies on the location of job and housing development. SCAG's jobs/housing ratio is estimated to be 1.30 in 2020 and 1.29 in 2035, compared to 1.33 in 2008, based on the 2012 RTP/SCS. Figure 15 illustrates this trend.

Figure 15. Jobs/Housing Ratio in the SCAG Region 2008 to 2035

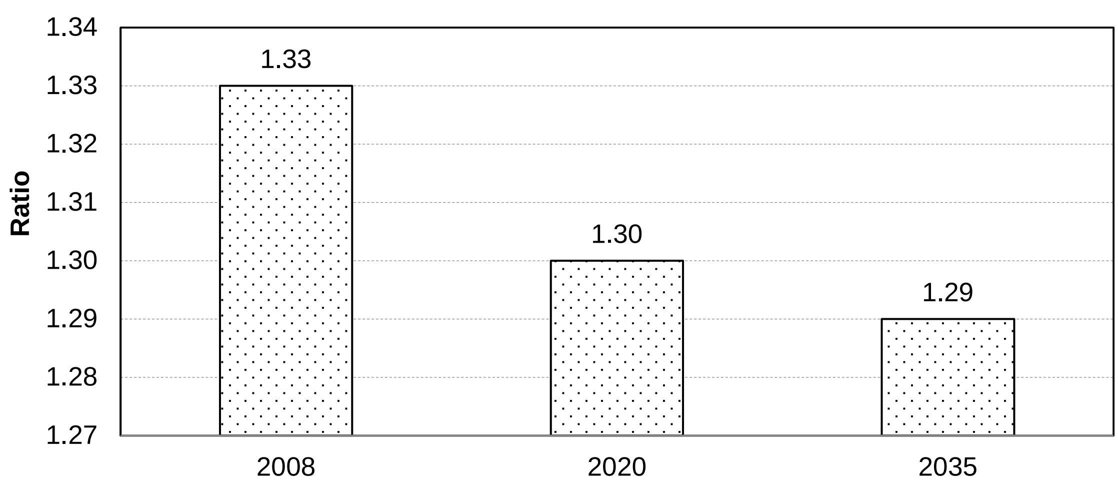
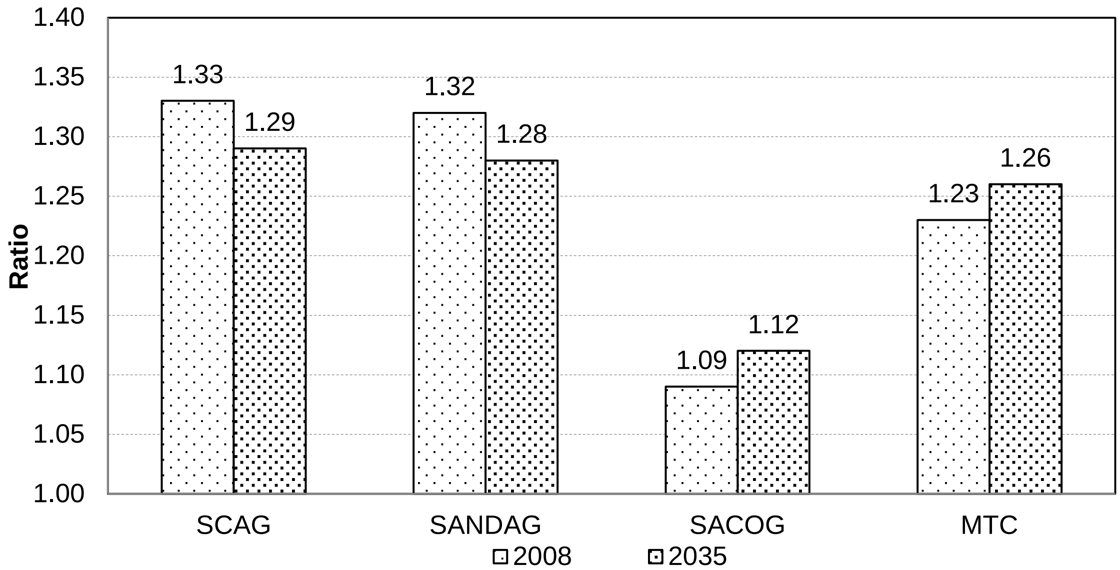


Figure 16 compares the jobs/housing ratio for the SCAG region to the three other largest MPOs in California. SCAG's projected jobs/housing ratio is similar to the projected jobs/housing ratio for the SANDAG and MTC regions. It is slightly higher compared to the SACOG region. Generally, the jobs/housing ratio for the SCAG region is consistent with those of the other largest MPOs in California.

Figure 16. Comparison of jobs/housing ratio with major MPOs in 2008 and 2035



Note: MTC ratio is estimated from 2010 data

The downward trend of the jobs/housing ratios over the period of the plan demonstrates that the future land use pattern, if implemented by local jurisdictions, will move the region toward a land use pattern that places job opportunities closer to housing opportunities. Based on the literature, this downward movement of the jobs/housing ratio over time suggests that commute trips could be shortened, thereby reducing VMT and GHG emissions.

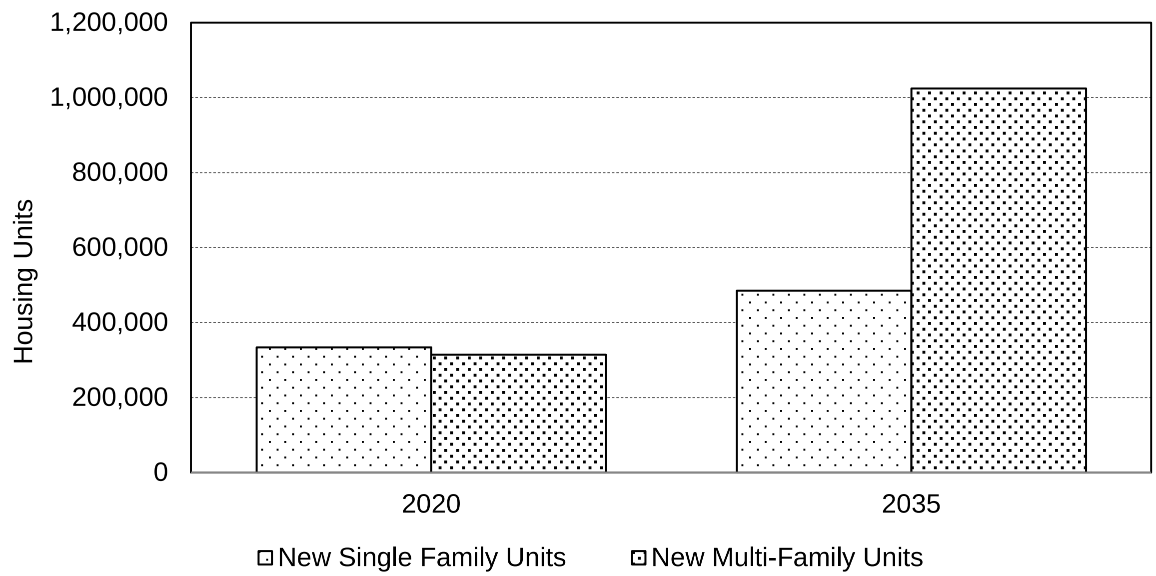
c) Changes in the mix of housing types

SCAG's 2012 RTP/SCS indicates the overall land use pattern will continue to be represented by existing single-family neighborhoods even as future growth and a more diverse housing stock are accommodated though infill density near transit stations. SCAG forecasts an increasing shift from single-family residential development towards multi-family residential development post-2020, in addition to an increase in small lot single family units.

The 2012 RTP/SCS estimates that 68 percent of new homes in the SCAG region in 2035 will be multi-family units, compared to 45 percent of multi-family housing units in 2008. Of the new housing units in 2035, the proportion of multi-family housing will significantly exceed the single-family housing. Figure 17 outlines the share of new single-family housing units and new multi-family housing units for 2020 and 2035 from the year 2008.

