Reducing Greenhouse Gases from On Road Transportation in San Diego County

An Analysis of Local Government Policy Options

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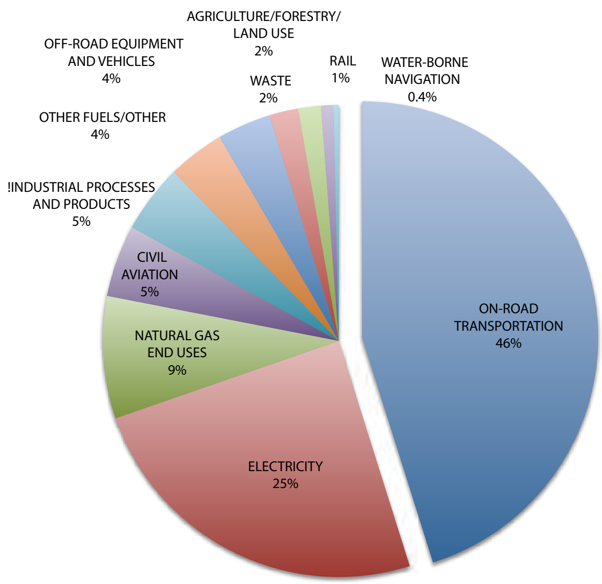
1 INTRODUCTION

In September 2008, the Energy Policy Initiatives Center (EPIC) released the San Diego County Greenhouse Gas Inventory report, a comprehensive assessment of greenhouse gas emissions in the region and to serve as a resource for local and regional decision makers as they consider ways to reduce emissions at the local and regional levels.[1] To that end, the project team had calculated historical greenhouse gas emissions from 1990 to 2006 using the best available data, and then estimated future emissions to 2020 for San Diego County. While many different sources emit greenhouse gases in San Diego County, only a few, and the same, sources account for the vast majority of emissions in San Diego County (Figure 1) during those years.

Figure 1 Greenhouse Gas Emissions by Source, San Diego County, 2006



The on-road transportation category – comprising cars and trucks – is by far the largest user of fossil fuels and the largest contributor of greenhouse gas emissions in the region, accounting for 46% of the total, almost twice as much as the next largest sector, electricity generation with 25% of the total. This follows the global trend,[2] the national trend in most countries (though not the US national trend[3]), and the California state trend. Tackling the emissions from on-road transportation therefore becomes a major challenge to achieve significant reductions in GHG emissions in the long run.[4]

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[1] EPIC Greenhouse Gas Inventory and Reduction Strategies, San Diego County, 2008, *available at*, www.sandiego.edu/epic/ghginventory.

[2] Climate Change 2007: Synthesis Report, Summary for Policymakers, IPCC 2007, *available at*, http://www.ipcc.ch/publications_and_data/publications_and_data_figures_and_tables_IPCC_AR4_synthesis_report_SYR.htm.

[3] The US on-road transportation GHG emissions constituted 30% of the total emissions in 2007, however electricity generation is the greatest GHG contributor, at 34%, to the US total due to the dependence on coal power. *See* 2009 GHG FastFacts at http://www.epa.gov/climatechange/emissions/usinventoryreport.html. California generates most of its electricity from natural gas.

[4] Recently the G8 group of wealthiest nations accepted that a 2 degree centigrade global mean temperature increase limit is essential to avoid dangerous consequences to climate change. This level forms the scientific

Although the California Global Warming Solutions Act of 2006, AB 32,[5] does not require individual sectors or jurisdictions (e.g., cities and counties) to reduce emissions by a specific amount, we applied the targets provided there to calculate the theoretical emissions reductions necessary in each emissions category (e.g., transportation, electricity, etc.) for San Diego County to reduce emissions to 1990 levels by 2020 – the statewide statutory target under AB 32. We also sought to identify and quantify potential broad emissions reduction strategies to determine the feasibility of reducing emissions to 1990 levels by 2020.

While a necessary step in the mitigation process, the Inventory report did not provide any specific analysis to help decision makers understand which policy actions would achieve the savings identified. Nor did it provide any way to prioritize activities and policies.

This report conducts more detailed analysis on a selection of strategies related to on-road transportation. Building on the results of the Inventory report, the purpose of this project was to conduct research to identify and assess the local policy options or measures that can contribute to the three most significant GHG reduction strategies identified in the inventory project for on-road transportation. All policy options evaluated in this report deal with mitigation measures, which complement any adaptation measures we may have to take in addition.[6] The purpose of this study is to assess local policy options based on their potential to reduce greenhouse gases, cost and time to implement, and experience by other jurisdictions to help decision makers prioritize mitigation actions.

Although the study is not intended to provide a detailed cost analysis of each policy, we make a preliminary attempt to provide cost information to help policy makers understand orders of magnitude for cost and GHG reduction potential. We did not develop a methodology to normalize costs across measures; therefore, direct comparison of the cost effectiveness of the measures cannot be made definitively. But estimates of orders of magnitude can be made. We use only the GHG reduction amounts to evaluate the benefits of a measure and other external benefits other than GHG reduction, such as reduction in criteria air pollutants, or labor productivity gains are excluded.

1.1 Purpose and Organization of the Report

Building on the results of the Inventory project, the purpose of this project was to conduct research to identify and assess the local policy options or measures that can contribute to the broad reduction strategies identified for on-road transportation. Following the Key Findings in Section 1.2, we present a brief summary of the inventory results and the GHG trends for the City of San Diego in Section 2. As the main driver of on-road transportation emissions is the ownership and use of private vehicles, we also address in this section the socio-economic relationships that affect the ownership and use of private vehicles as well as the policy implications of these relationships for San Diego County.

In Section 3 we discuss the potential interaction between vehicle miles traveled (VMT), fuel efficiency standards and alternative fuel use and how these might affect achieving the AB 32 target applied to San Diego County in 2020. In Sections 4 through 7 we present the evaluation of on-road transportation measures already being implemented (existing) that can reduce GHGs, those that are

basis of the 80% GHG reduction for 2050 that is the goal of California Executive Order S-03-05, *see*. http://www.cbc.ca/world/story/2009/07/09/g8-summit-italy-climate-change374.html.

[5] The text of Assembly Bill 32, the California Global Warming Solutions Act, is available at http://www.arb.ca.gov/cc/ab32/ab32.htm.

[6] For more on the potential regional effects of climate change, see San Diego's Changing Climate: A Regional Wake-Up Call – A Summary of the Focus 2050 Study Presented by the San Diego Foundation, available at http://www.sdfoundation.org/news/pdf/Focus2050glossySDF-ClimateReport.pdf.

planned that could reduce GHGs (planned) and those that could feasibly be planned and implemented (potential) that could contribute to GHG reduction. There are measures to reduce VMT, fuel use reduction measures, and pricing measures to reduce GHGs. Altogether we identified more than 100 policy options. However, as we focus on measures over which we have local control or local influence, this reduces the options considerably, and certain policies are subparts of a more major option better understood as a whole.

The measures that can contribute to achieving reductions within each strategy are analyzed according to the following framework, when possible: (a) greenhouse gas reduction impact, using local data where data are available, and alternatively, estimated from research data; (b) cost issues associated with the measure; (c) pros and cons of the measure or group of measures; and, (d) policy implications for local and regional governments.

We also assess the effect on GHG reduction of hypothetical percentages of hybrid electric vehicles or electric vehicles in the passenger fleet in 2020 (Section 8). In Section 9 we discuss cost bases for the measures we have analyzed. We conclude the report with a summary of policy recommendations for local governments based on our assessment.

1.2 Key Findings

- According to the San Diego Greenhouse Gas Inventory, to achieve 1990 levels of regional greenhouse gas (GHG) emissions by 2020, it would be necessary to reduce transportation fuel use, increase use of low-carbon fuels, and reduce the number of vehicle miles traveled (VMT) by passenger vehicles in the San Diego Region.
- The San Diego County Greenhouse Gas Inventory also estimated that these strategies could reduce regional GHG emissions from on-road transportation by 6.8 million metric tons (MMT) CO_2E by 2020.
    - Federal fuel economy standards for passenger vehicles and state measures to reduce tail pipe emissions are expected to provide 3.2 MMT CO_2E reduction;
    - The state-wide low carbon fuel standard (LCFS) would contribute 1.6 MMT CO_2E;
    - Other state measures for heavy duty vehicles would contribute 0.6 MMT CO_2E, and
    - The reduction of VMT locally by 10% by 2020 is expected to contribute 1.4 MMT CO_2E.
- Implementation of federal and state measures could reduce greenhouse gases by 5.4 MMT CO_2E, 79% of the total reduction needed (6.8 MMT CO_2E) to achieve the 2020 target in our region.
- However, both the federal and state measures - technological improvements in fuel economy of vehicles and the introduction of subsidized alternative fuels - have been shown to increase VMT. This is known as the rebound effect. If this rebound effect occurs in our region, the reduction target of 6.8 MMT CO_2E could increase to 7.6 MMT CO_2E and could trigger a greater role for local governments to reduce GHGs than initially estimated.
- A range of policy options exists within the authority of local governments that can significantly reduce community-wide greenhouse gas emissions from the on-road transportation category.
- Local transportation measures that are either currently being implemented (existing) and that are planned to be implemented (planned) could reduce GHG emissions by 0.4 MMT CO_2E. The combination of these local measures with expected implementation of federal and state measures could reduce GHG emissions by 5.8 MMT CO_2E, 86% of the target. If the rebound effects occurs, the total reductions from existing and planned local measures in combination with federal and state measures would provide 76% of the target adjusted for the potential rebound effect (7.6 MMT CO_2E).
    - Existing local measures to reduce VMT, including congestion pricing, vanpools and planned

smart growth policies by the cities could reduce emissions by 0.4 MMT CO_2E, 5% of the total reduction amount (6.8 MMT CO_2E) needed.[7] Without planned smart growth policies, the reductions achievable are somewhat over half this amount.

   - Existing measures to reduce fuel use through highway expansion could reduce GHG emissions by 0.1 MMT CO_2E, 1 % of the estimated reduction amount needed (6.8 MMT CO_2E).

- The combination of existing, planned, and potential (not planned) local measures evaluated in this report, and federal and state policies can achieve nearly the entire 6.8 MMT CO_2E reduction target, or 89% of the target adjusted for the potential rebound effect (7.6 MMT CO_2E).
- Potential local measures to reduce VMT assessed in this report include:
- A mass transit system with 16% commuter mode share by 2020 that could reduce GHGs by 0.6 MMT CO_2E;
- A telecommute policy for 20% of commuters by 2020, 2 days a week, that could reduce GHGs by 0.3 MMT CO_2E, and
- A parking cash-out policy with 12 % commuter uptake by 2020 that could reduce GHGs by 0.1 MMT CO_2E.
- There are many potential local measures to reduce overall fuel use through advanced technologies or demand management measures:
- Limiting congestion by highway expansion may reduce emissions by 0.08 MMT CO2E in 2020 but this effect could decrease after 2020 due to population growth.
- Traffic light retiming could reduce emissions by 0.02 MMT CO_2E.
- Replacing stop-intersections with roundabouts could reduce emissions by 0.06 MMT CO_2E, depending on the number replaced.
- Most of the potential local measures can be planned and implemented in time spans from months to 5 years.
- Based on research, it appears that a comprehensive road pricing strategy could also provide significant GHG reductions, perhaps 5-10% of the business-as-usual emissions in 2020. A pricing strategy appears to be most successful when implemented in combination with an effective mass transit system.
- A comprehensive pricing strategy together with local fuel use reduction and VMT reduction measures could provide the necessary GHG reductions to meet the 2020 goal in our region.
- Increasing electricity as a transportation fuel could have a significant impact on regional emissions.
   - Increasing the composition of the passenger vehicle fleet with more than 80% hybrid-electric vehicles, or about 50% electric vehicles could achieve 100% of the estimated reduction target in 2020, even with the rebound effect, assuming current carbon intensities of electricity;
   - However, these penetration levels are significantly higher than currently projected and there are relatively limited policy measures available to local governments to achieve such levels of penetration.
- Reaching the overall 2050 target of 80% GHGs below 1990 levels will require more aggressive policies from the on-road transportation category.

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[7] These values are rounded off for readability. Please refer to the tables in the main text for the actual numbers and percentages calculated.

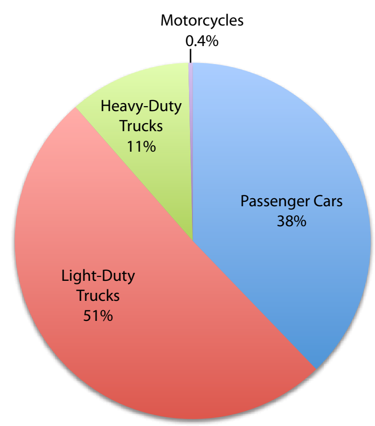
2 BACKGROUND

In this section we provide background information for region-wide emissions from the on-road sector based on the results of the Inventory, trends in GHG emissions in the City of San Diego and socio-economic factors affecting the ownership and use of vehicles.

2.1 On-Road Transportation Emissions

In 2006, light-duty trucks (LDTs) accounted for just over 50% of total on-road emissions, passenger cars accounted for nearly 38% and heavy duty trucks and buses produced 11% of the on-road transportation emissions (Figure 2).

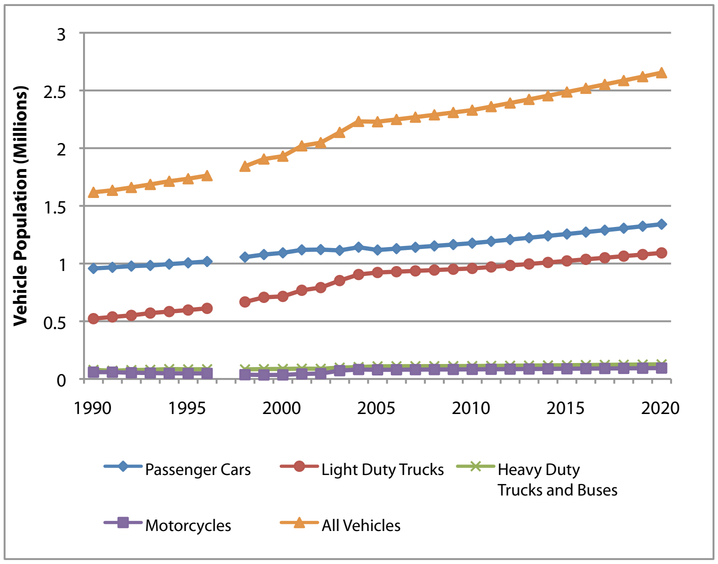
Figure 2 On-Road Transportation Emissions by Vehicle Type, San Diego County, 2006



This is despite the number of passenger cars being greater than those of light duty trucks (Figure 3) and is in keeping with the trend nationwide. Two federal policies adopted in the 1990s encouraged this trend: the CAFE standards to increase the fuel economy of passenger cars up to 3,500 lbs while exempting vehicles of greater weight from fuel economy requirements, and a tax policy of taxing less fuel efficient cars but not trucks.[8] When that tax was enacted, light duty trucks (LDTs) made up less than 25% of the fleet and were used mostly in rural areas, as pickup trucks or by construction companies and the farming industry. As a result, auto manufacturers built more LDTs to avoid the tax penalty for fuel inefficient (<27.5 miles per gallon, mpg) passenger cars that contributed to the emissions pattern shown in Figure 4.

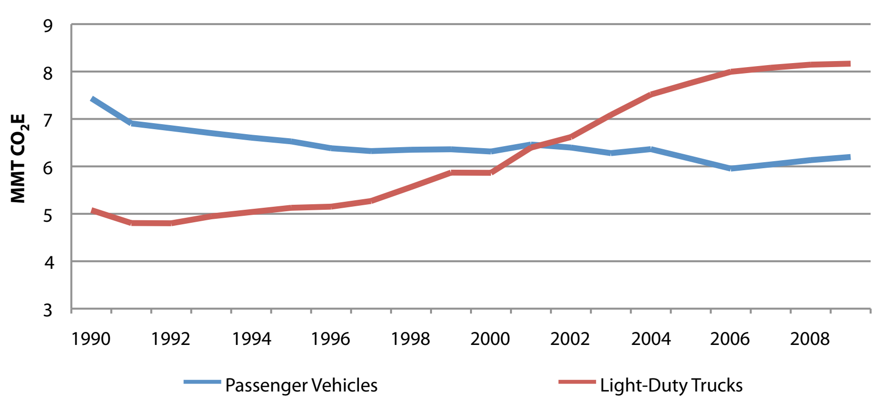
[8] An explanation of the various tax measures is provided in 'Federal and state tax policy concerning SUVs and high mileage vehicles,' OLR Research Report, 2005-R-0555 (July 12, 2005), *available at,* http://www.cga.ct.gov/2005/rpt/2005-R-0555.htm.

Figure 3: Number of Vehicles by Type, San Diego County (Note: no data for 1997)



Light duty trucks became the largest emitting vehicle type in San Diego County about 2003. The CAFE standards have only recently (2009) been increased for both passenger vehicles and light duty trucks;[9] therefore, these emissions trends are expected to continue at least until 2020.

Figure 4 GHG Emissions Trends from Passenger Cars and Light Duty Trucks



[9] The new CAFÉ standards apply to model years 2012-2016 for all passenger vehicles sold in the US such that the combined average fuel economy is 35.5 mpg, with 39 mpg for cars and 30 mpg for light duty trucks. Because these standards apply to the manufacturer supply, the vehicle fleet turnover is considered to be about 15 years. Therefore, will not see this 40% improvement in fuel economy of the fleet until after 2020. The 2009 standards achieve the target goal four years ahead of that required under the laws passed by Congress in 2007. *See http://www.dieselnet.com/standards/us/fe.php*.

2.1.1 Greenhouse Gas Reduction Targets

AB 32 seeks to reach 1990 levels (29 MMT CO_2E in San Diego County) by 2020. This represents 33% below the business-as-usual (BAU) projections for 2020 (43 MMT CO_2E). The business-as-usual GHG emissions from the on-road transportation sector are expected to reach 19 MMT CO_2E in 2020.

We developed four broad reduction strategies from the on-road transportation sector to contribute to meeting the AB 32 target for our region in 2020 (Table 1). We estimated that a reduction of 6.8 MMT CO_2E was feasible from the on-road transportation sector towards the AB 32 target for the region by 2020. The 6.8 MMT represents 49% of the total reduction (14 MMT CO_2E) needed to meet the AB 32 target applied to San Diego County. Three of the four broad strategies we used relied on either existing statutes or policy directives then under consideration addressing fuel economy, tailpipe emissions and fuel type. The fourth broad strategy involved a reduction in vehicle miles traveled (VMT). The CAFE standard[10] is a measure affecting fuel economy of cars and light duty trucks; and California's AB 1493 (Pavley) regulation provides tailpipe emissions reductions without necessarily affecting fuel economy. Together, CAFE and Pavley are expected to provide 23% of the AB 32 reductions. The California Low Carbon Fuel Standard (LCFS) adopted as an early action measure for meeting AB 32 emissions reduction targets could reduce the carbon intensity of transportation fuels sold in California by 10% by 2020[11] and provide 12% of the total GHG reduction in our region. Finally, we estimated that a decrease of 10% in VMT locally could provide reductions of 1.4 MMT, or 10% of the total AB 32 reduction amount needed.

Table 1: Broad GHG Emissions Reduction Strategies Identified from On-Road Transportation

Strategy	Estimated GHG Reduction in 2020 (MMT CO_2E)	Percentage of Total On-Road Transportation Reduction	Percentage of EPIC Target Based on AB 32
CAFE and Pavley	3.2	47%	23%
Low Carbon Fuel Standard	1.6	24%	12%
Other State Measures	0.6	9%	4%
10% VMT Reduction	1.4	21%	10%
Total	6.8	100%	49%

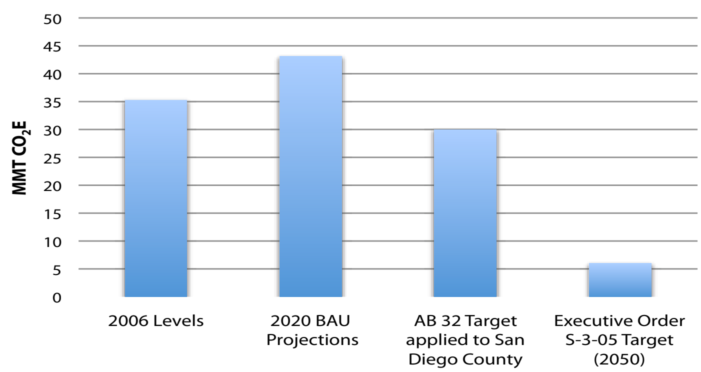
We should further keep in mind that the Executive Order GHG reduction target for 2050 aims to achieve 80% below 1990 levels. If we applied these targets to our region, we would have to achieve 6 MMT CO_2E emissions in 2050 (Figure 5). On a per capita basis we would have to reduce GHG emissions in our region from about 12 MT CO_2E in 2006, to 8 MT CO_2E in 2020 and about 1 MT CO_2E in 2050.[12]

[10] HR6, Title I, Section 102, 2005.

[11] The LCFS was developed on the basis of an Executive Order specifying the carbon intensity target in transportation fuels in 2020. *See* http://gov.ca.gov/index.php?/executive-order/5172/.

[12] One metric ton per person refers to GHG emissions from the use of fossil fuels and other greenhouse gases but does not reflect the amount of energy that may be needed and feasible through non-fossil fuel sources per capita. As a point of reference, Switzerland has a national strategy to reduce energy use per person from a current 6,000 Watts and 8-9 metric tons CO_2E to 2,000 Watts in a timeframe of 100-150 years, of which 1,500 Watts is to come from non-fossil fuel sources, and 1 metric ton CO_2E per person from the fossil fuel sources.

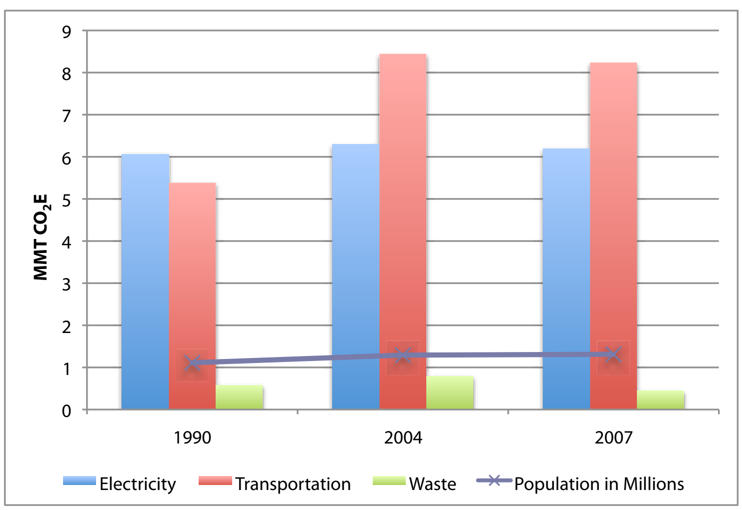
Figure 5 Greenhouse Gas Targets Applied to San Diego County



2.2 On-Road Transportation Emissions Trends in Local Cities

The City of San Diego carried out a GHG assessment for three emissions categories for 1990, 2004 and 2007 (Figure 6).[13] Greenhouse gas emissions from the three categories assessed have increased by 23% over the period 1990 to 2007, with on-road transportation showing the largest increase, of 53% from 1990, although all three categories show decreases from 2004-2007. Population growth in the city of San Diego from 1990 to 2007 was 18% and per capita GHG emissions increased from 10.8 MT CO_2E in 1990 to 11.4 MT CO_2E in 2007. Note that these per capita values are not directly comparable to the per capita values obtained in the regional GHG inventory because this contains only three categories of emissions sources, while the regional inventory contains 11 categories.

Figure 6 City of San Diego GHG Changes



Any transportation energy reduction measures taken by the city have had a minimal effect and appear

Wuppertal Institute Study, Vom Bioenergiedorf zur 2000 Watt Gesellschaft: Energiepolitische Zielkonzepte im Spannungsfeld zwischen erneurbaren Energien und Energieeffizienz, Working Paper Nm. 3, 2007.

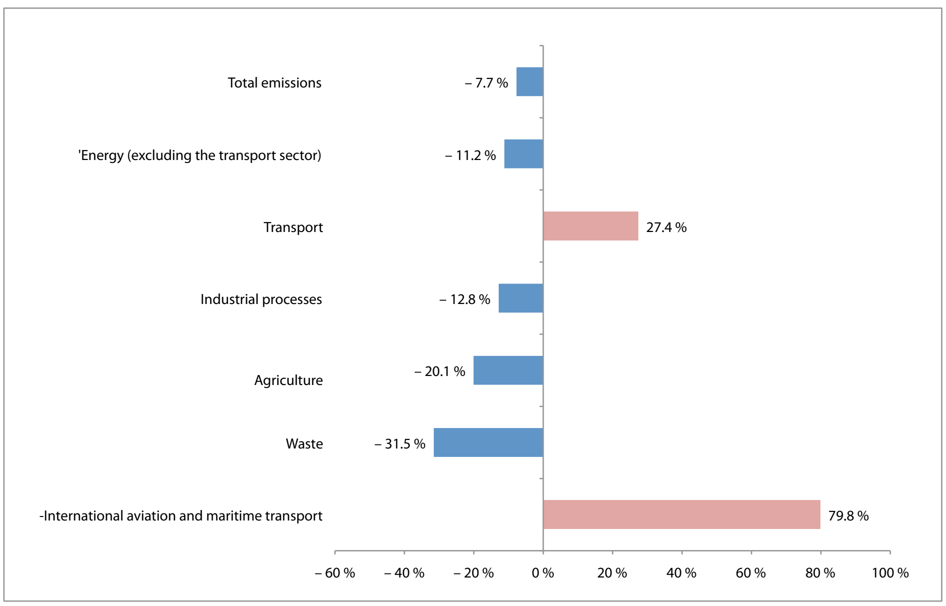
[13] Provided by the City of San Diego.

to have been overtaken by the growth in VMT and vehicle use.

2.2.1 Experience in the European Union

Practice in the European Union (EU-12, EU-15 and EU-27),[14] where GHG and energy use reduction measures have been implemented since 1990, shows that overall GHG reductions of 7.7 % (429 MMT CO_2E EU-27), 2.2 % (93 MMT CO_2E EU-15) and 25.3 % (337 MMT CO_2E EU-12) below 1990 levels had been achieved by 2006.[15] Although the achievement of the EU-12 is spectacular, it is in part due to reductions achieved by shutting down inefficient communist era industrial production facilities in 1990. The data show that all sectors, with the exception of the transportation sector, were able to achieve reductions (Figure 7 for EU 27). The transportation sector comprises domestic, maritime, and aviation transportation. Domestic transportation is comprised more than 90% of passenger vehicle emissions. The fact that the EU-27 already have relatively high modal splits for mass transit in total, commuter and leisure (16% average between 1995 and 2007 without counting walking and bicycle), and somewhat over 50% commuter mode split for passenger vehicles[16] in urban areas means that reductions from the transportation sector beyond those already achieved in the EU-27 will be difficult to achieve and serves as a lesson for our region.

Figure 7 GHG Changes EU-27 1990-2006



[14] The EU 27 consists of Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom. The EU-15 consists of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom. The EU-12 consists of Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, and Slovenia.

[15] Greenhouse Gas Emissions Trends, March 2009, *available at* http://themes.eea.europa.eu/IMS/ISpecs/ISpecification20040909113419/IAssessment1220277858018/view_content.

[16] Panorama of Transport, Eurostat Statistical Books, a publication of the European Commission, Edition 2007.

2.3 Socio-Economic Relationships Affecting Vehicle Ownership and Use

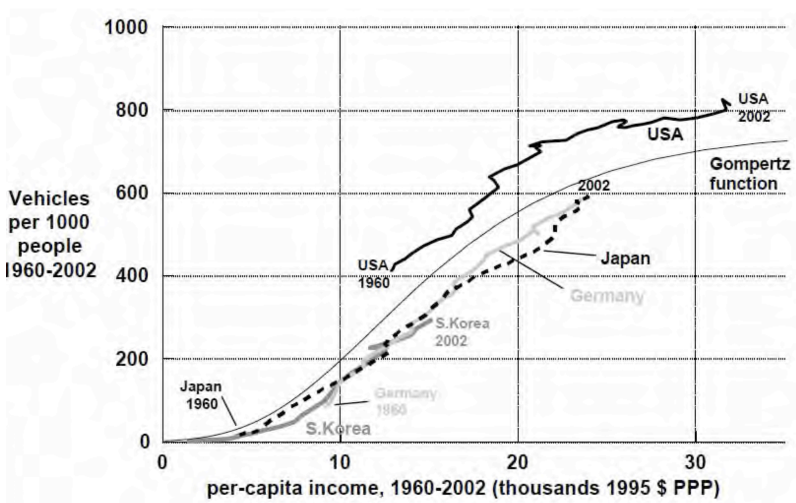
On-road transportation cannot be seen in isolation of its socio-economic background because of the heavy dependence of GHG emissions on the use of private vehicles. In this section we present research results on the relationships between vehicle ownership, vehicle use, and various social and economic factors to provide context for the rest of the report.

As important as policies affecting market decisions and trends in the types of vehicles purchased is research in the last two decades that has shown how residential or housing density, urban form, urban wealth, transport infrastructure and transport energy use are interrelated. A comprehensive study of these relationships carried out by Kenworthy in 2003 compared 84 cities based on data drawn from the Millennium Cities Database for Sustainable Transport compiled for the International Union (Association) of Public Transport (UITP).[17] From this study, and others, we can identify underlying reasons for the patterns of energy use so that we have a better understanding of what can be done to reduce GHGs and transport fossil fuel use also in our region.

2.3.1 Wealth and Vehicle Ownership

On a country basis, research has indicated that rising wealth is a primary cause for greater vehicle ownership and use (Figure 8), although there appears to be a saturation level. However, broken down by city and personal wealth, rising wealth is *not* a single or good indicator for vehicle ownership in urban areas. Using 1995 data, Kenworthy showed that there is no significant relationship between the level of <u>*urban*</u> wealth and vehicle ownership (Table 2). If vehicle ownership is expressed as a factor of wealth, European and high-income Asian city dwellers have only a fraction of cars per 1,000 people (13 and 6 respectively) of US urban residents (19) although Australian and Canadian cities top the list at 25-30.

Figure 8 Vehicle Ownership and Per Capita Income on a Country Basis 1960-2002[18]



[17] Kenworthy. Jr. Transport Energy Use and Greenhouse Gases in Urban Passenger Transport Systems: A Study of 84 Global Cities, (2003).

[18] Dargay, Joyce, Getaly, Dermot and Sommer, Martin. Vehicle Ownership and Income Growth, Worldwide: 1960-2030 (January 2007). This type of curve where growth is slow at the start and at the end of a time period is known as Gompertz function and is also characteristic of population growth in a confined area, where growth is eventually limited by resources.

Table 2 Urban Vehicle Ownership and Urban Wealth[19]

	Unit	USA	Western Europe	High Income Asia	Australia-New Zealand	Canada
Metropolitan Gross Domestic Product (MGDP) per Capita	US $	$31,386	$32,077	$31,579	$19,775	$20,825
Urban Vehicle Ownership	cars/$1 GDP	18.7	12.9	6.7	29.1	25.4

In 2008, the number of passenger vehicles per 1000 persons in San Diego County was 735. The average personal per capita income in San Diego County for 2008 is $42,801.[20] Therefore, the number of vehicles is somewhat less than what the per capita income: ownership relationship (Figure 9) would suggest, and allows some room for growth. On the other hand, the real regional gross domestic product for 2006 was reported as $157.5 billion,[21] which translates to 21 cars/$1 GDP per capita in our region (based on 2006 data), somewhat higher than the US average. As vehicle ownership flattens out with increasing wealth, and reaches a saturation point, which for the US is generally taken as about 850 per 1,000 persons,[22] it is likely, if viewed from a country perspective, that the vehicle density in San Diego County will increase over the next decades, and the absolute number will grow too due to the projected population growth. On the other hand, since increasing wealth in urban areas is <u>not</u> related to vehicle ownership, it may be that we have already reached our saturation point for vehicle ownership in the region.[23]

It has also been shown that within the per capita variation in any region, high-income households favor SUVs over cars whereas lower income groups prefer pickup trucks to cars. [24] Lower population densities also favor pickup trucks or SUVs over cars. [25] Therefore in general all income groups favor either SUVs or pickups over cars.

[19] 1995 data, Kenworthy, see Note 17.

[20] Emily Picha & Sheila Martin, *Metropolitan Knowledge Network: Exploring Our Region's Prosperity (May 2009)*, *available at,* http://mkn.research.pdx.edu/2009/02/exploring-our-regions-prosperity/2/. The personal income for a metropolitan region is the current income that is received by, or on behalf of, the residents of that area from all sources, minus their contributions for social insurance.

[21] U.S. Bureau of Economic Analysis, Regional Economic Information System. Updated annually, *available at,* http://www.bea.gov/regional/index.htm. GDP by metropolitan area is the sub-state counterpart of the nation's GDP. GDP by metropolitan area is derived as the sum of the GDP originating in all the industries in the metropolitan area. Real GDP by metropolitan area is an inflation-adjusted measure based on national prices for the goods and services produced within that metropolitan area.

[22] See Note 17.

[23] Leaving aside the relatively short-term effects of the economic recession, we witness other demographic and socio-economic factors that indicate vehicle saturation. These factors are: growing wealth inequality, an aging population and fewer households with children. *See* SANDAG, Regional Comprehensive Plan for the San Diego Region, (July 2004).

[24] Zhao, Yong and Kockelman, Kara Maria, Household Vehicle Ownership by Vehicle Type, Application of a Multivariate Negative Binomial Model, University of Texas (July 2000).

[25] Golob, Thomas, F. and Brownstone, David, *The Impact of Residential Density on Vehicle Usage and Energy Consumption*, University of California Energy Institute, Paper EPE 011 (2005), *available at*, http://repositories.cdlib.org/ucei/policy/EPE-011/.

2.3.2 Residential Density and Vehicle Ownership

A University of California study (2005) for California based on housing density and vehicle usage (Figures 9, 10) suggests that the number of housing units must increase to 1,000-3,000 units/mi2 in order to realize reductions in transport energy use. [26]

Figure 9 Passenger Vehicle Ownership, Transport Fuel Use, and Residential Density[27]

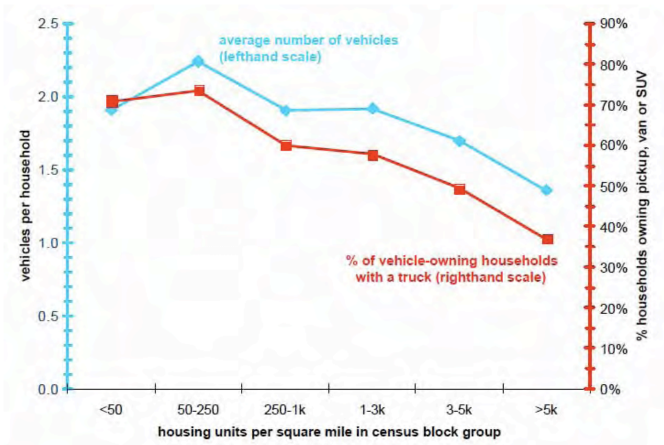
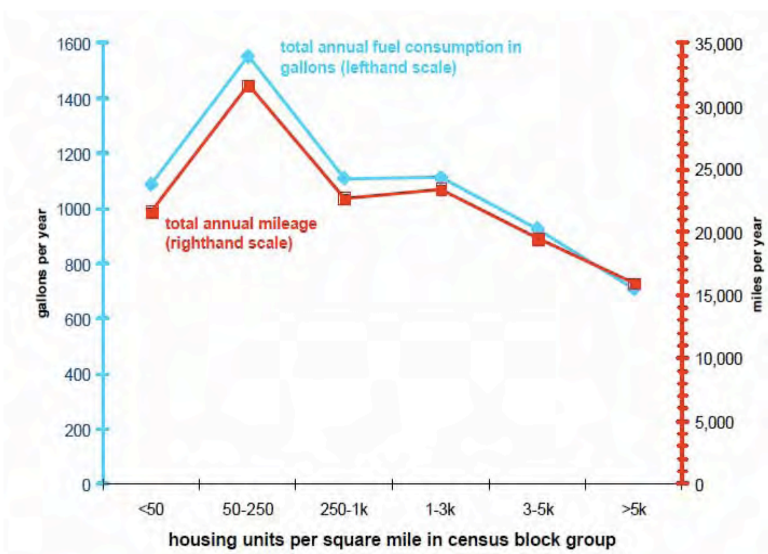


Figure 10 Fuel Use and Housing Density[28]



[26] Housing units are estimates of occupied units based on the existing data, adding new construction and annexations and subtracting demolitions and conversions from the last census or past year's estimates. Occupied housing units are estimated by applying a derived civilian occupancy rate, based on the last census, to the estimated civilian household units. As such, it does not exactly reflect population density, which will vary depending on income distribution and immigrant population, for example. See State of California, Department of Finance, E-5 Population and Housing Estimates for Cities, Counties and the State, 2001-2009, with 2000 Benchmark, Sacramento, California, May 2009.