Because housing changes occur over the long-term, SCAG anticipates minor housing type changes for the year 2020, with housing type changes becoming more apparent by 2035.

Figure 17. Share of housing units between single and multi-family in the SCAG region for 2020 and 2035



The shift to new multi-family units reflects the projected long-term housing demand due to an anticipated increase in households without children, going from 68 percent in 2005 to 73 percent in 2040. SCAG also projects an increase in single-person households. This changing demographic is also expected to shift housing preference from suburban to urban. Changing demographics, in combination with changes in home mortgage finance, will lead to the majority of the housing demand being for rental housing with new housing formats, such as accessory dwelling units—which are additional living quarters on single-family lots that are independent of the primary dwelling unit.

d) Housing and employment in High Quality Transit Areas (HQTAs)

In developing the future land use pattern, SCAG assumed the majority of new housing and employment development will occur within areas close to transit access points. SCAG calls these areas “High Quality Transit Areas” (HQTA). SCAG defines these as areas within a half mile of a well-serviced transit stop. A well-serviced transit stop is one which has a 15 minute or less service frequency during peak commute hours. Focusing new growth in areas with good access to frequent transit service is a key SCS measure that SCAG hopes will encourage transit ridership and reduce or eliminate the need for vehicle trips, increase use of walking or biking, and maximize the benefits of a denser, more compact land use pattern.

Relevant empirical literature provides supporting evidence for the reduction trend SCAG anticipates in GHG emissions. Proximity of housing and employment to transit is a commonly-used performance measure for evaluating the effectiveness of transit oriented development (TOD). The empirical literature indicates that commuters living within a TOD area use transit two to five times more than do other commuters in the region. Moreover, the literature shows that proximity of housing and employment to transit stations is highly correlated with increased transit ridership. Transit ridership sharply increases as housing and employment increases within a one mile radius of transit stations (Kolko 2011). Other studies show significant VMT reductions for placement of housing and employment closer to rail stations and bus stops (Tal, et.al 2010). In the SCAG region, the percentage of housing within a half mile of a transit station in HQTAs was less than 44 percent in 2008. SCAG projects that this will increase to nearly 50 percent in 2020 and over 53 percent in 2035. Similarly, the percentage of employment within a half mile of a transit station in 2008 was 52 percent but SCAG projects this to increase to nearly 60 percent in 2020 and over 63 percent by 2035.

Figures 18 and 19 illustrate housing and employment growth in the SCAG region from 2008 to 2035 in relation to the existing and future HQTAs. SCAG's future land use pattern focuses growth near existing and planned transit areas.

Figure 18. Housing growth in the SCAG region between 2008 and 2035

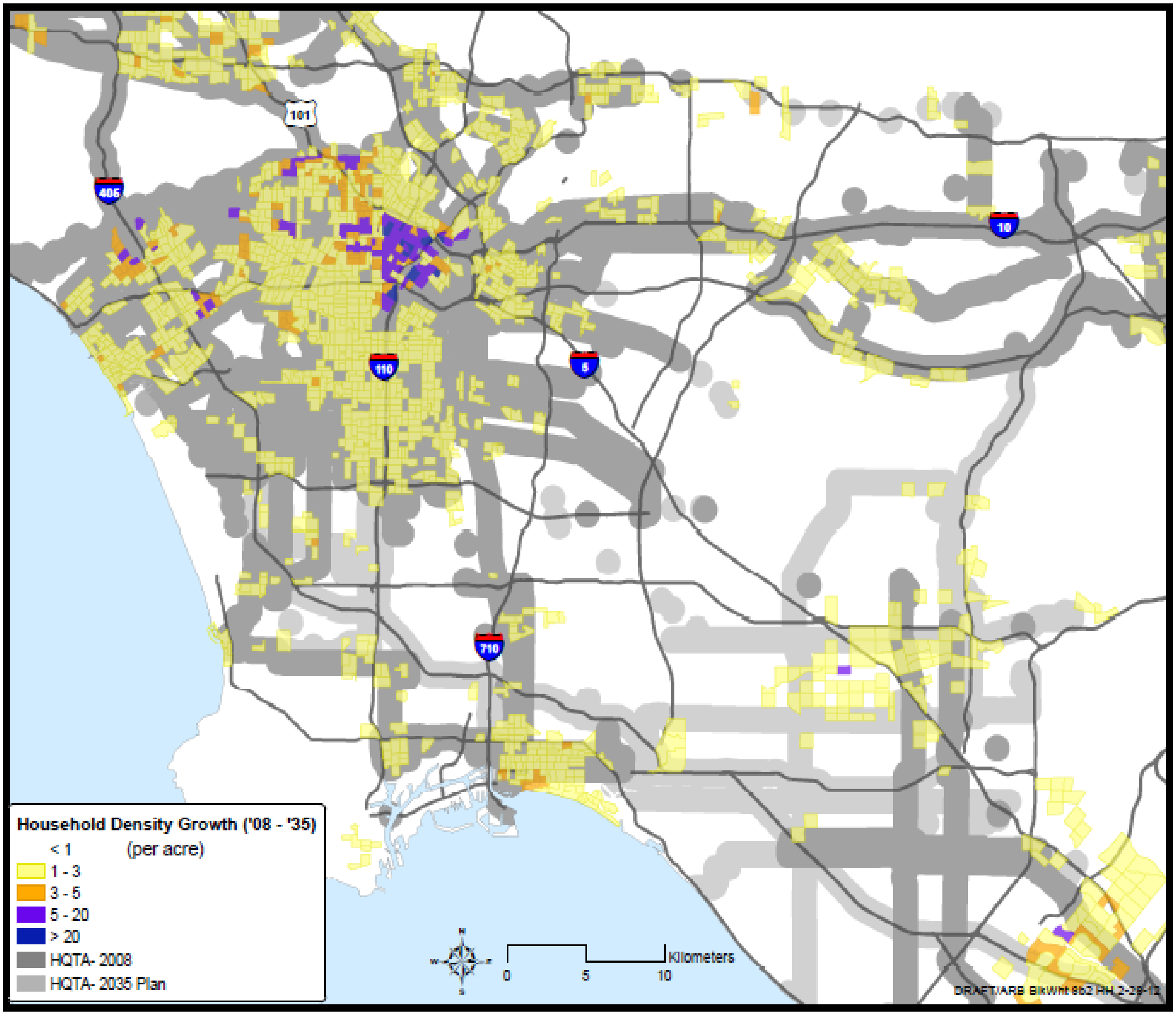
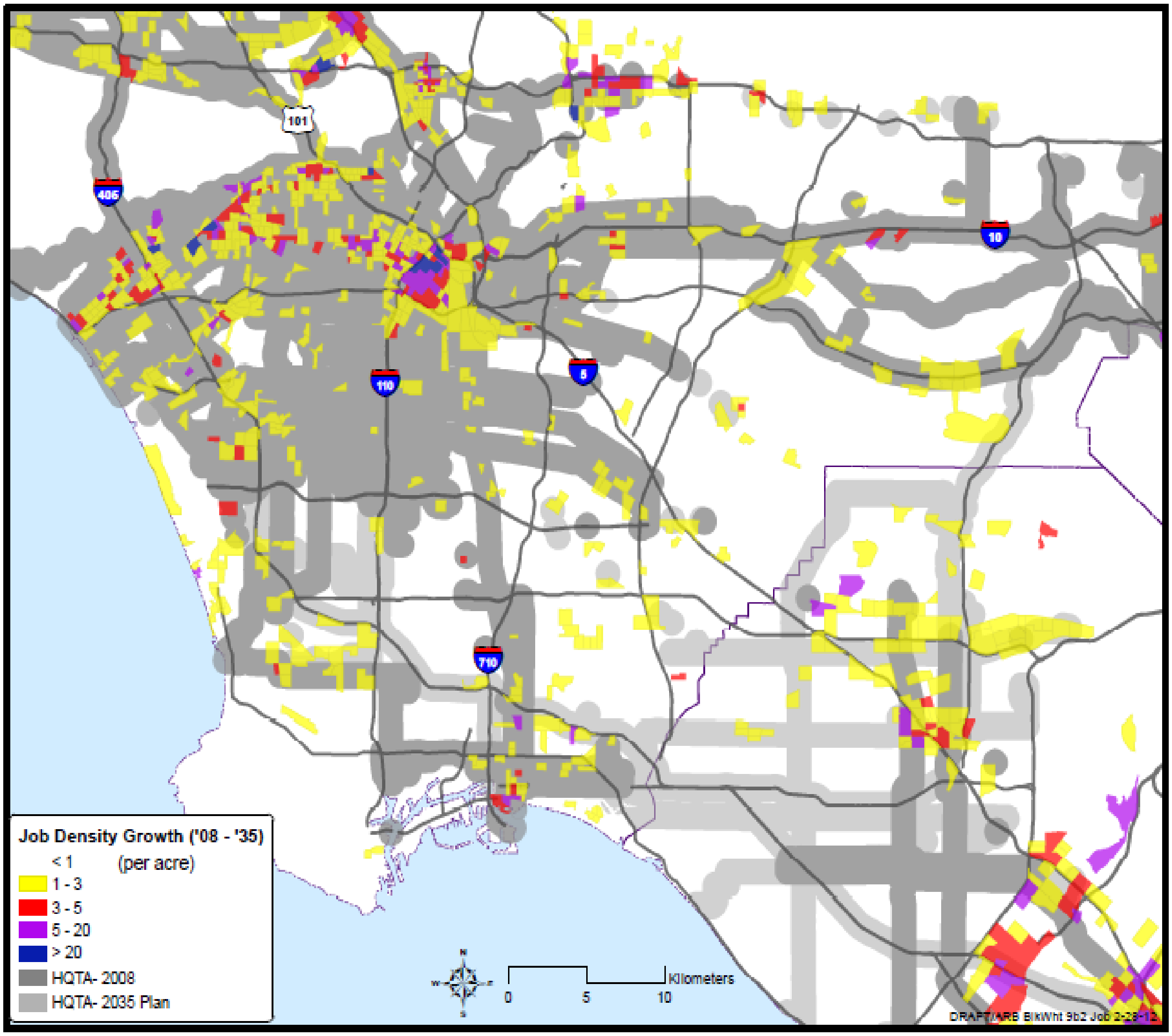


Figure 19. Employment growth in the SCAG region between 2008 and 2035



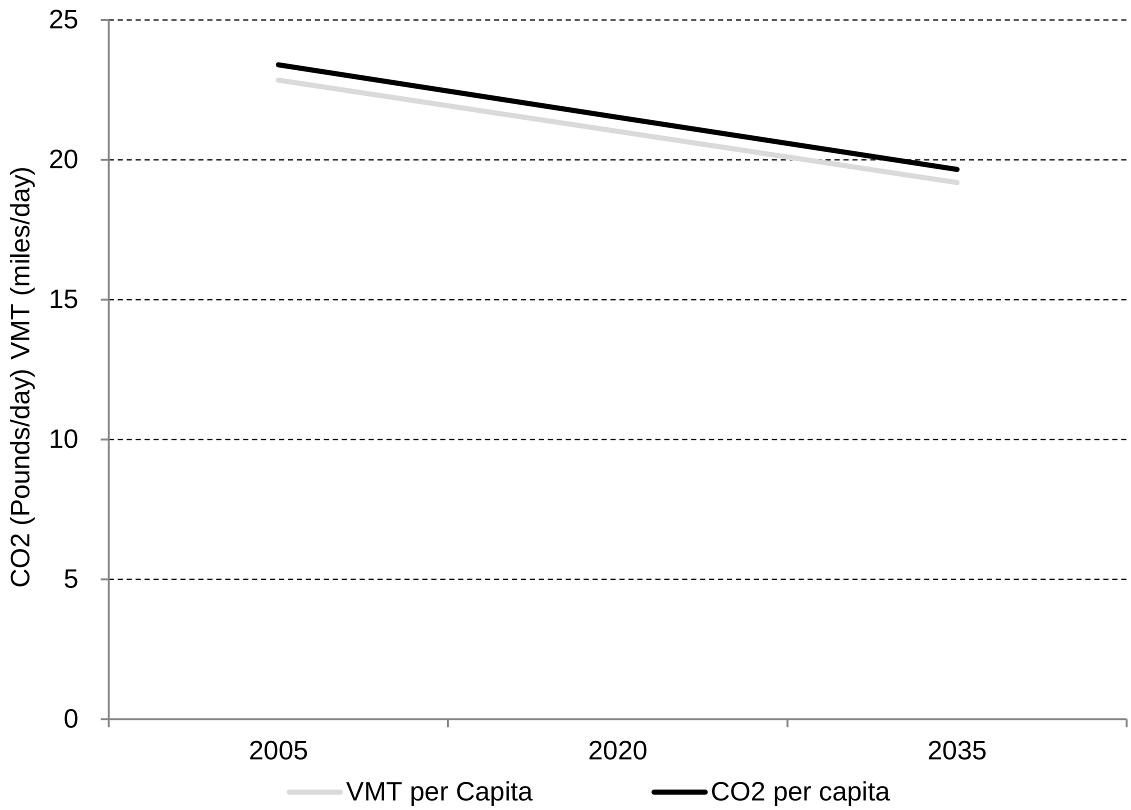
2. Transportation-Related Indicators

Six performance indicators related to the transportation system along with supporting data inputs, assumptions, and sensitivity analyses were evaluated. These indicators are passenger VMT, passenger mode share, vehicle delay by facility, and travel time along selected corridors.

a) Passenger Vehicle Miles Traveled

The SCAG SCS reports a VMT per capita trend that closely follows the trend in CO2 per capita emissions, showing a decline in both per capita CO2 emissions and VMT between 2020 and 2035 (Figure 20). Its direct relationship to vehicle CO2 emissions is particularly important. The quantification of CO2 emissions from passenger vehicles is a function of VMT and vehicle speeds.   Roadway conditions such as traffic congestion, maintenance activities, and construction on any given road segment will affect the speed profile of that road, and can influence the vehicle's GHG emissions.

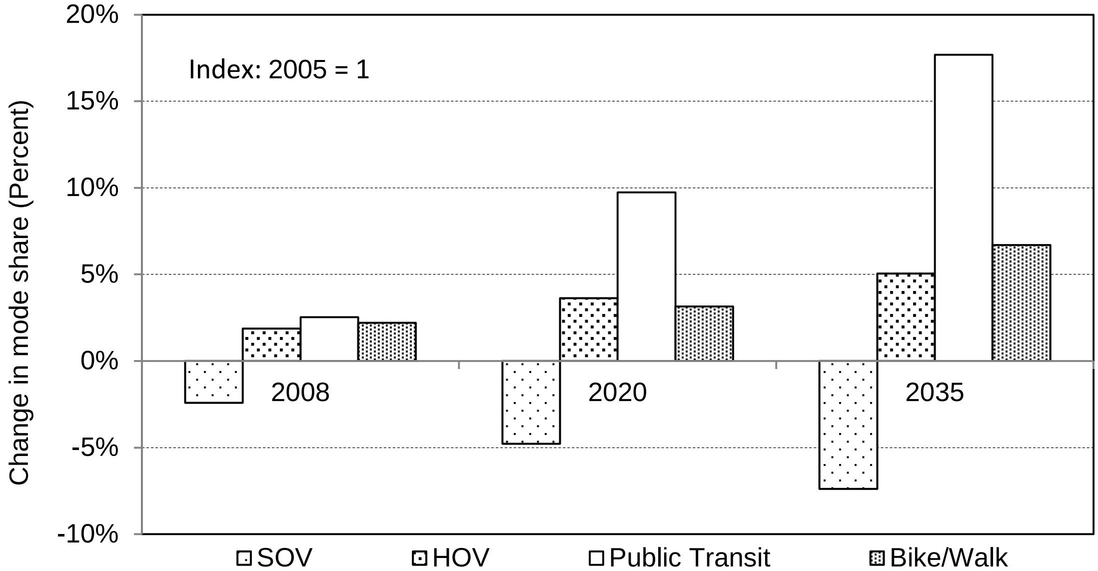
Figure 20. Per Capita Passenger VMT and CO_2 Trends



b)   Passenger Mode Share

Mode share is a critical performance indicator to understand the effectiveness of new investments in transit. Figure 21 depicts the change in mode share during the peak commute period in 2008, 2020, and 2035 compared to the 2005 base year. As the figure illustrates, single occupant vehicle (SOV) share of total trips declines, whereas the share of public transit use increases significantly (about 17 percent).   Over the 30-year period, the share of SOV would decrease by 7.4 percent and bike/walk share would increase by 6.7 percent. The declines in SOV are matched by an increase in high occupancy vehicle (HOV) share. The increase in transit ridership and bike/walk are also due to an increase in population. These trends further support the GHG emissions reductions estimated to results from implementation of the SCS.