[27] Kenworthy, See Note 17.

[28] *Id.*

The housing densities and the population density of each city and the unincorporated county are shown in Table 3. Although policy makers have preferences as to how best to present population-related densities, we use the housing density per square mile in order to compare our region with the results of the study mentioned above. Residential density can be higher than housing density. The lowest housing density is in the unincorporated county, at 44 units/mi2, and the highest is in the city of La Mesa, with 2,695 units/mi2. The city of San Diego has a housing density of 1,424 units/mi2 and the smallest city, Del Mar, has a density of 1,192 units/mi2.[29] While none of the cities reaches the high end of the range (3,000) of the research study, 16 out of the 19 areas do meet the lower end of the range of 1,000 units/mi2. These housing density values suggest that a significant number of cities would already benefit from measures that would encourage reduced use of personal vehicles within each city and to interconnect cities, or that the whole of the metropolitan area (equal to the County of San Diego) would profit from the availability of significant alternative modes of transportation. At the same time, and as is already happening in our region with the smart growth concept, the housing density may be permitted to increase with new growth so that additional transport energy use reductions may be achieved in future. The regional growth forecast to 2030[30] projects an annual average increase in households of 10,500 per year through 2030. In 2020 this would mean an additional 105,000 units, or about 10% more units than today. If this number of units were distributed equally amongst the 18 cities and unincorporated county, the housing density would rise closer to 3,000 in La Mesa and closer to 1,000 in Coronado. Although rezoning to accept such densities may be needed, the densities are already sufficient to accommodate alternative means of transport.

Population density and housing density are not always related. The population densities of the cities for 2008 are correlated with housing density only for the three least populated cities. In terms of population density, El Cajon is the most densely populated city but is number two in terms of housing density. National City is more densely populated that the housing density would suggest. For purposes of planning a mass transit system, or other system-wide improvements, these differences would need to be taken into account.

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[29] 2008 data extracted from SANDAG Fast Facts, *available at*, http://www.sandag.org/resources/demographics_and_other_data/demographics/fastfacts/index.asp.

[30] Regional Comprehensive Plan 2004, San Diego Association of Governments.

Table 3 Housing Densities, San Diego County Cities and Unincorporated County[31]

	Area mi²	Housing Units	Units/mi2	Units/acre (1 sq mi = 640 acres)	Population Density (pop/mi²)
La Mesa	9.0	24,258	2,695	4.2	6,296
El Cajon	14.4	34,593	2,402	3.8	6,801
Lemon Grove	3.9	8,581	2,200	3.4	6,567
Imperial Beach	4.4	9,376	2,131	3.3	6,409
Solana Beach	3.4	5,802	1,706	2.7	3,971
National City	9.2	15,325	1,666	2.6	6,652
Vista	18.6	29,794	1,602	2.5	5,149
Chula Vista	50.9	75,123	1,476	2.3	4,544
Oceanside	42.2	61,113	1,448	2.3	4,237
San Diego	342.5	487,775	1,424	2.2	3,903
Escondido	36.2	45,994	1,271	2.0	3,961
Encinitas	19.6	23,739	1,211	1.9	3,258
Del Mar	1.8	2,146	1,192	1.9	2,544
Santee	16.5	19,168	1,162	1.8	3,398
San Marcos	24.0	26,312	1,096	1.7	3,448
Carlsbad	39.1	40,417	1,034	1.6	2,655
Coronado	14.0	7,767	555	0.9	1,650
Poway	39.1	16,046	410	0.6	1,307
Unincorporated County	3,572.0	156,112	44	0.1	138
County	4,261	1,089,451	256	0.4	738

2.3.3 Urban Form and Transport Energy Use

Concerns about the quality of urban environments have led to some research on the impacts of urban form, air pollution, and energy since the 1990s[32] and more can be expected in the face of climate change mandates. Planning agencies are also increasingly aware of the importance of land use decisions on transportation. Complex modeling exercises are required to estimate the various impacts of different land use developments using different scenarios of population distribution, jobs, and retail developments. SANDAG has carried out modeling using transportation planning, land use, and demographics since 1987 and has been able to assess the impacts of proposed land use changes provided by the cities.[33] SANDAG has recently started to evaluate regional land use alternatives that implement smart growth principles to varying degrees, based on smart growth plans provided by the cities. From this modeling, it is possible to assess the VMT reduction impact of smart growth plans and evaluate the GHG reduction effects of planned smart growth projects.

Useful applications of the models to assess the impacts of urban form on travel include a comparison

[31] *Id.*

[32] A summary of concepts of urban form, energy and environment is found in Anderson, W., Palos, S.K, and Miller, E., Urban Form, Energy and the Environment: A review of Issues, Evidence and Policy, Urban Studies 1996; 33; 7.

[33] San Diego Association of Government, 2030 Regional Growth Forecast Update: Process and Model Documentation, April 2008.

of the BAU scenario with development occurring in varying degrees of accordance with the regional land use plan, from complete accordance to complete alternative of land use, regardless of local plans, as well as with varying degrees of revenue for mass transit. Other cities have carried out such evaluations. For example for the city of Hanover, Germany, an exercise was carried out to evaluate, among others, the effect of placement of new retail malls in different locations of the region. This evaluation showed that the impact of suburban malls could either increase or decrease total miles traveled depending on the location of the mall. A location in the center reduced VMT because of increased mass transit use and increased additional revenues accrued from public transport despite increase in distance to the mall.[34] As a result of location of the mall, this configuration was shown to reduce transport energy use despite development.

Currently SANDAG models the development plans as submitted by the cities. Conversely, SANDAG could evaluate potential scenarios outside of the plans submitted by cities, in order to compare possibilities for development that might lead to reduce transportation needs.

2.3.4 Vehicle Usage Determinants

Private vehicle usage is shown to be related to length of freeway available, length of public transit route availability, and ease of parking. In US cities, an average 11,000 miles per capita per year are needed to meet essential needs while equivalent counterparts in Europe and Asia require only 20% and 34% of that amount, respectively (Table 4). [35]

Table 4 Vehicle Usage Determinants[36]

	USA	Western Europe	High Income Asia	Australia -New Zealand	Canada
Passenger Car Miles per Capita	11,281	3,854	2,246	7,076	5,372
Length of Freeway Miles per Person	0.16	0.08	0.02	0.13	0.12
Parking Spaces per 1000 Jobs	555	261	105	505	390
Total Length of Reserved Public Transport Routes (Miles per 1,000 Persons)	48.6	192.0	53.3	215.5	55.4

Note: MGDP: Metropolitan Gross Domestic Product, MJ: Megajoules

US cities have the highest available freeway miles per person, as well as the highest number of designated parking spaces, which caters to private transport infrastructure rather than public transport and this is associated with greater vehicle and transport energy use, but not savings in time.

[34] Bohnet, M and Gutsche, JM. , Estimating land use impacts on transportation – findings from the Hanover region, Paper presented at the European transport Conference 2007, *available at,* http://www.etcproceedings.org/paper/estimating-land-use-impacts-on-transportation-findings-from-the-hanover-region.

[35] See Note 14.

[36] *Id.*

Therefore, Kenworthy finds that as congestion decreases through greater freeway construction, speed increases in the short term and this encourages more private car use, less alternative modes of transport and greater use of energy. Conversely, congestion acts as a brake to per capita vehicle use and acts "in favor of public transport" but only where " these options offer speed advantages with respect to " both being slowed by congestion and parking supply limits, rather than parking price limits."[37] Reducing congestion by freeway expansion favors private vehicle use and increases travel distances thereby increasing energy use and emissions.

Sprawl in our region is generally characterized by an extended aggregation of separate though lower density urban communities that together form a metropolitan area, in contrast to geographically continuous (high density) urban development emanating from one center, such as London or Paris. Both situations can arise unplanned or due to a market preference for low-density living. Even though the prevalent thinking is that the former metropolitan form can be more wasteful due to the segregation of land uses, and leads to an automobile dependent transportation system,[38] it is unclear whether these separate urban communities must necessarily lead to greater personal travel, for example, if each larger urban community were less dependant on personal interurban travel, or if there were less fuel intensive, less carbon intensive alternative forms of travel. Clearly, having interdependent but widely segregated urban communities is not conducive to walking or biking within the whole of the large metropolitan area, but it can be envisioned that proper interconnections and/or an alternative mass transit system can be planned and constructed to take advantage of the main routes of interurban travel.

An interesting metric is the transit route miles reserved that shows that the US average is 22% lower than the comparable Australian value but similar to Canada. If the price of land is much greater in the US than in Canadian cities, this metric would have cost implications for planning of future transit systems, and the data suggest that future growth scenarios should involve such a metric.

Based on the San Diego County Inventory project data, passenger vehicle (passenger cars, light duty trucks and motorcycles) miles per capita in San Diego county in 2008 were 9,700, less than the national average but still higher than comparable cities in even less densely populated cities of the world. We have not compared the length of freeway per person, the parking spaces per 1,000 jobs or reserved public transit route miles in our region. However, it is important to develop and track such metrics for our region in order to help identify impediments to achieving the reductions we need. If therefore, the total length of reserved public transport route per 1,000 persons in the San Diego region were similar to the US average, this would be at least a cost impediment to the expansion of a mass transit system.

2.3.5 Transport Energy per Capita

According to the same study of 84 global metropolitan areas, US cities lead the world with transport energy use of 60,000 Mega Joules (MJ) per person (1995 data) for passenger cars even compared with Australia and Canada using 30,000 MJ/person (Table 5). In 1995, 1.31 billion gallons of gasoline were used in San Diego County, largely for private vehicle use.[39] This is equivalent to 59,999 MJ per capita,[40] comparable to the US average derived in the global cities study. The global study found also that relative to wealth this transport energy use for private vehicles in US cities (and Middle Eastern cities) is the highest in the world, at 1,900 MJ/$1,000, while the next closest is Canada at 1,562

[37] *Id.*

[38] Ewing, R., Transportation and Land Use Innovations: When You Can't Pave Your Way Out of Congestion, Planners Press, Chicago (1997).

[39] Based on data from the EPIC San Diego County Inventory project, 2008.

[40] Conversion factors: 114,000 BTU/gallon gasoline, 0.001054 MJ/BTU.

MJ/$1,000 and Australia at 1,497 MJ/$1,000 per capita. San Diego County has a value of about 1,400 MJ/$1000 (2008) making it somewhat more efficient than the US average, the Canadian or Australian transport energy use.

Energy use based on the type and miles traveled of public transport shows that the public transport system that does exist in the US is relatively fuel inefficient compared with most other urban public transport systems in high income cities (Table 5). It is not known whether this is due to fuel economy inefficiencies of the system itself or the fewer passenger numbers. We have not calculated the energy use data for the public transport system in San Diego County in this report.

Table 5 Worldwide Urban Area Transport Energy Indicators (Mega joules)[41]

	USA	Western Europe	High Income Asia	Australia -New Zealand	Canada
Private Passenger Transport Energy Use per Capita	60,034	15,675	9,556	29,610	32,519
Private Passenger Transport Energy Use per Dollar of MGDP per Capita	1,913	489	303	1,497	1,562
Energy Use per Private Passenger Km	3.25	2.49	2.33	2.56	3.79
Energy Use per Public Transport Passenger Km	2.13	0.83	0.48	0.92	1.14
Energy Use per Passenger Km by bus (MJ/p.km)	2.85	1.17	0.84	1.66	1.5
Energy Use per Passenger Km by Tram (MJ/p.km)	0.99	0.72	0.36	0.36	0.31
Energy Use per Passenger Km by Light Rail (MJ/p.km)	0.67	0.69	0.34	na	0.25
Energy Use per Passenger Km by Metro Km	1.65	0.48	0.19	na	0.49
Energy Use per Ferry Km	5.41	5.66	3.64	2.49	3.62

Based on data from the San Diego County Inventory, the energy use from private transport generates GHG emissions (as CO_2E) comparable for the same year to the US cities' GHG (as CO_2) average provided by Kenworthy (Table 6).

[41] *See* Note 8.

Table 6 Urban Greenhouse Gas Emissions from Private Transport per Capita[42]

	GHG Emissions kg
US Cities (CO_2)	4,405
San Diego County (CO_2E, based on EPIC data)	4,442
Canada Cities (CO_2)	2,422
Australian Cities (CO_2)	2,226
Western Europe Cities (CO_2)	1,269
High Income Asian Cities (CO_2)	825
China Cities (CO_2)	213

Note: San Diego County data are from 1995 based on EPIC research (2008). Global cities data are 1995 averages based on Kenworthy (2003).

2.4 Policy Lessons for San Diego County Based on Global Cities Research

While we have not been able to evaluate all of the various metrics as carried out in the global cities research, and especially lack data on vehicle usage determinants, some of the metrics applied to San Diego county indicate better than US average values. There may be other metrics suitable to developing a more sustainable transportation system that we have not identified.[43] and the following general observations can be made:

A variety of metrics should be developed and used to better understand the relationship of transport energy use and GHG emissions in our region. For example, the miles of public transport reserved and parking supply per 1,000 jobs should be evaluated. These metrics can help determine where land use changes might be made.

The energy efficiency of the existing public transport system is not known, and, if it is as low as the average US data suggest, the question is whether the reason is lower passenger numbers rather than the inherent energy inefficiencies of the system itself. The energy efficiency of the existing public transport system should therefore be evaluated.44 Provided there is a reasonable uptake of mass transit by commuters – and reasonable depends not only on the numbers of participants but also on the fuel efficiency of the public transport system. A less fuel-efficient public transport system will be more fuel efficient than driving alone in single vehicles

Not only the ownership but also the use of vehicles drives emissions. Vehicle ownership in urban areas is not dependant on wealth. The US and San Diego County do not stand out in global comparisons in the metric of number of private vehicles per unit of wealth (18.7 and 20 respectively),

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[42] *Id.*

[43] Bigazzi, A.Y. and Bertini, R.L., Adding Green Performance Metrics to a Transportation Data Archive, paper presented at the 88th Annual Meeting of the Transportation Research Board, January 2009.

[44] The European Union has been concerned with efficiency in transportation systems in recent years, *see* The Thematic Research Summary, Efficiency in Sustainable Mobility, European Commissions DG Energy and Transport (December 2, 2009), downloaded from http://www.transport-research.info/web/projects/transport_themes.cfm.

and is closer to the European metric than to those of Australia or Canada. Smart growth concepts, and other policy measures to reduce GHGs could further contribute to this effect.

Lower density living (<1,000 per square mile) favors SUV/pickup truck use over cars. However, if the density cannot be increased, these vehicles must improve in efficiency and/or alternative low carbon based public and private transport system must be planned in order to decrease fossil fuel use.

Housing density is high enough in most cities of our region, which are interconnected, to benefit from alternative modes of transport within each city and within the greater metropolitan area. Given the diffuse nature of our urban communities within the region, non-motorized modes of bicycle and walking among the urban communities may not be able to provide significant GHG reductions. However, biking and walking are zero-carbon alternative transport modes and can play a large role when employment is located within a city. While we have no survey data for our region, research studies in the US show that most people are willing to walk 0.28 miles to 0.5 miles (or about 5-15 minutes) to either reach the workplace or transit but this varies based on sense of safety, topography, and quality of walkway.[45]The distance an individual would be prepared to cycle will not only vary by age, weather, personality, the type of job needing the use of a car, but also by topography. The San Diego region is characterized by high hills that would impede many bicycle riders as a commuter option.

[45] *See* Walking Distance Abstracts, *available at*, http://www.fairfaxcounty.gov/planning/tod_docs/walking_distance_abstracts.pdf.

3 INTERACTIONS BETWEEN STRATEGIES

The San Diego County Greenhouse Gas Inventory included broad strategies to achieve the reductions needed if AB 32 targets were applied to the region but did not include possible interactions amongst the strategies. It is known among planners and transportation researchers that improved fuel economy of passenger vehicles can lead to increases in vehicle use. More research is needed to model these interactions quantitatively in the San Diego County setting. Systems dynamics modeling is a tool used by planners to assess and understand the effects of various policies on technology, society, and economics. It has been used for water resource planning, climate change policy and economics, and in transportation planning, to understand barriers to the market penetration of alternative fuel vehicles, the modal share of urban transportation systems, and predicting the best structure of a feebate[46] system. However, recently, Stepp et al (2009)[47] have taken this analysis further to evaluate the effects of multiple policies in transportation energy use on a decadal scale. Such modeling is not yet common outside of academic research; however, we can estimate the strongest interactions among the broad strategies by the application of research study estimates using data from our County.

3.1 Fuel Efficiency Standards and Vehicle Miles Traveled

The federal CAFE standards are expected to reduce GHG emissions from on-road transportation by improving the fuel efficiency of future passenger vehicles. Research has demonstrated that increasing vehicle fuel efficiency, by reducing cost for the consumer, can also increase annual VMT. This effect is commonly known as the 'rebound effect' and in economic theories of transportation it is referred to as the elasticity of annual mileage with respect to vehicle operating cost. A 10% increase in fuel efficiency has been shown to lead to a 2-4% increase in passenger vehicle mileage. [48]

The CAFE standards are expected to lead to about 12% decrease in GHGs in San Diego County. Applying the above elasticity relationship, this represents a VMT increase of 2.4-4.8% by passenger cars and light duty trucks. This VMT increase of 2.4-2.8% from only passenger cars and light duty trucks by 2020 represents a 2.2-2.6% increase of VMT of all vehicle types in 2020. Therefore it could happen that a larger percentage reduction in local VMT or other GHG reducing measures would be needed to compensate for the increase in VMT predicted by the increase in fuel efficiency.

3.2 Alternative Fuels and Vehicle Miles Traveled

Although the VMT effects of alternative fuels and alternative fuel vehicles (AFVs) vary, research has shown that if there is a cost subsidy or favorable tax status for alternative fuels and AFVs, then a general assumption can be made that VMT will increase by 3% for every 10% reduction in GHG emissions from AFVs. [49] The LCFS is expected to provide 10% GHG reduction in San Diego County

[46] A feebate system is a self-financing system of fees and rebates used to shift the cost of externalities onto those purchasing a product. It is used in the transportation and energy sectors. Schade. In January 2008, the French initiated a car feebate system that provides rebates or bonuses for buying the lowest GHG emitting cars (it is mostly electric cars that qualify for the upper limit of 60 g/km) and charges an extra tax on high emitting vehicles. Due to the success of this system, France is considering expanding the feebate system to other domestic products, such as televisions. Wolfgang, Krail, Michael. Modeling and calibration of large scale system dynamics models: the case of the ASTRA model, paper presented at the 24th International Conference of the System Dynamics Society, 2006.

[47] Stepp, M.D. et al, Greenhouse gas mitigation policies and the transportation sector: The role of feedback effects on policy effectiveness, Energy Policy 37 (2009) 2772-2787.

[48] Litman. Todd. Efficient vehicles Versus Efficient Transportation, Victoria Transport Policy Institute, 6 May 2005.

[49] See Note 47.

by 2020. Applying this relationship to our region, we expect an additional 3% increase in VMT from this effect.

Adding the VMT increases from both effects gives a net 5.4-7.8% increase, or average 6.6% increase in VMT in 2020. This suggests that if the above effects between VMT, fuel efficiency and alternative fuels occur in our region, about 0.8 MMT CO_2E above the BAU emissions could be added from passenger vehicles, potentially raising the on-road transportation target from 6.8 to 7.6 MMT CO_2E. This could mean a greater role for local governments and greater importance for local measures to reduce GHGs in order to reach the AB 32 target.

4 MEASURES TO REDUCE VEHICLE MILES TRAVELED

The San Diego County GHG Inventory estimated that reducing VMT by at least 10% through 2020 could reduce GHGs by 1.4 MMT CO_2E (Table 7). In 2008 we believed that a VMT reduction of 10% was reasonable based on the effect of gasoline price increases in 2007-2008. We observed, and it was reported by the Federal Highway Authority, that VMT decreased by 3-4% in the first quarter of 2007 when the price increased.[50] However, a largely market-based gasoline pricing system does not provide the consistent and predictable pricing that would lead to the necessary reductions. In addition, the price elasticity of demand for gasoline may be relatively low in San Diego County since, failing effective alternatives, people cannot easily give up use of their vehicles. On the other hand, a pricing strategy, such as discussed in Section 8 can also provide significant reductions in VMT. Pricing measures are discussed in Section 8. In this section, we examine the potential for measures to reduce VMT by the amount needed.

Table 7 Estimated GHG Reduction Potential from VMT Reduction

Strategy	Estimated GHG Reduction by 2020 (MMT)	Percentage of Total On-Road Transportation Reduction Potential	Percentage of Total EPIC Target Based on AB 32
10% VMT Reduction	1.4	21%	10%

4.1 Existing and Planned VMT Reduction Measures

To estimate what local measures could reduce VMT to meet this level, we first estimated the GHG reductions expected from three measures incorporated in the 2030 Regional Transportation Plan (2030 RTP):

- Continued increase of vanpools at the current linear rate of increase results in reduced use of single occupancy vehicles (SOVs) and therefore VMT. We calculated the GHG reduction from this measure based on the average number of occupants (8.3) in a van, assuming that the travelers would otherwise be driving alone in a vehicle, and subtracting the emissions caused by the average fuel efficiency of the vans in use (16 miles per gallon of gasoline);
- The I-15 High Occupancy Toll (HOT) lanes induce a certain level of carpooling that result in VMT reduction. The HOT lane system will be expanded to 80 miles by 2020. The percentage of carpools on the HOT lanes has been documented by SANDAG. We assume this percentage will continue to occur also in the expanded HOT lanes through 2020, that there are only two persons per carpool and one passenger vehicle is removed from the road, and the average commute distance is 20 miles.
- Planned smart growth projects reported by the regional cities to SANDAG[51] are expected to lead to a VMT decrease from a current 27.65 miles per capita (2006, all day) to 27.30 in 2030. We used this component of smart growth to calculate the GHG reduction from the expected VMT reduction. It is assumed that the increase in transit ridership projected by the 2030 RTP (7.3% of the peak hour which translates into a lower of total commuter transit ridership) is included in the

[50] The US Bureau of Transportation publishes VMT data on a monthly basis. *See* http://www.bts.gov/publications/key_transportation_indicators/.

[51] San Diego Association of Governments, Regional Transportation Plan 2030, Table 6.8, *available at*, http://www.sandag.org/index.asp?classid=13&fuseaction=home.classhome. We have not accounted for uncertainties in these VMT values. However, the uncertainty in the EMFAC model for producing VMT data is about 4%.

estimated smart growth VMT reduction. It is also assumed that this VMT decrease will be achieved by 2020.

Together, the three measures provide about 25% of the 1.4 MMT CO_2E needed from the VMT reduction measures (Table 8). If the planned smart growth does not take place, we would obtain about half this reduction amount. The current RTP measures, which, apart from smart growth, were planned for purposes of congestion reduction and not directly for reduction of GHGs, are insufficient to achieve significant GHG reduction from VMT reduction as these leave 75% of the VMT GHG reduction needed to be achieved through other measures.

Table 8 Estimated GHG Reduction from Existing and Planned VMT Measures

VMT Measure	GHG Reduction (MMT CO_2E)	Percentage of Reduction Needed (1.4 MMT CO_2E)
Vanpools	0.03	2%
Congestion Pricing	0.12	9%
Smart Growth Planned	0.19	14%
Total RTP Measures	0.35	25%
Without Planned Smart Growth	0.16	11%

Note: Smart Growth measures included here concern only the expected reduction in VMT by 2020

4.2 Potential Local VMT Reduction Measures

Three additional VMT reduction measures that are not currently being implemented (potential) were evaluated for the potential to reduce GHGs and because they were considered feasible for our region:

- An expanded mass transit system with a commuter mode split of 16% has the largest impact on GHG reduction. A 16% commuter mode split is considered a reasonable target for a city with currently limited mass transit and a SOV culture, such as San Diego County.[52]
- A region-wide policy in which 20% of all commuters telecommute 2 days a week, thus saving the average daily commute of 20 miles in an SOV.
- A policy that expands the existing state parking cash-out law and provides financial incentives for commuters to either work from home, carpool, or use mass transit and eliminate the need for parking. Research indicates that in a city with limited mass transit, implementation of a parking cash-out program could be taken up by between 12% and 20% of the employees to whom the

[52] This value is based on best practice applications of bus rapid transit (BRT) systems in other cities worldwide. BRTs vary in complexity but have in common core elements that contribute to high capacity and high speed such as a segregated right of way, provisions for short dwell times, priority over car traffic, modal integration, reasonable comfort and administrative regulation. Several cities in Europe started implementing such systems in the 1970's. In the US, Seattle and Boston have versions of BRT, which use the trolleybuses and an underground section currently being converted to light rail. BRT systems can be created with a light rail option. Other cities that have full scale BRTs held up as exemplary are Brisbane, Bogota, and Quito. Several cities in China are implementing BRTs, as is Mexico City. *See,* for example, Cristian Canales et al, Public Transport Policies in Europe: Implementing Bus Rapid Transit Systems in Major European Cities, 2006, a paper presented at the European Transport Conference 2006 , European Transport Policy and Research, Urban Transport Policy, available at http://www.etcproceedings.org/paper/public-transport-policies-in-europe-implementing-bus-rapid-transit-systems-in-.

incentive is offered. We have assumed the lower end of this range as the potential in our region in our GHG calculations.

Together, these three potential policies could reduce GHGs by 1 MMT CO2E in 2020, with mass transit having the largest impact. Table 9 compares the reduction effects of existing, planned and potential VMT measures on GHG reduction. The order in which the policies are adopted and implemented affects the magnitude of the GHG reduction possible. In the order of implementation of measures given here, we assume that those who telecommute are removed from the pool of commuters available to use mass transit.

Table 9 Estimated GHG Reduction from Existing, Planned, and Potential Local VMT Measures

VMT Measure	GHG Reduction Amount (MMT CO_2E)	Percentage of Reduction Needed (1.4 MMT CO_2E)
Vanpools	0.03	2%
Congestion Pricing	0.12	9%
Congestion Miles Reduction	0.08	6%
Parking Cash-Out Potential	0.11	8%
Mass Transit Potential	0.55	39%
Telecommute Potential	0.30	22%
Total Potential	1.19	86%

In a second scenario, if mass transit were given priority over a telecommute policy, still assuming a 16% mode share for commuters, greater reductions can be achieved, and we would obtain 102% of the reduction target, or 1.43 MMT CO_2E (Table 10).

Table 10 Estimated GHG Reductions from VMT Measures on GHGs
(Mass Transit Given Priority over Telecommute Policy)

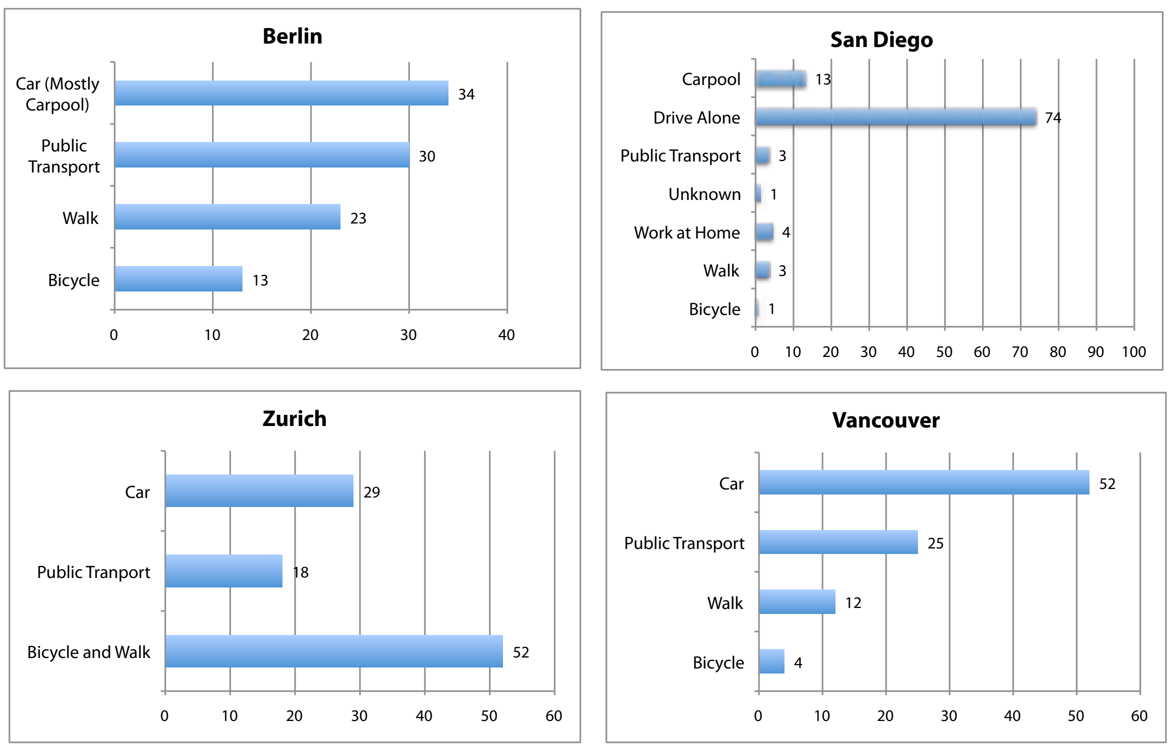
VMT Measure	GHG Reduction Amount (MMT CO_2E)	Percentage of Reduction Needed (1.4 MMT CO_2E)
Vanpools	0.03	2%
Congestion Pricing	0.12	9%
Congestion Miles Reduction	0.08	6%
Parking Cash-Out Potential	0.11	8%
Mass Transit Potential	0.78	56%
Telecommute Potential	0.30	22%
Total Potential	1.42	102%

Though all existing, planned and potential measures would be needed to meet the VMT target reduction amount of 1.4 MMT CO_2E, planning and implementing such a combination of minor and major VMT reduction measures will be a challenge. Note that all VMT reductions have been calculated on the basis of only commuter VMT and any policy option that can also capture leisure travelers would be advantageous to achieve additional GHG reduction.

4.2.1 Expanded Alternative Commute Modes and Other Non-Motorized Transport Modes

How San Diegans traveled to work in the year 2000 in comparison with some other global cities is shown in Figure 11. More than 70% of the commuters travel in SOVs and more people walk and bike to work than use public transportation. Nearly the same percentages were quoted by SANDAG in 2004[53] and the percentages have probably not changed much today. The current use of public transport by commuters is approximately 3.3%. Cities that have lower transport energy use have a more balanced mix of mode share[54] and the aim of the region should be to achieve such a balance.

Figure 11 Mode Share in Road Transportation for Selected Cities



The 3.3% of commuters who use mass transit in San Diego County comprises mostly low-income groups (Table 11).[55] The largest percentage that drive alone are in the group earning more than $75,000, however, there is a tendency in this group to also use of carpools that may suggest a willingness to use mass transit if quality meets their needs.

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[53] Info: Commute Characteristics of the San Diego region, Publication 11183689-3.pdf, 2004, *available at,* http://www.sandag.org/index.asp?classid=13&fuseaction=home.classhome.

[54] *Id.*

[55] *Id.*

Table 11 Relationship between Household Income and Means of Transportation to Work
(San Diego Region (1999)

Household Income	Total Workers	Drive Alone	Carpool	Transit	Other
< $30,000	17%	15%	20%	36%	23%
$30,000-$49,999	21%	20%	24%	25%	20%
$50,000-$74,000	24%	24%	25%	19%	21%
>$75,000	38%	40%	32%	20%	37%

The 2030 RTP forecasts an increase in the use of transit by peak hour commuters in 2030 but this is still expected to provide less than 5% of the total number of commuters using transit. This includes the measures in the Regional Transit Plan developed in the 2030 RTP. Early action plans for transit are a UTC/UCSD Super Loop shuttle, South Bay and I-15 BRT projects and the Mid-Coast Light Rail Transit, an 11 mile extension of the light rail transit from Old Town to major activity centers such as UCSD. The latter project, known as the Mid Coast Corridor Transit Project, is expected to be completed in 2015. There are currently no additional plans for significant additional expansion of public transport in the region. From time to time other ideas have been raised such as extending trolley service to the San Diego International Airport[56] but apart from the early action projects mentioned, even the sum total of those will not bring the significant mode share from transit that would be needed from transit. The most recent study[57] on a system that has the potential to provide up to 16% commuter mode split was commissioned in 2008 by the Federal Transit Administration and the US Department of Transportation to evaluate the role of a rapid bus system that could rapidly, apparently cost effectively and time-effectively achieve the transit ridership targets set by cities in many parts of the world.

While it is clear that the energy consumption of mass transit is considerably less per person than for an SOV, research suggests that mass transit must have two other components to succeed: be time competitive with the car, and have a perceived quality of comfort and modernity to attract a majority of middle-income commuters.

In the study of 84 cities worldwide discussed in Section 2, Kenworthy showed that the level of urban transportation energy use and GHG emissions is related less to the level of urban wealth and more to the extent and quality of its public transport system, including the dedicated miles of transit right of way and the service provided. Wealthy cities with high levels of transit use have focused in the past on high quality speed competitive rail systems that are attractive to the majority of middle class users, whether commuters or leisure travelers. High quality speed competitive bus rapid transit systems with or without a light rail option are gaining traction in several parts of the world as a financially more feasible alternative to light rail. In either case, a time competitive mass transit system attracting sufficient numbers of passengers has a low energy use compared with private systems.

Although identifying impediments to GHG reduction measure is not part of the scope of this project,

[56] Schmidt, Steve (March 29, 2008). "Added transportation to the airport is discussed", *The San Diego Union-Tribune, available at,* http://www.signonsandiego.com/news/metro/20080329-9999-1m29airport.html.

[57] Advanced Network Planning for Bus Rapid Transit: The "Quickway" Model as a Modal Alternative to "Light Rail Lite" Report No. FL-26-7104-4, United States Department of Transportation, *available at,* http://www.nbrti.org/docs/pdf/BRT Network Planning Study - Final Report.pdf.

two studies carried out over the years in San Diego County should be mentioned. One suggests that the emphasis on local land use priorities is a major impediment. [58] The other more recent study identifies funding problems[59] to even maintain the existing levels of transit as a major impediment to an effective expanded public transit system. More recent studies indicate that the largest impediment may be time competitiveness with the car and quality of service, [60] supporting the research findings of Kenworthy in 2003. Quality of service needs to increase with levels of affluence. These are all significant impediments to their greater climate change and environmental advantages and suggest that investment first be placed to increase the quality of service along routes of high commuter use. In addition, it must be established to what extent additional rights of way for public transit are needed, and this cost also taken into account.

Bicycle and walking rates in the region have remained about the same in the last few years. According to the 2030 RTP, these rates are expected to remain about the same despite increases in bike and walking path miles to 2020. Research suggests that Level of Service (LOS) indicators may be applied

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[58] In a 1996 case study of the San Diego Trolley implementation as part of transit oriented development barriers, interviews with five planning directors, zoning data, inspection of station area land use and archival research were used to understand impediments to TOD. The directors were questioned on the five most significant barriers generally identified in implementing smarter growth: whether existing land use patterns near rail stations constrain opportunities for TOD, of difficulties assembling large parcels of land that limit TOD opportunities, if the private land market is at times unable to sustain new development projects, whether the local economic and fiscal impacts of TOD might discourage localities from pursuing such projects and whether local officials might not be adequately educated in both the regional and local advantages of TOD. The main impediments identified were that few planners had as priority to change existing zoning to accommodate modern growth patterns, that high density development was looked on with suspicion, that sales tax revenues within a city return to the city so that a city would consider commercial operations more desirable in contrast to medium or high density housing. Also, " While all planners …agreed with the regional goals for rail transit put forth by MTDB and SANDAG, each also made it clear that local goals came first with respect to land use". Further interviews suggested that "education, by itself, will not overcome structural factors such as pre-existing development, land availability and market force which are not conducive to widespread TOD implementation". Of the seven cities only La Mesa overcame any structural barriers and created opportunities to develop the station and increase population density.