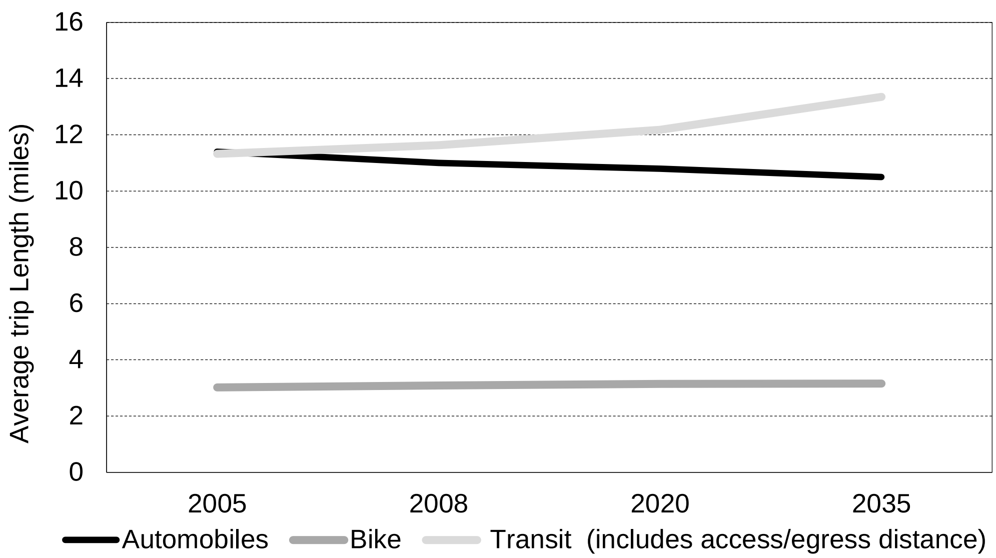
Figure 21. Mode share change during peak period relative to 2005



c) Average trip length

Figure 22 shows the change in average trip length by mode for all trip purposes in the SCAG region. The data shows that the average trip length for the transit mode increases by 18 percent between 2005 and 2035, while during the same time period, automobile trip length decreases by 8 percent. The average trip lengths remain relatively stable for the bike mode. These trends support the GHG emissions reductions estimated for the SCAG region.

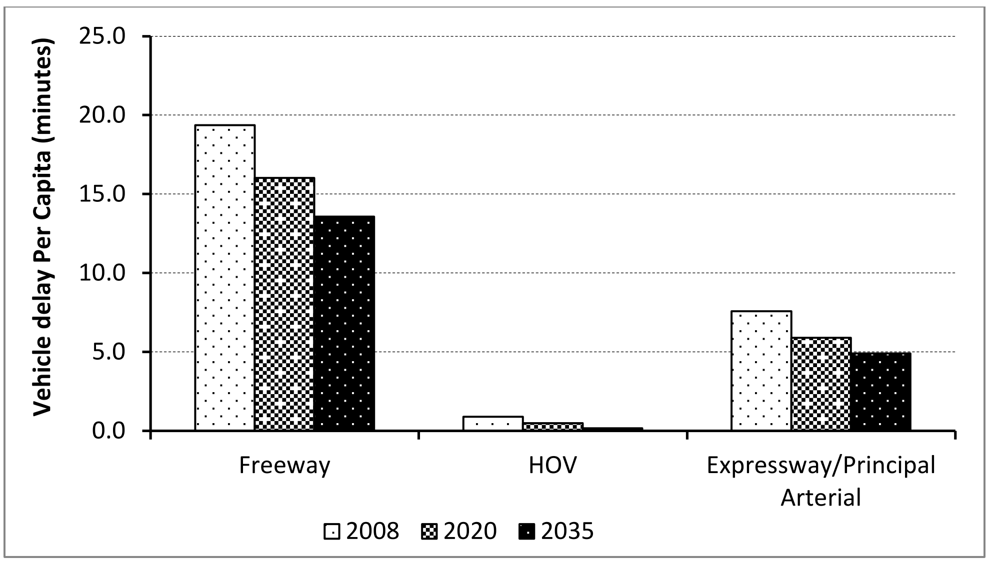
Figure 22. Average trip length by mode in SCAG region



d) Vehicle delay by facility

Vehicle delay is characterized by slower speed, longer travel times, and increased queuing. It is calculated by determining the difference between the estimated travel time under free flow conditions and congested conditions. This indicates the level of traffic demand and the available capacity by facility. Figure 23 demonstrates the vehicle delay in the SCAG region by facility type. Vehicle delay in the freeway system declines by 9 percent and 13 percent in 2020 and 2035, respectively, compared to 2008. Similarly, in arterial streets, vehicle delay declines by 16 percent and 22 percent during the same time periods. This indicates that the overall traffic flow in the network improves, which helps to reduce the GHG emissions in the SCAG region.

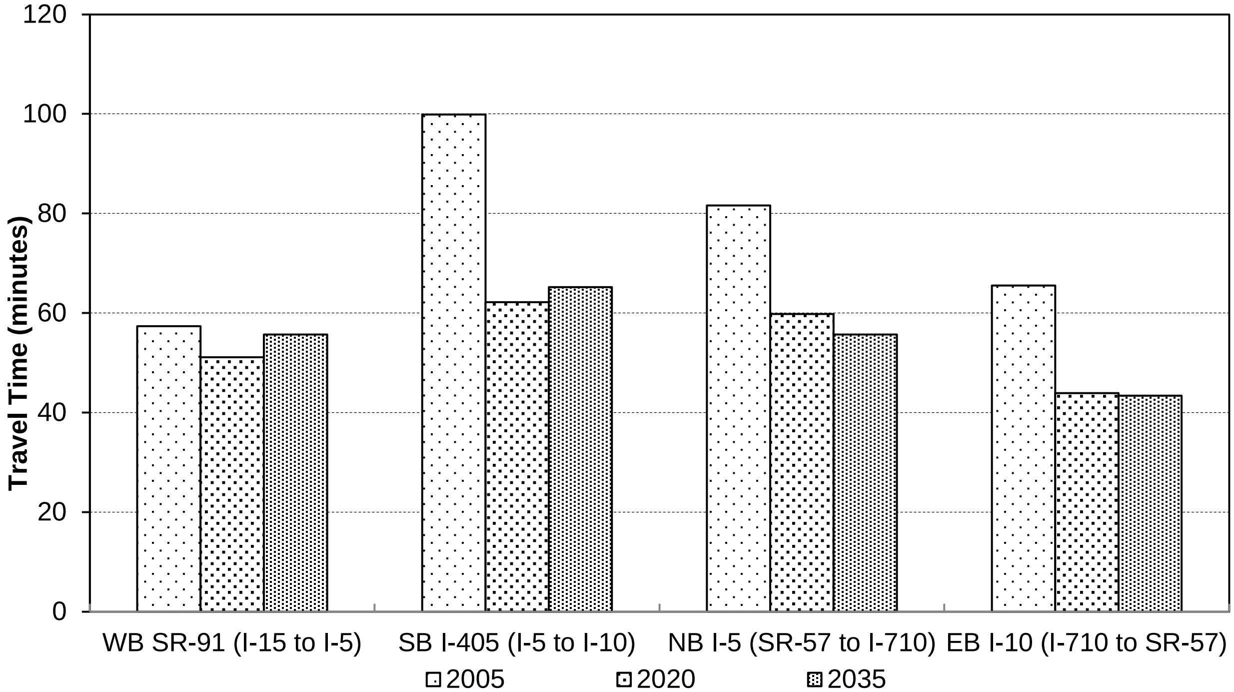
Figure 23. Vehicle delay by facility in SCAG region



e) Travel time along selected corridors

Travel time is an indicator of the efficiency of a transportation system. It measures the commuter's travel experience and how congestion affects users. Travel time is influenced by the speed at which the vehicle travels and any delays due to congestion in the corridors. Figure 24 shows the predicted recurrent congestion in selected corridors in the region between 2005 and 2035. This does not include non-recurrent congestion due to accidents, special events, or weather related delays. As shown in Figure 25, by 2020 and 2035, travel time would be reduced 3 to 38 percent compared to 2005 along selected corridors. The overall increase in speed from slower and heavily congested conditions could reduce fuel consumption and GHG emissions. Better fuel economy may lead to more driving in a long-term which may still be less than before due to efficient operating speed. A study by Barth and Boriboonsomsin (2008) in Southern California has estimated that speed management could reduce 7 to 12 percent of CO2 emissions. Further discussion about the induced demand is presented in modeling tools section.

Figure 24. Travel time in SCAG region along selected corridors



f) Active transportation

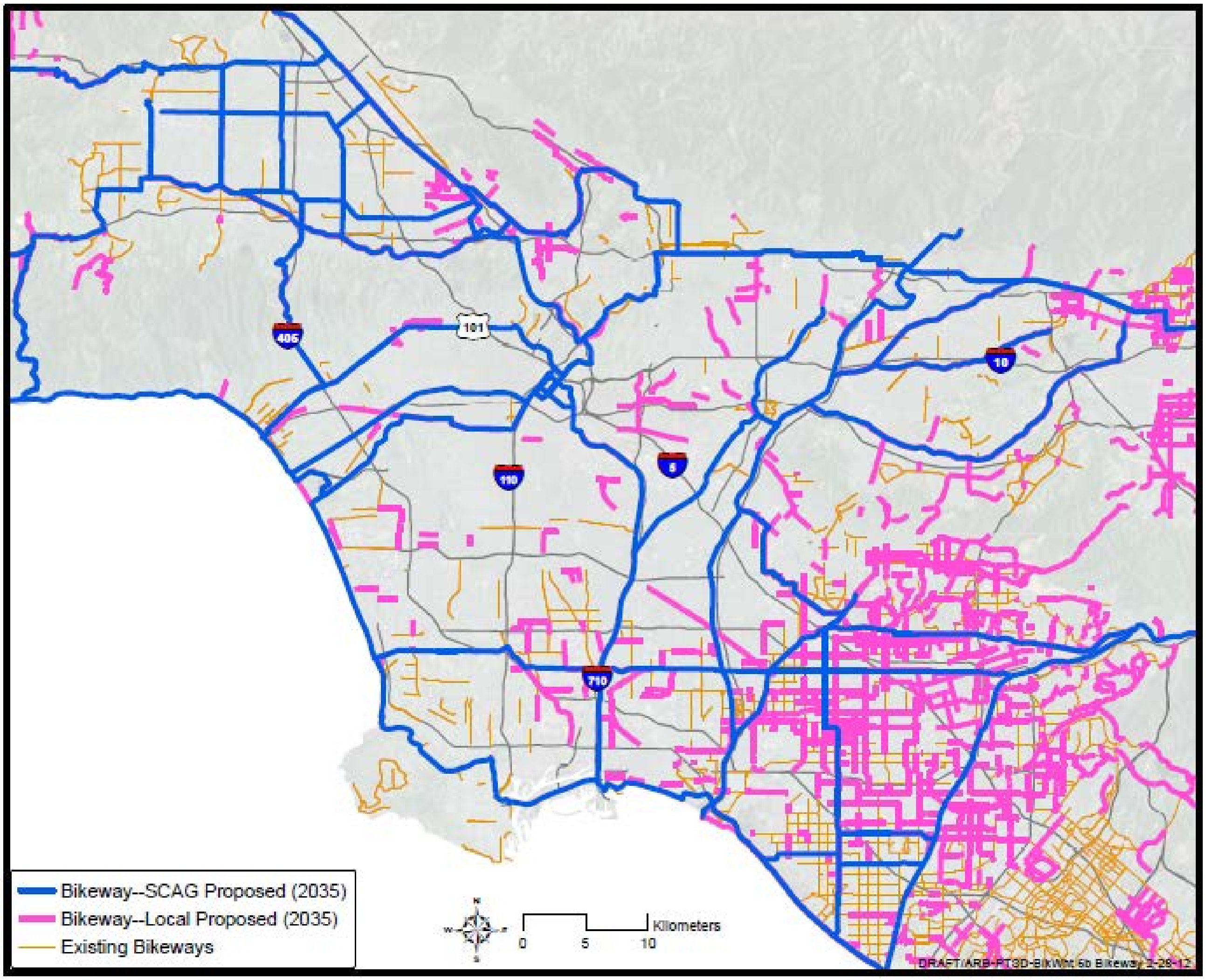
Active transportation methods refer to a variety of modes of travel that are generally human powered, such as bicycling and walking. In most cases, when a person chooses to replace a car trip with a bike or walk trip to a destination, passenger VMT is reduced, along with GHG emissions. In reviews of the empirical literature related to the impacts of putting bicycling- and pedestrian-related strategies in place, Handy, Sciara, et.al. (2010, 2011) found that a variety of strategies have the potential to reduce vehicle trips and VMT. Increasing the number of miles of bikeways and sidewalks, making changes to existing bike/pedestrian infrastructure to improve the safety, security, or comfort of cyclists and pedestrians, or creating better bike/pedestrian links to transit stations are among the strategies that have been found to increase the likelihood of a shift in trips from cars to bicycles, walking, and/or transit.

SCAG's SCS focuses on developing a network of bicycle and pedestrian facilities that connect adjoining communities together, providing better bike/walk access to transit facilities, maintaining the existing bike/walk facilities, and creating a safer and more secure active transportation system. SCAG's SCS includes more than 5,800 miles of new bikeways throughout the region, more than doubling the existing number of miles since 2008, bringing the total to 10,122 miles of bikeways throughout the SCAG region. In addition, SCAG's 2012 RTP/SCS proposes 12,000 miles of existing sidewalk upgrades to address Americans with Disabilities Act requirements. SCAG's 2012 RTP/SCS includes a significant commitment of $6.7 billion dedicated to active transportation measures. This is more than three times the expenditures called for in the 2008 RTP. With these proposed additions to the active transportation infrastructure, SCAG expects about a 1 percent reduction in per capita GHG emissions. Table 31 and Figure 25 provide details about the existing and proposed bicycle infrastructure.