The study stated, " that the aggregate behavior of several different municipalities resembles the science of muddling through", and "Each city exploits its opportunities". Therefore TOD, a component of smart growth, was only being implemented incrementally. That research also suggests that though planners may be sufficiently educated as to regional goals and desires, the structural barriers preventing smart growth would require wholesale education of elected officials.

1996 Study on Transit Oriented Development in San Diego County: Incrementally Implementing a Comprehensive Idea, 1996, Working Paper, June 1996, UCI.

[59] Under the terms of the Settlement Agreement of 2006, SANDAG conducted a study to identify known and reasonably foreseeable financial and all other impediments to maintaining long-term transit service levels throughout San Diego County as well as identification of recurring funding sources that provide, or can provide, operational expenses for public transit. The study states that major problems exists to provide long-term funding for even existing transit services, and because of the dependence for both capital and operating expenses on state and federal funds, this study that outreach for more funding "cannot be achieved without a public consensus on the priority for transit funding". It also states that even maintaining long-term ridership is an issue larger than just funding and that behavioral economics must also be drawn into the discussion. However, it also states that mass transit is only one component of the multimodal approach but does not approach the issue by discussing how much of a model split might be desirable in the region. In addition, it is pointed out that funding from the gasoline tax decreases with increasing use of alternative fuel, and that the local Transnet tax is likely to be raided by the state general funds in times of state hardship. Settlement Agreement provided by SANDAG.

[60] Poudeux, Pascal, The Effect of Transportation Policies on Energy Conservation and Greenhouse Gas Emissions from Urban passenger Transportation, Transportation Research Part A 42 (2008), 901-909.

to bicycling and walking in the same way as for road use to measure improvements over time.[61] Improving bicycle and walking options appear to most likely affect leisure VMT (not analyzed for this report), thus contributing in general to overall GHG reduction. For improved walking and bicycling options, cities could focus on the following factors within neighborhoods:

- Traffic-calming measures to encourage and accommodate non-motorized travel (NMT), especially in residential neighborhoods
- Land-use arrangements and urban design oriented to NMT (rather than cars)
- Restrictions on motor vehicle use within neighborhoods or city center
- Provision of bicycle facilities, bicycle paths, and sufficiently wide sidewalks
- Better traffic and bicycle education of both motorists and non-motorists
- Enforcement of traffic regulations protecting and encouraging cyclists and walkers

There is limited literature data on the effects of increased NMT on VMT or fuel use[62] if only due to the low rates of participation in these modes of transport.

4.2.2 A Regional Telecommuting Policy for Government Employees

Telecommuting is one aspect of a virtual work world enabled by modern technology. Other aspects are virtual meetings (teleconferencing, webex meetings), e-commerce, and flexible working hours. The common theme is that the work takes place through the Internet.

Telecommuting has many potential individual, organizational, and societal benefits for employees and employers: greater productivity, reduced administrative costs due to reduced office space needs, reduced relocation costs, less commute stress and associated cost savings, tax benefits, family benefits, independence and flexibility, reduced absenteeism, attracting employees as a benefit, and increased women in labor force. Recently, the avoidance of pandemics and terrorist attacks have been cited as additional benefits. Potential disadvantages include less workplace interaction, the need for self-discipline, the need for coordination among employees and employer, and for employers, issues of data security and monitoring of productivity. For labor unions there are also issues of equity in career prospects.[63] The main drawback for the purposes of GHG reduction is that telecommuting affects only commuter transport and is only a sure source of transport energy reduction *if* most of those miles are not used for other purposes. An additional socio-economic drawback may be the lack of job creation through a telecommute policy.

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[61] Litman, Todd, Build for Comfort, Not just Speed, September 2008, Victoria Transport Policy Institute, *available at,* http://www.vtpi.org/quality.pdf

[62] Steve Lockwood , Non-Motorized Transportation, A white paper for participants of the 2006 James L. Oberstar Forum Transportation Choices: The Important Role of Walking and Biking, April 9-10, 2006, Minneapolis, Minnesota, Sponsored by Center for Transportation Studies University of Minnesota. Several states have statewide bicycle and pedestrian plans: Arizona, http://www.azbikeped.org/statewide-bicycle-pedestrian-intro.html, Idaho, http://www.itd.idaho.gov/planning/bike/IDT.pdf, North Carolina, http://www.ncdot.org/transit/bicycle/about/longrangeplan2.pdf, New Jersey, http://www.bikemap.com/RBA/NJBikePed.pdf, Oregon, http://www.oregon.gov/ODOT/HWY/BIKEPED/planproc.shtml, Wisconsin, http://www.dot.wisconsin.gov/projects/state/ped2020.htm.Washington, http://www.wsdot.wa.gov/walk/designinfo.htm.

[63] The US government General Accounting Office reported on barriers to telecommuting in private firms in 2001. See Telecommuting: Overview of Potential Barriers Facing Employers, July 11. Briefing for the US House of Representative Majority Leader Dick Armey, *available at,* http://www.gao.gov/newitems/d01926.pdf. Accessed July 2009.

Forecasts of the potential for telecommuting that have been touted since the late 1980's, estimated that even up to 16% of the total workforce in the US could telecommute in part or full. In reality telecommuting has been less popular.[64] In the US, a study in 2007 showed that more than 50% of companies offer some type of telecommuting. Also in 2007, the US Office of Personnel Management determined that only 6.6 percent of federal workers actually performed any level of telework.[65] Similarly, in 2008, the Telework Coalition reported that 24.1 million workers worked from home one day a month.[66] Of this, 16.5 million were self-employed so that about 7.6 million may be considered true teleworkers. This represents about 6% of the total US labor force. With the need to reduce VMT due to climate change mandates, telecommuting could be revisited both for the business community and for the government sector since it can produce large reductions in energy use and GHGs at low cost relative to other GHG reducing measures. Technological barriers to telecommuting have nearly disappeared with advances in technology such as high-speed Internet access and virtual private networks have reduced concern over security.

At the federal level, the US Congress authorized five pilot telework programs in the National Air Quality and Telecommuting Act of 1991,[67] but as mentioned above, only 6.6 percent of the federal workforce telecommutes. Legislation was introduced again in March 2009 – the Telework Improvements Act of 2009 (HR 1722) to compel the development of a government-wide telework policy where employees would be permitted to telework at least 20% of hours worked in every two administrative weeks.[68]

The City of San Diego adopted a telecommute policy in early 1990[69] but according to city officials, telecommuting is even less popular in the city today than at the time of introduction, although further analysis is necessary to evaluate the current status and attitudes towards telework.

In contrast to telecommuting, a four-day week with longer hours has been more popular with management at the government level, and is often available voluntarily. In effect this is able to provide similar VMT reduction as an official telecommuting program. In 2008, the state of Utah became the first in the U.S. to mandate a four-day workweek for most state employees, closing offices on Fridays in an effort to reduce energy costs. Workers still work 40 hours a week by starting earlier and ending later during four weekdays, and having Fridays off not only reduces VMT but also saves on heating, cooling, and electricity expenses.[70]

Trip reduction ordinances (TRO) have been discussed before in our region. In 1990 the City of San Diego had passed a trip reduction ordinance requiring employers with 100 or more workers to increase ridesharing by 2 percent each year. Employers failing to meet the goal had to submit a transportation management plan specifying how they could reduce the number of drive-alone employees. Under the ordinance, all employers were required to conduct transportation surveys, appoint an employee transportation coordinator, and provide information about transportation

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[64] Hoang, Anthony T., Nickerson, Robert C., Beckman, Paul and Eng, Janie, *Telecommuting and Corporate Culture: Implications for the Mobile Enterprise*, Information Knowledge Systems Management 7 (2008) 77-97.

[65] Status of Telework in the Federal Government, Report to the Congress, June 2007, *available at,* www.telework.gov/surveys/2006_TW20Report.pdf.

[66] Facts are available from the Telework Coalition, *available at,* http://www.telcoa.org/id33.htm.

[67] HR 2084/Public Law 106-69, Section 365.

[68] Bill HR 1722 is in the first stage of the legislative process in the 111th Congress 2009-2010. Its progress can be followed at http://www.govtrack.us/congress/bill.xpd?bill=h111-1722.

[69] Mokhtarian P. (199 1) Defining telecommuting. Transpn Res. Rec. 1305, 273-281.

[70] The Four-Day Work Week is Winning Fans, Time Magazine on-line, September 2009, *available at*, http://www.time.com/time/magazine/article/0,9171,1919162,00.html.

alternatives. This would have generally involved adopting a telecommuting policy. But when an EPA study concluded that employer-based transportation control methods have limited effectiveness in reducing smog and congestion and that the federal and state regulators would not be enforcing trip reduction ordinances, the City repealed the ordinance.

The city ordinance superseded the county Air Pollution Control District (APCD) requirement for large employers to file a Traffic Abatement Plan. The APCD plan outlined ways employers planned to reduce automobile trips in the event of a severe Stage 2 smog alert, which has not occurred in San Diego County since 1979. The APCD plan also required employee transportation surveys every 18 months and to pay a $142 processing fee. Once the city ordinance was rescinded, the APCD suspended the Traffic Abatement Plan indefinitely.

Most of the large employers interviewed then reported that the cost of implementation would be relatively high since all telecommuting employees would have to be provided with home office equipment.[71] SANDAG is reported to have continued recording voluntary TRO's. Today, since all employees have access to modern technology a telecommute policy could be re-investigated, without the need for a TRO.

There can also be a business case for telecommuting.[72] Several large private companies that have a significant number of jobs that could be performed remotely, such as IBM[73] and CISCO, have more than 25% of the workforce working full time from home or at telecenters — offsite locations where the worker is linked to the full range of capabilities available at the regular office site that offer an alternative to teleworking from home.

For the calculation of GHG reductions from a telecommute policy, we assumed:

- Telecommute 2 days/week, every week of the year.
- 20% of all workers are eligible for telecommuting. An average of 17,235 of the total workers have been government employees in the period 1990-2006,[74] and this sector could provide a significant proportion of the telecommute population.
- The daily commute is 20 miles.
- These commuters would otherwise use a gasoline powered SOV.

4.2.3 Parking Cash Out Potential

State law requires certain employers who provide subsidized parking for their employees to offer a

[71] Mokhtarian P. and Saloman, E. Modeling the Desire to Telecommute: The Importance of Attitudinal Factors in Behavoral Models, Transpn. Res. –A, Vol 31, No 1, pp 35-50, 1997.

[72] M. Conlin, "Square Feet. Oh, How Square!— The Rise of Mobile Workers has Companies Unloading Space and Rethinking What's Left," *Business Week*, 3 July 2006, *available at,* www.businessweek.com/magazine/content/06_27/b3991073.htm.

[73] IBM provides a model example of the business case for telecommuting. It is reported that nearly half of IBM's more than 330,000 employees use the telecommuting option part of the time and that 25% use it full-time. The company claims to save more than $50 mi in real estate costs alone. IBM claims a higher retention rate of telecommuting employees than non-telecommuters, and a 10-20% higher productivity rate than in-house employees. The company uses its own virtual workplace known as Second Life (Metaverse) to create a virtual workplace for remote workers. See Telework: A Productivity Paradox? Ruth, S. Chaudhry, I., George Mason Univ., Fairfax, VA. Internet Computing, IEEE, Nov.-Dec. 2008, Volume: 12, Issue: 6.

[74] Data from California Employment Development Department, *available at,* http://www.labormarketinfo.edd.ca.gov/?pageid=166.

cash allowance in lieu of a parking space. This law is known as the Parking Cash-Out Program (Assembly Bill 2109, Katz; Chapter 554, Statutes of 1992). The law states:

> (a) In any air basin designated as a nonattainment area pursuant to Section 39608, each employer of 50 persons or more who provides a parking subsidy to employees, shall offer a parking cash-out program. "Parking cash-out program" means an employer-funded program under which an employer offers to provide a cash allowance to an employee equivalent to the parking subsidy that the employer would otherwise pay to provide the employee with a parking space.

The law further restricts the scope by applying only to employers who lease (not own) parking and those who will not suffer a penalty if the leasing arrangements are altered such as to reduce the parking leased.[75] According to the California Air Resources Board (CARB), there are no funds to administer this state program; however, a survey was conducted in 1996 as part of a larger project by a survey research firm (Planning Consultants Research) on the use of parking cash-out by 417 employers in the Southern California region. As the project was not completed, the survey was not released to the general public.[76] The data on parking cash-out was provided to EPIC by CARB. This showed that of the 417 employer-respondents, 51 had some leased parking, 17 had some unbundled leased parking, and 13 of the 51 did not have a penalty for reducing leased spaces. As the law is restricted to employers that have parking leases that can be unbundled or changed without penalty, parking cash-out appeared to apply only to about 3% of the employers surveyed.[77]

In addition, in contrast to mass transit subsidies provided by employers to employees, which are non-taxable income to both employee and employer, parking cash out is subject to tax by employer payroll tax and employee income tax. The average payroll tax that an employer pays on taxable income is about 12%. However, if the employee chooses to receive all or part of his/her cash-out allowance together with a non-taxable transit benefit, then the parking cash-out subsidy is non-taxable both the employee and the employer.

As San Diego County is an area of non-attainment for ozone, this law applies here for employees with more than 50 employees. SANDAG has a website that shows all employer commuter incentives programs registered with them.[78] According to the website, only 2-3 employers had a parking cash-out program in the region in 2008.

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[75] (c) As used in this section, the following terms have the following meanings:

(1) "Employee" means an employee of an employer subject to this section.

(2) "Parking subsidy" means the difference between the out-of-pocket amount paid by an employer on a regular basis in order to secure the availability of an employee parking space not owned by the employer and the price, if any, charged to an employee for use of that space.

(d) Subdivision (a) does not apply to any employer who, on or before January 1, 1993, has leased employee parking, until the expiration of that lease or unless the lease permits the employer to reduce, without penalty, the number of parking spaces subject to the lease.

(e) It is the intent of the Legislature, in enacting this section, that the cash-out requirements apply only to employers who can reduce, without penalty, the number of paid parking spaces they maintain for the use of their employees and instead provide their employees the cash-out option described in this section.

[76] Personal Communication, California Air Resources Board, Jeff Weir, 16 April 2009.

[77] Two state bills may eventually result in the expansion of the law to a greater number of employers: SB 728 (Lowenthal), which would allow local government enforcement of the parking cash-out law, and AB 1186 (Blumenfield) which would require unbundling of parking.

[78] *See generally*, http://www.ridelink.org/EmployerServices/Other_Employers.aspx.

As with telecommuting, a business case may also be made for a parking cash-out policy beyond the minimal potential of the state law as it stands now.[79] Parking spaces, particularly in urban areas, are costly. The EPA estimated in 1993 that employers provide an estimated 85 million free parking spaces for commuters with a net worth of nearly $31.5 billion. Employers can save a substantial amount of money by reducing the number of parking spaces required, based on the annual cost of parking, which can vary from $360 to $2,000.[80] The economic benefits of parking cash-out range from the reduced need for employee parking and costs associated with owned or leased parking space, reduced maintenance costs of parking areas, the possibility for businesses to convert employee parking spaces to customer parking spots or into revenue-producing activities, and to reduce the need for future parking construction. In effect, by saving parking space, the employer not only saves on parking costs, but may also attract other paying customers.

For the GHG calculation we assumed:

- 12% of workers offered parking cash-out will use it. This is the lowest in the range (12-20%) shown possible by research for employers with more than 50 employees. [81]
- It would only apply to employers with more than 100 employees in San Diego.
- Employers provide 1 parking spot per employee.
- The commute distance in 20 miles.

4.3 Other VMT Reduction Measures

In addition to the measures to reduce VMT discussed above, several other options are possible. Each is discussed briefly below.

4.3.1 Freight Truck Measures

The United Nations IPCC declared in its summary for policy makers that shifting transport from road to rail would be a key measure to reduce GHGs from transportation.[82] SANDAG has plans to shift some road freight to rail. The large and growing volumes of border freight truck traffic (1.6 million trucks in 2006 total in both directions), the ensuing border wait times, and air pollution effects have prompted the development of a trade corridors improvement plan and proposal consisting of both freeway expansion and railroad expansion.[83] Planned improvements at the publicly held San Diego-

[79] Shoup has estimated that nearly 75% of US employers provide free or even subsidized parking to employees. Therefore, employers can save a substantial amount of money by reducing the number of parking spaces required, thereby reducing not only the cost of ownership or leasing, but also to reduce the maintenance costs. This can allow businesses to convert employee parking spaces to other revenue producing areas. See Shoup, Donald, The High Cost of Free Parking, 2005, and EPA Office of Air and Radiation March 2005, Parking Cash Out; Implementing Commuter Benefits as One of the Nation's Best Workplaces for Commuters.

[80] Victoria Transport Policy Institute, Online TDM Encyclopedia, *available at* www.vtpi.org/tdm. Costs are based on land, construction, and operations costs for suburban and urban locations, and for surface, structured, and underground parking.

[81] Shoup, Donald C. 1997a., Evaluating the Effects of Cashing Out Employer-Paid Parking: Eight Case Studies, Transport Policy, Vol. 4, No. 4, October 1997, pp. 201-216.

[82] Working Group III contribution to the Intergovernmental Panel on Climate Change, Fourth Assessment Report, Climate Change 2007: Mitigation of Climate Change, Summary for Policymakers, p. 14, available at: http://www.ipcc.ch/SPM040507.pdf.

[83] San Diego Association of Governments, Trade Corridors Improvement Project Funds Proposal, (December 2007).

Tijuana border rail terminal, the San Ysidro Yard, to expand the capacity of the San Ysidro Yard to nearly double the number of annual carloads for an additional 9,600 carloads per year, is projected to reduce 31,800 annual truck trips by 2030. This converts to 3.8 million fewer truck miles less in the San Diego region by 2030. Similarly, the associated improvements in the region's North Line (the LOSSAN Corridor) is also expected to produce rail capacity and velocity improvements such that 28,000 truck trips and 5.7 million truck miles can be eliminated. The total VMT reduced with these improvements by 2030 is projected to be 9.5 million miles.