Table 31. Existing and Proposed Miles of Bikeways by 2035

2035 (Proposed)				
	Existing (2008)	**Local Jurisdictions**	**SCAG (Regional connections only)**	**Total Regional Bicycle Network Miles**
Miles	4,315	4,980	827	10,122

Figure 25. Existing and Proposed 2035 Bikeways in Los Angeles and Orange County Areas



Based on a study "The New Transit Town: Best Practices in Transit-Oriented Development" (Ohland, 2004) showing that people are willing to walk up to a half mile to access transit, SCAG mapped locations within a half mile of all transit stops, and calculated the percentage of the population that has access to transit by walking (85.7 percent), based on existing bikeways in 2008. In addition, based on recommendations by the Mineta Transportation Institute "Envisioning Neighborhoods with Transit-Oriented Development Potential" (2002) showing that people are willing to ride a bicycle up to two miles to a transit station, SCAG mapped locations within two miles of all transit stations, based on existing bikeways in 2008, and calculated the percentage of the population that has access to transit by bicycle (97.0 percent). SCAG also considered the distance that bicyclists would need to travel to have access to a bikeway. According to the Oregon Transportation Research and Education Consortium (2008), "access" to a bikeway is considered to be no more than 0.27 miles and found that only 42.6 percent of the region's population has such access to bikeways existing in 2008. However, upon implementation of just those bikeway additions proposed by the local jurisdictions, 62.4 percent of the region's residents will be within 0.27 miles of bikeways. SCAG recognizes, however, that even with such access to transit stops, people may not utilize transit, as it may not provide the particular connections to work, school, or other destinations that they need. SCAG notes the need for additional analysis regarding the adequacy of access to transit via bicycle and pedestrian facilities.

Notwithstanding the need for further analysis, by increasing the opportunities for bicycling and walking, including providing a greater connectivity with transit, SCAG expects a slight increase in the bike/walk mode share, with a 0.3 percent increase by 2020 and a 0.6 percent increase by 2035 (Table 32). Although the change in mode share is relatively small, the significant increase in bikeway and sidewalk miles, and the significant increase in dollars dedicated to active transportation in the 2012 RTP/SCS do provide additional qualitative supporting evidence that GHG emissions reductions will occur from the active transportation strategies included in the 2012 RTP/SCS.

Table 32. Bike/Walk Mode Share

	2005	2008	2020 with project	2020 without project	2035 with project	2035 without project
Non-Motorized: Bike	0.99%	1.01%	1.04%	1.04%	1.07%	1.06%
Non-Motorized: Walk	8.58%	8.77%	8.83%	8.76%	9.14%	9.10%
Totals	9.57%	9.78%	9.87%	9.80%	10.21%	10.16%

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Appendix A. 2010 CTC RTP Guidelines Addressed in SCAG's RTP

This Appendix lists the requirements in the California Transportation Commission's (CTC) Regional Transportation Planning (RTP) Guidelines that are applicable to the SCAG regional travel demand model, and which SCAG followed. In addition, listed below are the recommended practices from the CTC RTP Guidelines that SCAG incorporated into its modeling system.

Requirements

- Each MPO shall model a range of alternative scenarios in the RTP Environmental Impact Report based on the policy goals of the MPO and input from the public.
- MPO models shall be capable of estimating future transportation demand at least 20 years into the future. (Title 23 CFR Part 450.322(a))
- For federal conformity purposes, each MPO shall model criteria pollutants from on-road vehicles as applicable. Emission projections shall be performed using modeling software approved by the EPA. (Title 40 CFR Part 93.111(a))
- Each MPO shall quantify the reduction in greenhouse gas emissions projected to be achieved by the SCS. (California Government Code Section 65080(b)(2)(G))
- The MPO, the state(s), and the public transportation operator(s) shall validate data utilized in preparing other existing modal plans for providing input to the regional transportation plan. In updating the RTP, the MPO shall base the update on the latest available estimates and assumptions for population, land use, travel, employment, congestion, and economic activity. The MPO shall approve RTP contents and supporting analyses produced by a transportation plan update. (Title 23 CFR Part 450.322(e))
- The metropolitan transportation plan shall include the projected transportation demand of persons and goods in the metropolitan planning area over the period of the transportation plan. (Title 23 CFR Part 450.322(f)(1))
- The region shall achieve the requirements of the Transportation Conformity Regulations of Title 40 CFR Part 93.
- Network-based travel models shall be validated against observed counts (peak- and off-peak, if possible) for a base year that is not more than 10 years prior to the date of the conformity determination. Model forecasts shall be analyzed for reasonableness and compared to historical trends and other factors, and the results shall be documented. (Title 40 CFR Part 93.122 (b)(1)(i))
- Land use, population, employment, and other network-based travel model assumptions shall be documented and based on the best available information. (Title 40 CFR Part 93.122 (b)(1)(ii))
- Scenarios of land development and use shall be consistent with the future transportation system alternatives for which emissions are being estimated. The distribution of employment and residences for different transportation options shall be reasonable. (Title 40 CFR Part 93.122(b)(1)(iii))

- A capacity-sensitivity assignment methodology shall be used, and emissions estimates shall be based on methodology which differentiates between peak- and off-peak link volumes and speeds and uses speeds based on final assigned volumes. (Title 40 CFR Part 93.122 (b)(1)(iv))
- Zone-to-zone travel impedance used to distribute trips between origin and destination pairs shall be in reasonable agreement with the travel times that are estimated from final assigned traffic volumes. (Title 40 CFR Part 93.122(b)(1)(v))
- Network-based travel models shall be reasonably sensitive to changes in the time(s), cost(s), and other factors affecting travel choices. (Title 40 CFR Part 93.122 (b)(1)(vi))
- Reasonable methods in accordance with good practice shall be used to estimate traffic speeds and delays in a manner that is sensitive to the estimated volume of travel on each roadway segment represented in the network-based travel model. (Title 40 CFR Part 93.122(b)(2))
- Highway Performance Monitoring System (HPMS) estimates of vehicle miles travel (VMT) shall be considered the primary measure of VMT within the portion of the nonattainment or maintenance area and for the functional classes of urban area basis. For areas with network-based travel models, a factor (or factors) may be developed to reconcile and calibrate the network-based travel model estimates of VMT in the base year of its validation to the HPMS estimates for the same period. These factors may then be applied to model estimates of future VMT. In this factoring process, consideration will be given to differences between HPMS and network-based travel models, such as differences in the facility coverage of the HPMS and the modeled network description. Locally developed count-based programs and other departures from these procedures are permitted subject to the interagency consultation procedures of Section 93.105(c)(1)(i). (Title 40 CFR Part 93.122(b)(3))

Recommendations

- During the development period of more sophisticated/detailed models, there may be a need to augment current models with other methods to achieve reasonable levels of sensitivity. Post-processing should be applied to adjust model outputs where the models lack capability, or are insensitive to a particular policy or factor. The most commonly referred to post-processor is a “D’s” post-processor, but post-processors could be developed for other non-D factors and policies, too.
- The models should address changes in regional demographic patterns.
- Measures of means of travel should include percentage share of all trips (work and non-work) made by all single occupant vehicle, multiple occupant vehicle, or carpool, transit, walking, and bicycling.
- To the extent practical, travel demand models should be calibrated using the most recent observed data including household travel diaries, traffic counts, gas receipts, Highway Performance Monitoring System (HPMS), transit surveys, and passenger counts.

- It is recommended that transportation agencies have an on-going model improvement program to focus on increasing model accuracy and policy sensitivity. This includes on-going data development and acquisition programs to support model calibration and validation activities.
- Agencies are encouraged to participate in the California Inter-Agency Modeling Forum. This venue provides an excellent opportunity to share ideas and help to ensure agencies are informed of current modeling trends and requirements.
- MPOs should work closely with state and federal agencies to secure additional funds to research and implement the new land use and activity-based modeling methodologies. Additional research and development is required to bring these new modeling approaches into mainstream modeling practice.
- The travel model set should be run to a reasonable convergence towards equilibrium across all model steps.
- A simple freight model should be developed and used.
- Several employment types should be used, along with several trip purposes.
- The models should have sufficient temporal resolution to adequately model peak and off-peak periods.
- Agencies should, at a minimum, have four-step models with full feedback across travel model steps and some sort of land use modeling.
- In addition to the conformity requirements, these regions should also add an auto ownership step and make this step and the mode choice equations for transit, walking and bicycling and the trip generation step sensitive to land use variables and transit accessibility.
- Small Traffic Analysis Zones (TAZ) should be used, to increase sensitivity to infill potential near to rail stations and in Bus Rapid Transit (BRT) corridors. Parking quantity and cost should be represented in the travel model.
- The carpool mode should be included, along with access-to-transit sub modes.
- Feedback loops should be used and take into account the effects of corridor capacity, congestion and bottlenecks on mode choice, induced demand, induced growth, travel speed and emissions.
- Freight models should be implemented in the short term and commodity flows models within a few years.
- Simple Environmental Justice analyses should be done using travel costs or mode choice log sums, as in Group C. Examples of such analyses include the effects of transportation and development scenarios on low-income or transit-dependent households, the combined housing/transportation cost burden on these households, and the jobs/housing fit.
- Household travel surveys should be activity-based and include a tour table. GPS sampling is encouraged or extra emphasis should be placed on accurate geocoding of households, workplace locations, and stops. Regions should take care in the design and data collection procedures of the survey to ensure survey results are appropriate to the type of model being utilized. Coordination with Caltrans' travel survey efforts is encouraged.

Appendix B. SCAG's Modeling Parameters for SCS Evaluation (Data Table)

This appendix contains SCAG's responses to data requests, received on March 5, 2012, to supplement ARB staff's evaluation of SCAG's quantification of GHG emissions. ARB requested this data in accordance with the general approach described in ARB's July 2011 evaluation methodology document.

Modeling Parameters	2005	2008	2020		2035		Data Source(s)
	If available	Base Year	With Project[1]	Without Project[2]	With Project[1]	Without Project[2]	
DEMOGRAPHIC							
Total population (000s)	17,498	17,892	19,700	19,700	22,146	22,146	SCAG 2012 RTP Growth Forecast
Group quarters (000s)	334	337	350	350	367	367	SCAG 2012 RTP Growth Forecast
Total number of households (000s)	5,650	5,814	6,462	6,462	7,323	7,323	SCAG 2012 RTP Growth Forecast
Persons per household	3.04	3.02	2.99	2.99	2.97	2.97	SCAG 2012 RTP Growth Forecast
Auto ownership per household	1.97	1.97	1.95	1.95	1.89	1.92	SCAG Travel Demand Department
Total number of jobs (000s)	7,771	7,738	8,417	8,417	9,436	9,436	SCAG 2012 RTP Growth Forecast
Average unemployment rate (%)	5.1	7.3	5.0	5.0	5.0	5.0	SCAG 2012 RTP Growth Forecast
Weighted Median household income ($)	52,712	52,811	52,350	52,350	52,222	52,234	SCAG 2012 RTP Growth Forecast
LAND USE							
Total Households (000s)	5,650	5,814	6,462	6,462	7,323	7,323	
Total acreage developed	1,695,360	1,767,680	2,003,840	2,064,000	2,209,920	2,396,160	SCAG Rapidfire
Total acreage available for new development	N/A	4,115,454	N/A	3,546,322	3,615,831	3,218,711	SCAG

Modeling Parameters	2005 If available	2008 Base Year	2020 With Project[1]	 Without Project[2]	2035 With Project[1]	 Without Project[2]	Data Source(s)
All transit stations and stops [3]							
Percent housing within 1/4 mile of transit stations	N/A	66.9	65.8	64.9	65.1	62.2	SCAG Comprehensive Planning
Percent housing within 1/2 mile of transit stations	N/A	83.8	82.5	81.8	82.1	79.2	SCAG Comprehensive Planning
Percent employment within 1/4 mile of transit stations	N/A	75.6	74	74.2	72.3	73.1	SCAG Comprehensive Planning
Percent employment within 1/2 mile of transit stations	N/A	90	88.9	89.4	87.4	88.5	SCAG Comprehensive Planning
Transit stations and stops in HQTA [4]							
Percent housing within 1/2 mile of transit stations and stops	N/A	39.9	44.2	39.2	51.1	37.5	SCAG Comprehensive Planning
Percent employment within 1/2 mile of transit stations	N/A	49	55.7	49.4	61.7	47.6	SCAG Comprehensive Planning
Fixed guideway transit station							
Percent housing within 1/4 mile of transit stations	N/A	1.5	2.4	1.7	3	1.8	SCAG Comprehensive Planning
Percent housing within 1/2 mile of transit stations	N/A	5.6	8.5	6.1	10.1	6.3	SCAG Comprehensive Planning
Percent employment within 1/4 mile of transit stations	N/A	4	6.7	4.2	6.8	4.1	SCAG Comprehensive Planning
Percent employment within 1/2 mile of transit stations	N/A	10.3	16.5	11.2	17.3	10.8	SCAG Comprehensive Planning
Multifamily and Other Households (000s)	2,560	2,621	2,935	2,935	3,645	3,645	SCAG 2012 RTP Growth Forecast

Modeling Parameters	2005 If available	2008 Base Year	2020 With Project[1]	2020 Without Project[2]	2035 With Project[1]	2035 Without Project[2]	Data Source(s)
Single family Households (000s) units	3,090	3,193	3,527	3,527	3,678	3,678	SCAG 2012 RTP Growth Forecast
Acreage of land zoned (used and available) for mixed use	N/A	1,245	N/A	N/A	129,535	129,535	SCAG Existing And General Plan Land Use
High Quality Transit Areas							
Percent new housing (08-20) in HQTA [5]	N/A	N/A	34.9	25.6	--	--	SCAG Comprehensive Planning
Percent new housing (20-35) in HQTA [6]			--	--	59.5	31.4	
Average density- dwelling units per acre Per residential land designations of General Plan (residential land, mixed use & specific Plan)	N/A	6.09	6.74	6.56	7.54	7.24	SCAG (LSPT Model estimation)
TRANSPORTATION SYSTEM							SCAG Travel Demand Department
Freeway general purpose lanes - mixed flow, auxiliary, etc. (lane miles)	10,795	10,919	11,493	11,078	11,811	11,103	
Freeway managed lanes--HOV, HOT, Tolled, etc. (lane miles)	1,082	1,205	2,121	1,574	2,931	1,609	
Major Arterial / Expressway (lane miles)	16,139	16,203	17,665	16,595	17,866	16,595	
Minor Arterial (lane miles)	21,076	21,218	22,592	21,590	23,084	21,590	
Collectors (lane miles)	12,196	12,221	13,019	12,422	13,475	12,422	
Locals (lane miles)	5114	5117	5117	5126	5131	5126	
Regular transit bus operation miles	644,263	644,555	676,835	647,045	707,405	647,045	
Bus rapid transit bus operation miles	NA	6,089	21,384	14,276	21,384	14,276	
Express bus operation miles	102,510	103,923	111,533	103,911	153,485	103,911	
Transit rail operation miles	32,431	32,431	108,549	61,411	129,226	61,411	
Bike lane miles	NA	4,315	6,000	5,358	10,122	6,661	

Modeling Parameters	2005 If available	2008 Base Year	2020 With Project[1]	2020 Without Project[2]	2035 With Project[1]	2035 Without Project[2]	Data Source(s)
TRIP DATA							
Number of trips by trip purpose							
- Home-based work	11,796,849	11,701,523	12,011,687	13,037,425	12,279,715	13,844,210	SCAG Travel Demand Department
- Home-based school	4,851,705	4,851,705	5,050,500	5,050,500	5,527,741	5,527,741	
- Home-based college	687,314	687,731	702,497	702,768	742,895	743,414	
- Home-based shopping	5,148,956	5,349,090	5,916,734	5,923,185	6,632,454	6,674,703	
- Home-based recreational	4,741,362	4,922,616	5,397,740	5,407,317	6,027,619	6,081,044	
- Home-based others	13,319,745	13,836,653	15,078,174	15,107,240	16,849,850	17,023,415	
- Non home-based other	17,544,516	18,031,179	19,883,895	19,905,021	22,090,943	22,144,982	SCAG Travel Demand Department
By travel mode							
Average auto trip length (miles)	11.4	11	10.8	11	10.5	10.7	
Average walk trip length (miles)							
Average bike trip length (miles)	3.02	3.09	3.15	3.14	3.16	3.11	SCAG Travel Demand Department
Average transit trip length (miles) (includes access/egress distance)	11.3	11.6	12.2	12.4	13.4	13.0	
Average auto travel time (minutes)	19.3	18.6	17.5	18.2	16.4	18.7	
Average walk travel time (minutes)	N/A	N/A	N/A	N/A	N/A	N/A	
Average bike travel time (minutes)	18.1	18.6	18.9	18.8	19	18.7	SCAG Travel Demand Department
Average transit travel time (minutes) (includes access/egress time and wait time)	63.9	64.9	64.9	66.7	65.5	69.1	