Achieving only half the potential VMT reduction by 2020 would represents only 0.34% of the total truck and bus miles projected for 2020 (1.4 billion miles). Converting this to GHG reductions gives 7,125 MT CO_2E, or 0.5% of the VMT reduction amount needed (1.4 MMT CO_2E). While these improvements will provide air quality relief at the border and communities along the routes, the GHG reductions will not be significant unless a much greater freight rail system is implemented. In addition, the planned freeway lane expansion to reduce freight congestion may offset any reduction obtained by the switch to rail.

4.3.2 Park and Ride Lots

The region has 4,092 Park and Ride lots spread out over 78 lots. These are available for carpoolers or vanpoolers separate from parking available for transit users. There are no plans for expansion of Park and Ride lots. If carpoolers used all parking spaces in 2020, some additional GHG reductions could be achieved.

For the GHG reduction calculation we assumed:

- All parking spaces would be used to full capacity in 2020.[84]
- Each parking space represents one passenger vehicle that is taken off the road per day due to carpooling.
- These carpools are additional to mass transit.

Implementing a program to achieve full use of all Park and Ride spaces in 2020 would provide GHG reductions of 10,568 MT CO_2E, or 0.75% of the GHG reduction needed from VMT measures (1.4 MMT CO_2E).

4.4 Summary of VMT measures

Together, all VMT reduction measures assessed could reduce emissions by about 1.2 MMT CO_2E, 87% of the estimated target (1.4 MMT CO_2E) (Table 12), with mass transit having the largest reduction potential. Even such as expanded mass transit system would not be sufficient, and two other significant VMT reducing measures, such as a telecommute and parking cash-out program, would be needed to achieve the 1.4 MMT CO_2E reduction.

[84] Actual use in 2006 was 43%. Personal communication, Mike Roy, Caltrans District 11.

Table 12 GHG Reduction from Existing, Planned and Potential VMT Reduction Measures

VMT Measure	GHG Reduction Amount (MMT CO_2E)	Percentage of Needed Reduction Amount
Vanpools	0.03	2%
Congestion Pricing	0.12	9%
Congestion Miles Reduction	0.08	6%
Parking Cash-Out Potential	0.11	8%
Freight Truck to Rail	0.01	0.5%
Park and Ride	0.01	0.75%
Mass Transit Potential	0.55	39%
Telecommute Potential	0.30	22%
Total Potential	1.20	87%

4.5 Policy Implications of VMT Reduction Measures

- As mass transit has the potential for the most significant GHG reductions, SANDAG should continue to assess possibilities for an expanded mass transit system that is time competitive with the passenger vehicle and of sufficiently high quality to attract middle-income commuters.
- The state of telecommuting in the county should be assessed and the potential for a region-wide coordinated telecommute policy amongst federal, state, county and city offices should be evaluated.
- The business case for a telecommute policy should be evaluated.
- The business case for an employer parking cash-out policy should be assessed.
- SANDAG should evaluate the cost effectiveness of congestion reduction measures not only in terms of highway safety improvements and labor hours lost but also in terms of GHGs and criteria pollution emissions. The research indicates that the cost is high compared with other measures when considering all these effects.
- VMT reduction should not be considered in isolation of the alternative fuels strategy or the fuel use reduction strategy due to the rebound effect. Therefore, if the rebound effect occurs in our region, the role of local government to reduce GHGs will be enhanced.

5 FUEL USE REDUCTION MEASURES

Increasing the fuel economy of vehicles (federal CAFE standards) and reducing tailpipe GHG emissions (California AB 1493/ Pavley) could to provide 47% of the total transportation GHG reductions needed to reach 1990 levels by 2020, or 23% of the total AB 32 reduction amount by 2020 (Table 13).

Table 13 Fuel Use and Tailpipe Emissions Reduction Strategies, San Diego County

Strategy	Estimated GHG Reduction by 2020 (MMT)	Percentage of Total On-Road Transportation Reduction	Percentage of Total EPIC Target Based on AB 32
CAFE and Pavley	3.2	47%	23%

The Obama Administration increased the federal CAFE standards for fuel economy in 2009 from the 2004 fleet (passenger cars and light duty trucks) average of 25 to 35.5 mpg by 2016, starting with the 2012 models. From 2021 to 2030 fuel efficiency must be the " maximum feasible". The 2020 level represents a 40% increase in fuel efficiency from the 2004 standard.

In June 2009, California obtained a waiver from the EPA[85] under the federal Clean Air Act to implement AB 1493 (Pavley), which requires passenger vehicle manufacturers to tailpipe GHG emissions levels shown in Table 14. All of these levels are greater than 200 grams CO_2E per mile. In comparison, electric vehicle emissions are less than 100 grams CO_2E per mile. The emissions standards are to apply from 2012 models. The fleet average tailpipe emissions reductions are envisioned to come through a variety of technical improvements assessed by the California Air Resources Board[86] and/or by combination with alternative fuel vehicles.[87] The federal government is expected to adopt the Pavley standards with agreement from California not to toughen its standards before 2017.

[85] Jim Tankersley, *EPA Gives California Emissions Waiver*, Los Angeles Times, June 30, 2009, *available at*, http://www.latimes.com/news/nationworld/nation/la-na-california-waiver30-2009jun30,0,1077405.story.

[86] Personal communication, Belinda Chen, California Air Resources Board, August 13, 2009, stated that the Pavley regulations are performance-based standards, so that there is no single specific requirement that automakers must follow to comply. It appears that much of the standard could be met through an assortment of available technologies, such as gasoline direct injection, variable valve timing and lift, turbocharging or cylinder deactivation, 6-speed automatic and automated manual transmission, electric power steering, improved alternator and more efficient, low-leak air conditioning although there are also credits available for changes in air conditioners and using alternative fuels.

[87] Note that electric vehicle tailpipe emissions are less than 100 grams CO_2E/mi.

Table 14 Pavley Regulation Fleet GHG Emissions Standards and Reduction Schedule

Fleet Average Greenhouse Gas Emissions (grams per mile CO_2E)

Model Year	All PCs; LDTs 0-3750 lbs.	LDTs 3,751- 8,500 lbs.
2009	323	439
2010	301	420
2011	267	390
2012	233	361
2013	227	355
2014	222	350
2015	213	341
2016+	205	332

Note: PC= passenger car, LDT = Light duty truck

It is doubtful that local policies can accelerate the introduction of more fuel-efficient vehicles or those with low tailpipe emissions (see also Section 4.2) to a greater extent than expected through federal and state policies; however, there are several local measures that can contribute to fuel use reduction in other ways. These are all speed harmonization methods. We quantified three potential measures that we thought were reasonable and feasible: (a) retiming traffic signals, (b) use of roundabouts in place of stop intersections, and (c) highway expansion to reduce congestion.

5.1 Retiming or Synchronization of traffic lights

Inappropriate traffic signal timing contributes to increased congestion, which increases fuel use and GHG emissions. [88] Retiming these signals can be an effective solution to address this problem and contribute to GHG reduction. The system of touch and feel response lights in general found within our county can cause considerable delay because of frequent transitions, because of the blocking effect of a single vehicle versus a large number in another direction and lack of interconnection over longer stretches of roadways.

The operation of signalized intersections can be made through a variety of low-cost improvements, including the development and implementation of new signal timing parameters, phasing sequences, and occasionally, minor roadway improvements. Retiming applications vary in control complexity from simple to adaptive and dynamic including priority for emergency and mass transit vehicles.

From 1983 to 1993, at a cost of $61 million, California ran the California Fuel Efficient Traffic Signal Management ("FETSIM") program to improve 12,245 signals statewide through optimizing traffic signal timing plans, coordinating traffic signal control, and implementing adaptive signal control.[89] This program provided grants to local governments to cover the costs of retiming signals. In assessing the effect of 55% of the signals retimed, there was an average 7.7 % reduction in travel time, 13.8 % reduction in delays, 12.5 % reduction in stops, and a 7.8 % decline in fuel use. No data was available on signals retimed in San Diego County under this program.

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[88] *See generally* the fuel reducing effects of the advanced traffic retiming system installed in Los Angeles, *available at*, http://ieeexplore.ieee.org/xplore/login.jsp?url=/stamp/stamp.jsp?arnumber=69967&isnumber=2453; http://trafficinfo.lacity.org/

89 *See* http://library.ceres.ca.gov/docs/data/1700/1766/HYPEROCR/hyperocr.html; http://www.itsbenefits.its.dot.gov/its/benecost.nsf/ID/42419C3E5993E9CD852569EA0071D556

In San Diego County, each of the 18 cities and County own and operate traffic signals; Caltrans owns and operates the signals at freeway ramps and along state highways. In 1993, roughly half of the then existing 2,092 traffic signals were uncoordinated. There was also limited coordination between jurisdictions. To comply with the federal Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991, as well as the federal and state air quality standards, SANDAG initiated an aggressive signal retiming effort in 1993 called the Traffic Signal Optimization Program.[90] This involved an inventory of all signal systems in the county followed by a plan to optimize and coordinate "virtually all traffic signals in San Diego region";[91] however, the plan was developed to provide maximum control by cities over their own signals, to have the ability to choose the type of controller then available, and to be able to monitor systems in adjacent cities when coordinating arrangements existed. This may have led to loss of effective traffic light coordination across inter-urban roads; however, there is no information on the outcome of this program.

A 2001 SANDAG report[92] documented that in the city of San Diego, out of the then existing 1,430 signals, 486 had been retimed since 1998 with plans to retime 320 more. The plan included allocation of $240,000 from the federal CMAQ (Congestion Mitigation and Air Quality) Program for traffic count data needed to retime those 320 signals. It is reported that these 320 signals were ultimately not re-timed. Using the 320 identified traffic signals for optimization previously identified, we calculated the GHG reduction per intersection based on the average value of savings reported in the literature, of 7,835 gallons per intersection. Although the GHG reduction benefits of this measure are minor in absolute terms, or 0.24 MMT CO_2E per year, the fuel cost savings benefit and therefore GHG reduction amount in relation to the investment cost is high (Figure 12).

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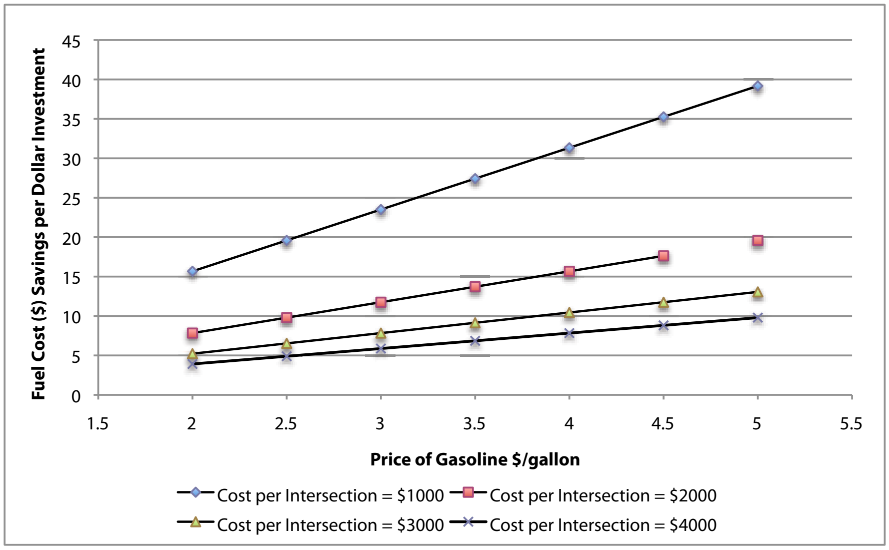
[90] San Diego Association of Governments, Traffic Signal Optimization Program (April 1994).

[91] *Id.*

[92] The City of San Diego Manager's Report, November 7, 2001. *See* http://docs.sandiego.gov/reportstocouncil/2001/01-244.wpd.pdf.

Figure 12 Fuel Cost Savings of Traffic Light Retiming[93]



5.1.1 Experience of Other Cities

The city of Portland optimized traffic signals at 135 intersections on 16 streets resulting in a savings of 15,460 tons of CO_2 each year,[94] greater than the savings generally reported in the literature and greater than the average savings we used in our GHG reduction calculations for this measure. The project was funded partly by the Climate Trust, which pays Portland based upon the amount of CO_2 emissions that will be avoided. In turn, Portland transfers ownership to the Climate Trust of the CO_2 offsets created by the reduced emissions.

Los Angeles has begun to use advanced traffic signal controls to determine when to retime the signals at particular intersections due to increased traffic volume at certain times of the day or due to road hazards.[95] The Los Angeles Automated Traffic Surveillance and Control System (ATSAC) is used at 3,100 of the city's 4,300 signalized intersections at a cost of approximately $71,000 per intersection – a cost much higher than merely providing signal retiming. ATSAC

> "is a computer-based traffic signal control system that monitors traffic conditions and system performance, selects appropriate signal timing (control) strategies, and performs equipment diagnostics and alert functions. Sensors in the street detect the passage of vehicles, vehicle speed, and the level of congestion. This information is received on a second-by-second (real-time) basis and is analyzed on a minute-by-

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[93] Calculated based on published average fuel use reductions upon retiming in a typical 4 lane highway, of 7,835 gallons per intersection, and typical cost of the equipment based on the SANDAG Traffic Signal Optimization Project Report, *see* Note 89.

[94] C40 Cities Climate Leadership Group, Transport – Portland, Optimizing Traffic Signal Timing Significantly Reduces the Consumption of Fuel, *available at,* http://www.c40cities.org/bestpractices/transport/portland_traffic.jsp.

[95] IEEE, *The Lost-Angeles Automated Traffic Surveillance and Control (ATSAC) System, available at,* http://ieeexplore.ieee.org/xplore/login.jsp?url=/stamp/stamp.jsp?arnumber=69967&isnumber=2453; and LADOT, *available at*, http://trafficinfo.lacity.org/.

> minute basis at the ATSAC Operations Center, located four floors below the street in the City Hall, to determine if better traffic flow can be achieved by changing the signal timing. If required, the signal timing is either automatically changed by the ATSAC computers or manually changed by the operator using communication lines that connect the ATSAC Center with each traffic signal. To supplement the information from electronic detectors, closed-circuit television (CCTV) surveillance equipment has been installed at critical locations throughout the City". [96]

Non-city grant funding has provided about 2/3 of implementation costs. The program paid for itself within approximately 1 year. Fuel consumption decreased 12.5% and air emissions decreased 10%. Recently it was reported that about 82% of the signal controlled intersections in Los Angeles have been synchronized.[97]

5.2 Replacing Traffic Light Intersections with Roundabouts

Research has shown that the use of modern roundabouts in place of traffic lights or stop signs can result in significantly better traffic flow, thus contributing to not only reduced congestion but also reduced air pollution.[98] Roundabouts result in slowing down approach to an intersection and result in slow but steady and continuous vehicle speeds in contrast to stop-and-go conditions caused by stop sign and traffic light intersections. They also eliminate left-turns and associated delays. The Insurance Institute for Highway Safety generally promotes the use of roundabouts[99] in place of stop or traffic light signals based on the additional benefit to the insurance sector of reduced vehicle accidents. The feasibility of replacement should be determined on an individual intersection basis.

In the San Diego region, the Bird Rock, La Jolla roundabout project is an example of a change from stop sign intersections to roundabouts. Replacing several 4-lane road stop-sign intersections with roundabouts is estimated to have reduced fuel use by 20,000 gallons per intersection. Fuel use reductions, and therefore the GHG reductions, achievable through this measure are significantly greater than those from retiming traffic signals, though considerably more costly (Table 15).

For the GHG reduction calculation, we assumed the same number of intersections (320) to be replaced with roundabouts as for signal retiming. This number seems reasonable compared with both the number of existing non-freeway intersections as well as the fact that it was possible to identify 4 roundabouts for La Jolla alone. This also allows us to compare the reductions from both measures. The theoretical GHG reductions possible from replacement of 320 traffic light signals or stop sign intersections with roundabouts is 60,480 MT CO_2E. Fuel cost savings at various final prices are shown in Table 15.

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[96] *Id.*

[97] LA Times Local, October 8, 2009, *available at* http://latimesblogs.latimes.com/lanow/2009/10/82-of-las-streets-now-covered-by-synchronized-traffic-lights.html.

[98] Retting, R.A.; Mandivilli, S.; and Russell, E.R. (2005). Traffic flow and public opinion impacts of newly installed roundabouts in New Hampshire, New York, and Washington. Arlington, VA: Insurance Institute for Highway Safety.

[99] Bergh, c, Retting, R and Myers, E., (September 2005). Continued Reliance on Traffic Signals: the Cost of Missed Opportunities to Improve Traffic Flow and Safety at Urban Intersections, *available at,* http://www.iihs.org/research/topics/roundabouts.html.

Table 15 Fuel Cost Savings from Roundabouts

Fuel Price ($/gallon)	2.00	2.50	3.00	3.50	4.00	4.50	5.00
Value of Fuel Saved	$40,000	$50,000	$60,000	$70,000	$80,000	$90,000	$100,000

Note: Cost per Intersection $500,000; Fuel Saved per Intersection 20,000 gallons; CO_2E saved per Intersection 189 MT

5.3 Reducing Congestion

Congestion mitigation through lane expansion is the most frequently used mitigation method in our region. While this can reduce congestion in the short run (5-10 years), it has been shown that the effect may be temporary. Rush hour traffic typically flows more freely after new lanes are opened, and congestion relief can raise the effective fuel efficiency of vehicles on the roadway; however, consistent with real-world experience, new highway capacity in a metropolitan area will gradually be filled by new trips, and congestion and stop-and-go driving will gradually increase to approximately the same level experienced prior to the highway expansion. Research shows that over time, CO_2 levels decline as a result of congestion relief compared to a "baseline" highway that is not widened, but emissions from additional traffic may overwhelm this short-term (first decade) congestion relief over time, resulting in net GHG increases.[100]

According to the SANDAG Congestion Management Plan Update of 2006,[101] there were 172 miles of congested freeways, highways and arterials in San Diego County in 2006 that were categorized as level of service (LOS) F, which is defined as traffic flowing at less than 20 mph with more than 45 passenger vehicles per lane mile. In 2008, there were 105 LOS F miles. Additional highway improvement measures – mainly additional lanes – are expected to reduce the LOS F miles by 2020 to 91. Based on research studies,[102] we assume that congestion leads to an average 40% decrease in fuel efficiency of passenger vehicles.[103] Traffic count data at peak hours were used to estimate the number of vehicles subject to LOS F per year and this was used to estimate the emissions avoided by planned congestion reduction measures – highway improvement measures - by 2020. Fuel cost savings are shown in Table 16.

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[100] Anthony Downs, Still Stuck in Traffic: Coping with Peak Hour Traffic Congestion, 2004, and Litman, Todd, Smart Congestion Reductions, Re-evaluating the Role of Highway Expansion For Improving Urban Transportation, Victoria Transport Policy Institute, 19 June 2009. A Sightline Institute publication suggests that over a 50 year life time, GHG reductions of highway expansion would overcome the congestion relief provided, *see* Williams-Derry, C., Increases in Greenhouse Gas Emissions, Sightline Research Backgrounder, October 2007.

[101] Congestion Management Plan Update 2006, San Diego Association of Governments, *available at,* http://www.sandag.org/index.asp?classid=13&fuseaction=home.classhome

[102] The drop in fuel efficiency of passenger vehicles varies with the weight and characteristics of the vehicle, but driving at speeds much less than about 30 mpg leads to fuel use decreases of between 30 and 50%. The decrease in fuel efficiency is less at speeds over about 65 mpg but is not as drastic as when driving slower. *See,* for example, fuel consumption versus speed (1988-1997 data) chart at http://www.fueleconomy.gov/feg/driveHabits.shtml.

[103] Analysis of the relationship between the growth in total roadway and VMT per capita shows little correlation but freeway construction induces more freeway driving per capita, especially under population growth scenarios, thus again increasing freeway congestion. *See* http://www.ti.org/vaupdate28.html.

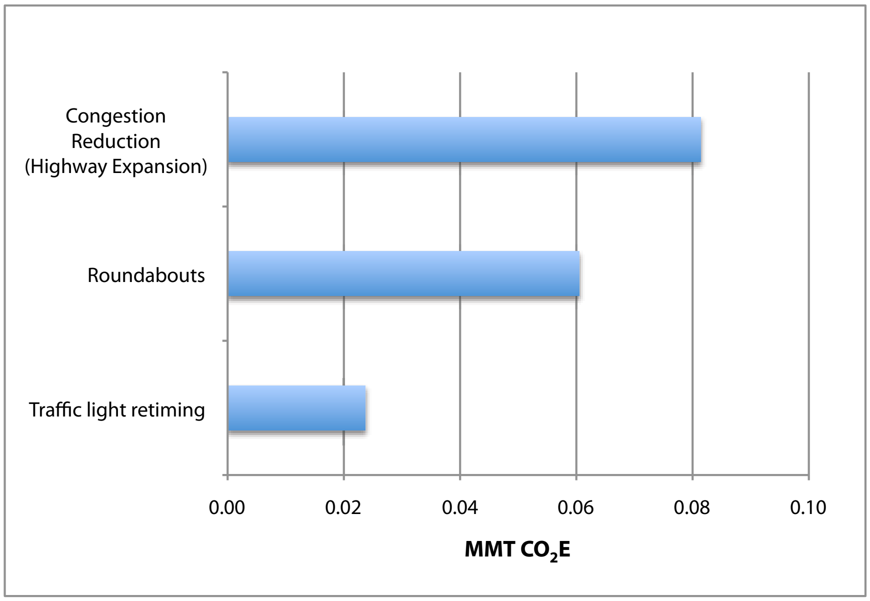
Table 16 Fuel Cost Savings from Highway Expansion as a Congestion Reduction Measures[104]

Fuel Price ($/gallon)	2.00	3.00	4.00	5.00
Value of Fuel Saved	$15,000,000	$22,500,000	$30,000,000	$37,500,000

Note: Estimated Cost to 2020 is $16.5 billion; Fuel Saved 8 Million Gallons; CO2E saved 0.83 MMT

The total GHG reductions possible from traffic light retiming, roundabouts, and planned highway expansion measures are 0.2 MMT CO_2E (Figure 13). Highway expansion provides only somewhat greater GHG reductions than potential roundabout installations at intersections though at higher cost.

Figure 13 Fuel Use Reduction Measures Effect on GHGs



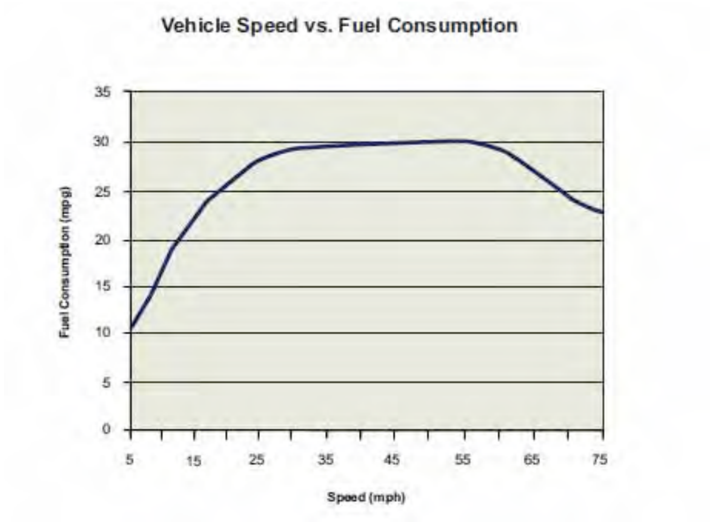
5.3.1 Other Potential Local Fuel Use Reduction Measures

Other local measures, such as advanced intelligent traffic management systems, the physical state of the roads, vehicle maintenance measures, and vehicle driving patterns affect fuel use and GHG reduction. We did not quantify these. Some local measures may interact negatively with others and not lead to reductions for a variety of reasons. For example, of the many transportation demand or systems management (TDM/TSM) measures that can reduce fuel use, it is documented that vehicle speed is a determinant of fuel use[105] (Figure 14).

[104] The costs of congestion reduction by highway expansion includes capital investment costs from 2006-2011, 2011-2020, as presented in Table 4.8 of the 2030 RTP.

[105] Fuel speed versus fuel consumption chart is available from the U.S. Department of Energy web site, *available at,* http://www.fueleconomy.gov/feg/driveHabits.shtml.

Figure 14 Fuel Consumption Versus Speed, Based on 1988-1997 Data.[106]



The chart is based on a range of vehicles dating from 1988 to 1997 and is often used by planners to show that reducing vehicle speed will lead to fuel use reduction. The optimal speed for the fleet of passenger vehicles ranges between 35 and 55 mph. The chart shows that driving at speeds lower than about 15 mph (congestion) leads to greater fuel use than driving at higher speeds above the typical freeway speed limit of 65 mph. Without more research, we cannot say with certainty by what percentage reducing the speed from over 65 or 55 mph will reduce fuel use and GHGs. We do not know what percentage of miles driven is driven at speeds of over 65 mph, or even what percentages are driven at any speed. In order to make proper estimates of the effect of speed on fuel use, we would have to know the speed distribution on the freeways. As we focus only on commuter miles driven, the estimated fuel use reduction would be less because of the fact that it is nearly impossible to drive at speeds greater than about 55 mph during commuter traffic hours.

A U.S. Government Accountability Office (GAO) report of 2008 assessed the effects of a potential reduced national speed limit.[107] This report states that a national speed limit would not affect many of the miles driven in the United States, such as those in urban areas, where most vehicles are already traveling at lower speeds due to lower speed limits or congestion. According to the report, less than one quarter of the VMT in the United States would likely be directly affected by a change in speed limit. Congestion forces some vehicles to travel slowly, no matter what the speed limit, meaning a reduction would have little or no impact on fuel consumed on congested roads. The estimate for potential savings from a national freeway speed reduction is between 0.3 and 3%, or an average of 1.5%. The National Maximum Speed Law of 1974 (55 mph/89 km/h) was enacted to reduce oil imports by reducing fuel use; however, the national speed limit was widely disregarded. As the law held penalties – loss of federal highway funds -- for states with greater than 50% of its drivers violating the limits, several states took to the courts. In addition, the cost of enforcement is reported to have been high, and the 55 mph limit was repealed in 1996.

It is possible that the speed-fuel use relationship is different from that represented in Figure 14 based on today's vehicles that are more fuel-efficient than this chart suggests. In addition, if commuting

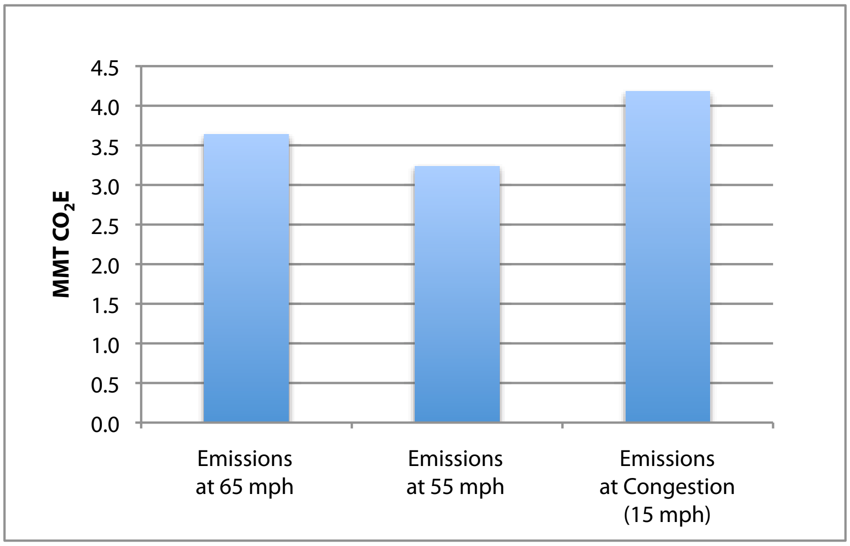
[106] *Id.*

[107] Energy Efficiency: Potential Fuel Savings Generated by National Speed Limit Would be Influenced by Many Other Factors, GAO report number GAO-09-153R, Nov 8, 2008, *available at,* http://www.gao.gov/htext/d09153r.html.

distances increase, there is motivation to travel at higher speeds, not lower speeds, thereby reducing the effect of other technological or TDM/TSM measures to reduce fuel use.

Applying the miles per gallon versus speed relationship shown in Figure 14 to the San Diego County VMT, and assuming that 25% of all passenger vehicles were driven above 65 mph instead of a theoretical 55 mph, we calculated the GHG emissions reduction possible. If the same number of miles were driven at congestion speeds of less than 25 mph, we would offset any benefits obtained from a speed reduction (Figure 15).

Figure 15 Theoretical Effects of Freeway Speed Changes on GHGs
(San Diego County, 2007 VMT Data)



Although freeway speed reduction from 65 to 55 mph would reduce GHG emissions, the same number of vehicles caught in the "low-teens" congestion on the freeways would emit more GHGs than the reduction in speed would cause. This might suggest that greater resources should be provided to reduce congestion than reduce speed. Also, on the whole, it appears unrealistic to expect most vehicles to be driven at reduced speeds without the introduction of significant penalties. More research is needed to assess the effect of variable speed limits on fuel use within our region, as well as the potential cost of enforcement. Within limits, local governments have jurisdiction to reduce highway speed within their jurisdiction.[108]

The aim of speed control should be speed harmonization that makes mobility more efficient across the region. Speed harmonization systems have been deployed successfully in many parts of Europe. It is based on a central system that monitors data coming from sensors along the roads and automatically triggers speed control when congestion and queue formation are about to occur. This occurs across all freeway lanes without operator intervention.[109]

Other potential fuel use reduction measures are:

- **Freight Truck Management Lanes –** The SANDAG plan[110] to open a new border crossing to

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[108] California Veh. Code '22358(a) & 22360.

[109] Variable Speed Limits (VSL) Case Studies, The European Approach, *available at*, variable speed limits_europeanExamplesAASHTO.pdf.

[110] State Route 11 and Otay Mesa East Port of Entry is scheduled to open in 2015, *see*

relieve the existing points of entry and existing congestion and the proposal to shift some truck freight to rail would lead to congestion reduction. However the expected increase in truck traffic may counteract any GHG reductions obtained through the new port of entry. Air pollution reductions to the immediate communities are still to be expected.

- **Advanced Intelligent Traffic Management Systems** - Ramp metering keeps traffic flow smoother than without but studies indicate that the decrease in emissions due to free flow may be offset by emissions due to queuing or may even lead to net increase in GHGs.[111] Dynamic ramp metering can reduce this problem though the problem may be shifted elsewhere. Road shoulder use during peak hours and to get around accidents in combination with dynamic speed control, dynamic parking systems and dynamic real time traffic and parking information are known measures to produce quick congestion reduction and fuel use reduction.[112] SANDAG is experimenting with some of these measures.[113] The effect of these measures on the total volume of traffic, or the miles traveled, is not known.[114]
- **Driver Training and Education –** These programs appear to be targeted at persons driving manual transmission vehicles as opposed to automatic transmission vehicles that are so prevalent in the United States. Therefore, the feasibility of such a program here in San Diego County directed to individual drivers seems low. The US EPA does have a Smartwise program with tips on "how to be more environmentally friendly" and on Inspection and Maintenance.[115] In the United Kingdom, the program known as EcoDrive run by the Energy Savings Trust and funded by the Department of Transportation has found that with better driver techniques drivers can reduce fuel use by 5-10%, with some reaching 20%. Therefore GHGs from on-road transportation could potentially be decreased by an average of 10%.[116]
- **Effect of Road Conditions –** the effect of road paving, whether even or not, and texture, has been shown to affect especially the fuel consumption of heavy-duty vehicles. Asphalt coated surfaces are smoother than concrete and reduce fuel use. At constant speeds, research shows that 12% of the fuel consumption of HDTs is due to rolling resistance of the tires (friction) while for passenger cars at 100 km/h losses may be higher. [117]
- **Vehicle Maintenance Measures –** The effect of a well-tuned engine, proper tire inflation, the use of proper engine oil are maintenance issues that can provide varying percentages of fuel use reduction.

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http://www.sandag.org/index.asp?projectid=56&fuseaction=projects.detail.

[111] Facts on Ramp Metering, *available at,* http://www.calccit.org/itsdecision/serv_and_tech/Ramp_metering/ramp_metering_summary.html

[112] Temporary Hard Shoulder Use in Hessen – Experiences and Strategic Planning, *available at,* http://i2tern.plan.aau.dk/doks/paper/paper92.pdf.

[113] See charts at http://www.dot.ca.gov/dist11/d11tmc/sdmap/direct/rampinfo.html.

[114] See also FTA Real Time Transit Information Assessment, White Paper, August 2002, *available at* http://www.itsdocs.fhwa.dot.gov/JPODOCS/REPTS_TE/13845.html.

[115] U.S. Environmental Protection Agency, Drive Wise, *available at*, http://www.epa.gov/air/actions/drive_wise.html.

[116] EcoDriven, Final Conference, *available at*,http://www.ecodrive.org.

[117] *See in general*, Delanne, Y. The influence of Pavement Evenness and Macrotexture on Fuel Consumption, Vehicle-Road Interaction, ASTM STP 1225, 1994, pp 240-247. *See* also Environmental Impacts and Fuel Efficiency of Road Pavements, Industry Report, March 2004, prepared by the European Asphalt Pavement Association and Eurobitume Task Force, *available at,* www.eapa.org/START/.../**Fuel**%20Efficiency%20Report.pdf.

5.4 Summary of Potential Fuel Use Reduction Measures

Several measures are available to reduce fuel use that provide incremental GHG reductions and are relatively cost effective. We focused on two potential measures and one existing measure that could be compared in terms of GHG: traffic light retiming, roundabouts and congestion reduction through highway expansion; however, no one measure stands out in terms of GHG reduction. Congestion reduction by roadway expansion can provide only slightly greater GHG reductions by 2020 than replacement of 320 intersections by roundabouts. Together, the three measures can provide 0.15 MMT CO_2E of reduction in the region. Identifying more traffic lights for retiming and more intersection replacements with roundabouts may provide greater GHG reduction than the planned congestion reduction measure. In terms of cost, congestion reduction by highway expansion is highly expensive if calculated only in terms of fuel saved. In addition, highway expansion is a short-medium term solution for traffic control and fuel use reduction since highway construction cannot keep up with demand as long as the population grows.

5.5 Policy Implications and Recommendations

Fuel use reduction methods may provide GHG reductions similar to planned congestion reduction measures if carried out in a coordinated way amongst the cities in the region but at a much lower cost. These measures could be considered low hanging fruit. Therefore the following actions are recommended for local governments:

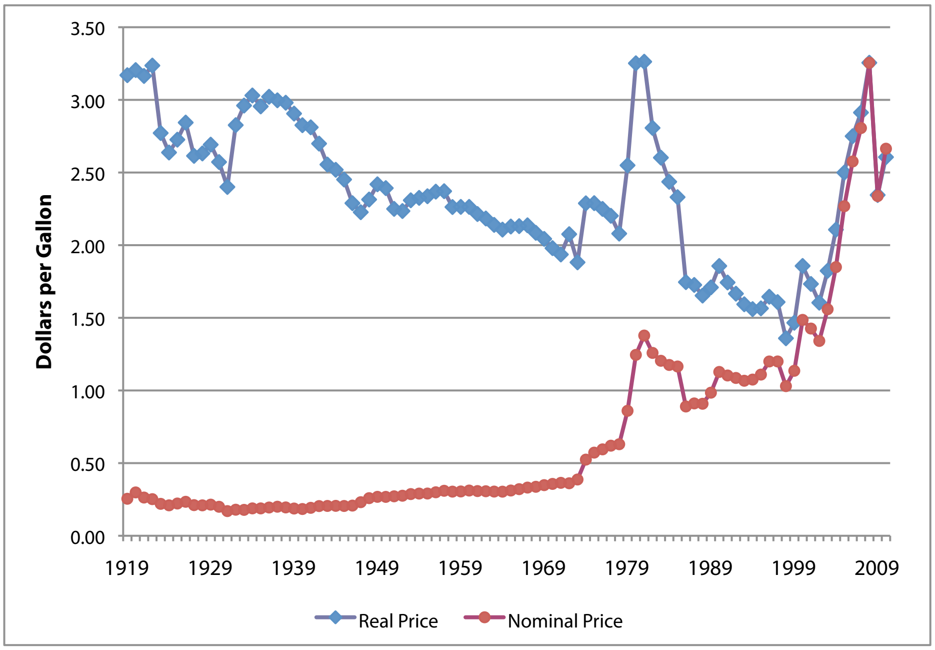
- Identify signals for retiming
- Identify new developments that may be suitable for roundabouts. The policy of adopting stop signs at every intersection is likely to have similar effects.[118]
- If additional incremental measures are needed to provide small amounts of GHG reduction SANDAG could evaluate further the effects on fuel use of asphalting roads, implementing advanced traffic control measures, and supporting driver training and vehicle maintenance programs.