Modeling Parameters	2005 If available	2008 Base Year	2020 With Project[1]	2020 Without Project[2]	2035 With Project[1]	2035 Without Project[2]	Data Source(s)
PERCENT PASSENGER TRAVEL MODE SHARE (whole day)							
SOV	46.54%	45.24%	44.48%	45.12%	43.41%	44.53%	SCAG Travel Demand Department
HOV	41.87%	42.66%	43.30%	42.80%	43.86%	43.13%	
Public transit (Regular Bus)	1.71%	1.71%	1.64%	1.70%	1.71%	1.64%	
Public transit (Express Bus)	0.19%	0.19%	0.18%	0.18%	0.18%	0.18%	
Public transit (BRT)	0.00%	0.05%	0.04%	0.05%	0.04%	0.05%	
Public transit (Rail)	0.44%	0.46%	0.69%	0.55%	0.76%	0.57%	
Non-Motorized: Bike	0.91%	0.93%	0.96%	0.95%	0.99%	0.97%	
Non-Motorized: Walk	8.35%	8.58%	8.71%	8.64%	9.00%	8.93%	
PERCENT PASSENGER TRAVEL MODE SHARE (peak period)							SCAG Travel Demand Department
SOV	44.67%	43.59%	42.53%	43.34%	41.37%	42.59%	
HOV	42.99%	43.79%	44.55%	43.90%	45.16%	44.32%	
Public transit (Regular Bus)	1.92%	1.91%	1.82%	1.90%	1.93%	1.83%	
Public transit (Express Bus)	0.23%	0.23%	0.22%	0.23%	0.21%	0.22%	
Public transit (BRT)	0.00%	0.04%	0.05%	0.05%	0.04%	0.05%	
Public transit (Rail)	0.62%	0.66%	0.95%	0.79%	1.08%	0.83%	
Non-Motorized: Bike	0.99%	1.01%	1.04%	1.04%	1.07%	1.06%	
Non-Motorized: Walk	8.58%	8.77%	8.83%	8.76%	9.14%	9.10%	

Modeling Parameters	2005 If available	2008 Base Year	2020 With Project[1]	2020 Without Project[2]	2035 With Project[1]	2035 Without Project[2]	Data Source(s)
VEHICLE MILES TRAVELED (000s)					[7]		SCAG Travel Demand Department
Total VMT per weekday for passenger vehicles (ARB vehicle classes of LDA, LDT1, LDT2 and MDV) (miles)	399,661	402,642	423,906	436,624	449,934	479,772	
Total internal VMT per weekday for passenger vehicles (miles)	365,374	370,542	385,802	398,560	404,872	430,318	
Total IX/XI VMT per weekday for passenger vehicles (miles)	31,269	29,490	35,100	35,075	41,850	45,892	
Total XX VMT per weekday for passenger vehicles (miles)	3,018	2,610	3,004	2,989	3,212	3,562	
CONGESTED TRAVEL MEASURES							SCAG Travel Demand Department
Congested weekday VMT on freeways (miles, V/C ratios > 1)	54,093	57,304	53,509	74,626	51,870	73,815	
Congested VMT on all other roadways (miles, V/C ratios > 1)	24,254	24,820	21,743	29,142	21,428	43,418	
CO2 EMISSIONS[7] (000)							SCAG Travel Demand Department
Total CO2 emissions per weekday for passenger vehicles(ARB vehicle classes LDA, LDT1, LDT2, and MDV) (tons)	204.65	205.43	211.43	220.61	222.88	249.15	
Total Internal CO2 emissions per weekday for passenger vehicles (tons)	187.09	189.05	192.43	201.38	200.56	223.47	
Total IX / XI trip CO2 emissions per weekday for passenger vehicles (tons)	16.01	15.05	17.51	17.72	20.73	23.83	
Total XX trip CO2 emissions per weekday for passenger vehicles (tons)	1.55	1.33	1.50	1.51	1.59	1.85	

Modeling Parameters	2005 If available	2008 Base Year	2020 With Project[1]	2020 Without Project[2]	2035 With Project[1]	2035 Without Project[2]	Data Source(s)
INVESTMENT (Billions)							
Highway capacity expansion ($)	**Investment totals are evaluated for the entire duration of the Plan through the horizon year, not for a single year.**				$72.30	N/A	Draft 2012 RTP
Other road capacity expansion ($)	N/A	N/A	N/A	N/A	$22.10	N/A	Draft 2012 RTP
Transit capacity expansion ($)	N/A	N/A	N/A	N/A	$101.20	N/A	Draft 2012 RTP
Bus transit capacity expansion ($)	N/A	N/A	N/A	N/A	included in above	N/A	Draft 2012 RTP
Transit operations ($)	N/A	N/A	N/A	N/A	$139.30	N/A	Draft 2012 RTP
Rail transit operations ($)	N/A	N/A	N/A	N/A	included in above	N/A	Draft 2012 RTP
Bike and pedestrian projects ($)	N/A	N/A	N/A	N/A	$6.00	N/A	Draft 2012 RTP
Other ($)	N/A	N/A	N/A	N/A	$183.80	N/A	Draft 2012 RTP
TRANSPORTATION USER COSTS AND PRICING							
Vehicle operating costs (cents per mile; year 1999 constant $)	17.45	20.63	23.47	23.47	23.77	23.77	SCAG Travel Demand Department
Gasoline price ($2009 per gallon)	2.79	3.6	4.74	4.74	5.24	5.24	
Parking price ($ per day)	N/A	N/A	N/A	N/A	N/A	N/A	Draft 2012 RTP
Toll price ($)	N/A	N/A	N/A	N/A	N/A	appx. $0.20 to $0.50 per mile on various toll facilities--depends on facility	Draft 2012 RTP
Congestion price ($ per mile)	N/A	N/A	N/A	N/A	N/A	appx. $0.02per mile VMT starting 2025--depends on facility	Draft 2012 RTP

[1] This scenario includes modeling of proposed projects in RTP/SCS for respective calendar year.

[2] This scenario will exclude proposed projects in RTP/SCS for respective calendar year. In other words, do nothing.

[3] When all transit stations and stops area are considered, the shares of jobs and housing are lower in 2020 and 2035 than the existing 2008 for the following reasons: (a) our plans largely focus on high quality transit areas rather than all transit stations and stops, and ; (b) many inefficient or ineffective stations are removed in future years, while planned stations in 2020 and 2035 may not be all first tier stations as those existing.

[4] Due to the reasons stated in [3], the results of analysis based on transit stations and stops in HQTA are provided instead of all transit stations and stops, which better portray the impact of our policies and plans on density changes near transit stations and stops

[5] YR 2020 plan scenario allocates 34.9% of new housing anticipated from 2008 to 2020 in 2020 plan HQTA; YR 2020 trend base scenario allocates 25.6% of new housing anticipated from 2008 to 2020 in 2020 base HQTA

[6] YR 2035 plan scenario allocates 59.5% of new housing anticipated from 2020 to 2035 in 2035 plan HQTA ; YR 2035 trend base scenario allocates 31.4% of new housing anticipated from 2020 to 2035 in 2035 plan HQTA

[7] Does not include 4-D processing.