[118] If replacing stop signs with yield promotes energy use reduction, it could worsen pedestrian safety in places where there is pedestrian traffic; however, San Diego suburban residential areas in general have little or no foot traffic and stop signs at nearly every residential intersection. The safety issues may be overcome by driver and public training. Especially in residential areas, use of yield signs in place of stops is not expected to promote vehicle use because of the limited additional vehicles using residential zones as travel-through areas.

6 A PRICING STRATEGY

Fiscal policies are user charges, taxes, or subsidies, which work indirectly through pricing to offset externalities that have not already been taken into account in the prices. In the United States, two cost developments related to vehicle ownership and use have resulted in a relatively low cost to individual ownership. The first cost development is that the history of gasoline prices in the United States (Figure 16) shows a continuous decrease in real terms since 1919.[119] However, since about 2003, the real price has been increasing and remained above $3/gallon in 2007.

Figure 16 Historical Annual Average Gasoline Price, USA. Source: EIA Short Term Energy Outlook, August 2009

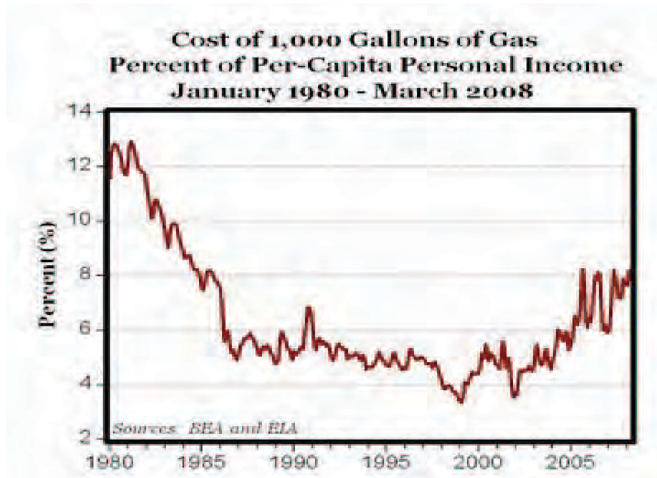


The second development is that the percentage of real income spent for gasoline has decreased since the 1980's (Figure 17). In the history of gasoline prices, the peak price of gasoline in real terms as a percent of income was in March 1981, when 1,000 gallons of gas cost 13% of per-capita disposable income. According to Perry,[120] gasoline today would have to reach a price of about $5.13 per gallon, before it would reach that percentage of the current income.

[119] Energy Information Administration, Short Term Energy Outlook, 2009.

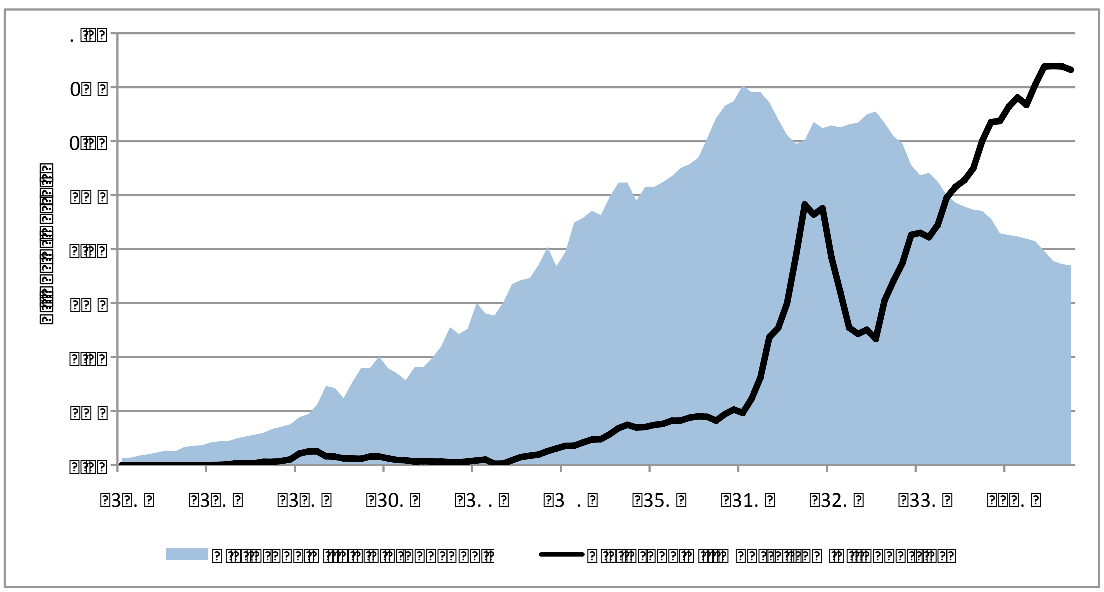
[120] Mark J. Perry, Economics and Finance Blog, *available at* http://mjperry.blogspot.com/2008/06/adjusted-for-income-and-fuel-efficiency.html.

Figure 17 Cost of Gasoline Relative to Personal Income[121]



On the other hand, US gasoline prices are increasingly dictated by imports (Figure 18) and might be expected to increase to 1980 levels during phases of global growth.

Figure 18 Supply of Oil in the US[122]



A study carried out by the US Congressional Budget Office in January 2008[123] showed that although consumers are not very responsive to gasoline price changes due to growth in real income, and thus a

[121] This chart has been created by Professor Perry, University of Michigan and is *available at*, http://mjperry.blogspot.com/2008/06/adjusted-for-income-and-fuel-efficiency.html. (Last visited July 15, 2009).

[122] Data for this chart was obtained form the Energy Information Agency, *available at*, http://www.eia.doe.gov/oiaf/aeo/supplement/regionallowmac.html.

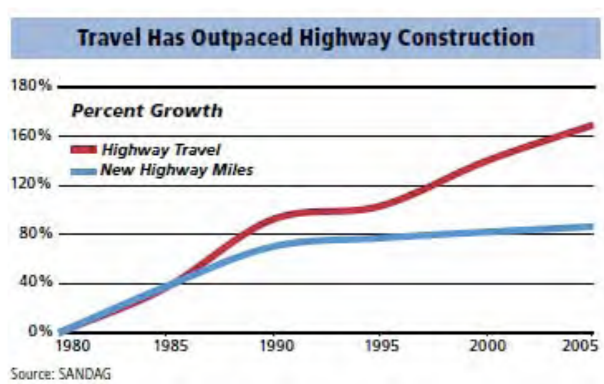
[123] Effects of Gasoline Prices on Driving Behavior and Vehicle Markets, The Congress of the United States, Congressional Budget Office, (January 2008).

decreasing proportion of disposable income is spent on gasoline, the price increases seen in 2007 did force drivers to adjust driving habits by reducing speed, reducing vehicle miles traveled, and also changing the type of vehicles they purchase. The study provided the following trends in driving behavior upon a short-term (1-2 years) increase in price:

- For every nominal 50-cent increase in gasoline price, driving speeds decreased by about ¾ mile per hour, and the amount of freeway traffic when located next to transit systems increased by the decrease in volume on the freeway.
- Since 2004, the share of light trucks has declined relative to cars despite the slight increase in financial incentives for light trucks in 2006. The purchase of new more fuel-efficient cars has also increased despite their relatively larger annual price increases.
- Many studies have analyzed the relationship of VMT and fuel price. A 10% increase in price can reduce VMT by 1.1-1.5% in the short run (within one year) and if sustained more than about 3 years can reduce VMT about 3%. A sustained (greater than 3 year) 100% increase in price is likely to reduce system wide VMT by 10% in that time.
- Higher gasoline prices are statistically significantly related to increased mass transit ridership

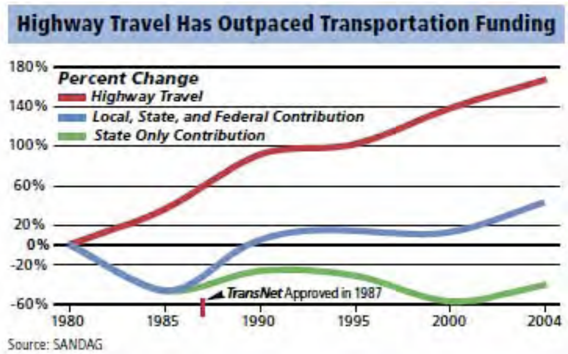
Fuel price alone may achieve significant reductions in transport energy use if sufficiently high. This suggests that an increased gasoline tax can have the same effect. In the US, and as shown below, the federal, state and local fuel taxes are relatively low and do not form a significant fraction of the gasoline price. Even as a source of revenue to fund and maintain existing transportation infrastructure, it is insufficient (Figures 19,20).[124]

Figure 19 Highway Travel and New Highway Construction



[124] SANDAG, The State of the Commute, 2005, San Diego County, *available at,* http://www.sandag.org/index.asp?projectid=257&fuseaction=projects.detail.

Figure 20 Highway Travel and Transportation Funding



Therefore, not only does the fuel tax revenue have practically no effect on GHG reduction, alternative sources of revenue must be found even to maintain existing road conditions. Due to this urgency to find new sources of revenue to maintain existing infrastructure, we might expect that only a significant increase in any type of transport revenue source can also be used to mitigate climate change. On the other hand, the need to find new sources of revenue for maintenance of existing infrastructure, the need to meet transportation energy reduction to meet climate change mandates, the expectation that global growth will cause fossil fuel price increases in the long term, all provide an opportunity to re-think funding opportunities in combination with GHG reduction for the medium to long term.

6.1 Existing State and Local Pricing Methods

Although not exhaustive, the following sections present a summary of taxes, fees and tolls associated with vehicle purchase and use in our region, and comparison with other cities that have successfully implemented pricing schemes as a source of revenue, to reduce congestion and to counteract externalities such as GHG emissions.

6.1.1 Registration Fees

California registration fees[125] are $31 one time and 1.15% of the purchase price annually. This annual vehicle fee revenue is returned to the cities and counties through the state Transportation Tax Fund. In addition, there are several fixed, one-time and variable fees for highway patrol ($9), highway emergency fee ($1), fingerprint ID fee ($1), smog abatement ($6) auto theft deterrence program ($1), abandoned vehicle fee ($1) and the county air quality management fee ($2 which can be raised to $6 if passed by a 2/3 majority of its board of supervisors). For a vehicle that costs $20,000, the total annual registration and vehicle license fees are about $184. In the case of this theoretical vehicle purchased at $20,000, the registration and other annual fees constitute just 0.92% of the total price each year.

The registration fees do not differentiate on the basis of fuel efficiency of the car. A fixed smog abatement fee is imposed. There is also no difference based on the type of fuel, whether less carbon intensive or not. Air quality fees are used by the districts to reduce air pollution from motor vehicles and for related planning, monitoring, enforcement and technical studies needed to implement the California Clean Air Act of 1988. Fees may also be charged for reviews, analyses, documents and procedures required or requested pursuant to CEQA (Rule 40, (a)(1), Regulation III, San Diego Air

[125] California Department of Motor Vehicles, Vehicle Registration Fee Calculator, https://mv.dmv.ca.gov/FeeCalculatorWeb/index.jsp.

Pollution Control District Rules).[126] There is no such charge imposed in SD County now.

6.1.2 Vehicle Taxes

This is a sales tax applicable to all goods sold on the market. It is 8.25% at the state level and counties may increase this by a certain percentage. In San Diego County the total state and county sales tax is currently 8.75% of the purchase price, except for the city of Vista, which has a total sales price tax of 9.25%.[127]

6.1.3 Fuel Taxes

A fuel tax is levied on the consumption of fuel and is traditionally used worldwide to raise revenue, and/or road maintenance, and mitigation of environmental externalities. The federal (Table 17) and state fuel taxes (Table 18) are fixed per gallon of fuel, thus the rate of fuel taxation varies with the price of gasoline. At $3/gallon gasoline, the total federal, state and local tax would come to 21% of the total price. There is also a state underground storage tank fee per gallon.

Table 17 Federal Fuel Taxes (cents, 2008)[128]

Gasoline	Diesel	Kerosene, Distillate, Stove Oil	Liquid Petroleum Gas	Compressed Natural Gas	Liquid Natural Gas	Alcohol Fuels
0.18	0.24	0.18	0.06	0.07	0.06	0.09

Table 18 State and Local Fuel Taxes and Fees[129]

Gasoline	Diesel	Kerosene, Distillate, Stove Oil	Liquid Petroleum Gas	Compressed Natural Gas	Liquid Natural Gas	Alcohol Fuels
0.18	0.24	0.18	0.06	0.07	0.06	0.09

Although the fuel taxes in California are among the highest in the US, it is still lower than Canada's and much lower than other developed countries. The fuel tax in Western European countries[130] is generally above 60% of the pump price with the Dutch fuel tax at nearly 70% and the Norwegian fuel tax at 63% (2007) despite having a low and scattered population and being an oil producer and exporter. The Canadian fuel tax is about 30% on average. Although the fuel tax is generally used for revenue generation for road construction and maintenance, varying amounts are used in nearly all countries to correct for environmental externalities.

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[126] County of San Diego, Current Rules and Regulations, http://www.sdapcd.org/rules/rules/randr.html.

[127] California State Board of Equalization, California City & County Sales and Use Tax Rates, http://www.boe.ca.gov/sutax/pam71.htm.

[128] Energy API, Motor Fuel Taxes, http://www.api.org/statistics/fueltaxes/.

[129] *Id.*

[130] See International Fuel Prices, various publications of the Deutsche Gesellschaft fuer Technische Zusammenarbeit (GTZ) GmbH, available at, http://www.gtz.de/en/themen/umwelt-infrastruktur/transport/10285.htm.

Fuel taxes and taxes based on carbon emissions can be considered part of a wider carbon tax policy, which could also include taxation according to tailpipe emissions (for example per ton CO_2E) equivalent to the way that stationary sources of criteria pollutants are charged. Fourteen European Union member states levy taxes that are totally or partially based on the car's CO_2 emissions and/or fuel consumption.[131] Finland for instance not only bases its registration tax on CO_2 emissions with rates varying from 10% for cars emitting 60g/km or less to 40% for cars emitting 360g/km or more, but also the annual circulation tax (currently based on weight) will be based on CO_2 emissions from 2010 onwards with rates from € 20 to € 605 per year. In Ireland, since 1 July 2008, the registration tax has been based on CO_2 emissions with rates from 14% for cars with CO_2 emissions up to 120 g/km to 36% for cars with CO_2 emissions above 225 g/km, and the annual circulation tax will also be based on CO_2 emissions from €100 (up to 120 g/km) to €2,000 (above 225 g/km). In Norway, the government refers to the fuel tax as an environmental tax. Sweden is currently proposing to increase its fuel tax also to fund mitigation for GHGs and reduce GHGs on top of a wider general carbon tax policy ($150 per ton CO_2 emitted). The carbon dioxide component of vehicle tax will be raised from SEK 15 to SEK 20, which means that from 2011 onwards the tax will be raised by SEK 5 for each gram of carbon dioxide a car emits. New light goods vehicles, light buses and camper vans will be brought into the carbon dioxide-based vehicle tax system. [132]

Although some cities and areas in the US have imposed a carbon tax on electricity use,[133] none have yet considered a carbon based vehicle emissions tax. There are major hurdles to imposing any increases in taxes in the United States based largely on its political infeasibility. In California, which has among the highest tax rates in the US, Article XIIIA of the California Constitution states that "any changes in state taxes enacted for the purpose of increasing revenues collected pursuant thereto whether by increased rates or changes in methods of computation must be imposed by an Act passed by not less than two-thirds of all members elected to each of the two houses of the Legislature."[134] The Article now covers all taxes, preventing the State, counties or any other "local district" from raising taxes without a super-majority (2/3) vote.[135] Since Article XIIIA was added to the Constitution, municipalities and local districts have sometimes attempted to find ways around the super-majority requirement to raise taxes, but courts have struck down all levies that were clearly designed for the purpose of increasing revenues. As a result, it is more than challenging to adopt changes to the tax revenues, including fuel taxes, or local sales taxes. Therefore although taxes and fees can send price signals to discourage greenhouse gas emitting activities, the US consumer has generally been against tax increases and this policy approach would seem to be less favorable than others, such as road pricing, and will not be discussed further.

6.2 Other Pricing Methods

Road pricing can be a major policy instrument. It is generally used as a source of revenue for new roads and to reduce congestion, but can be extended for purposes of pricing externalities, such as reducing GHGs. There are several variants on road pricing - pricing based on congestion by time of

[131] Overview of CO_2 Based Motor Vehicle Taxes in the EU, (February 22,2008), *available at,* www.acea.be/images/.../20080302_CO%202%20**tax**%20overview.pdf.

[132] Government Offices of Sweden, New Green Cars To Be Exempted from Vehicle Tax, (March 10, 2009), *available at*, http://www.sweden.gov.se/sb/d/11760/a/122175.

[133] Boulder, Colorado imposed a tax on electricity consumption (utility bills) that goes to fund programs by the City of Boulder, Colorado to reduce greenhouse gas emissions. However, because it is really a tax on net electricity usage instead of on carbon it applies to carbon-free sources of electricity unless the consumer buys their electricity through Xcel's WindSource program (wind-generated electricity).

[134] Cal. Const. art. XIIIA, §3. Sinclair Paint Co. v. State Bd. of Equalization, 15 Cal. 4th 866 (Cal. 1997) was the first case to apply XIIIA §3 at the state level rather than just local districts.

[135] Cal. Const. art. XIIIA.

day or degree of congestion, toll pricing, generally to finance new roads or bridges and which can be applied to both urban and long distance interurban roads, area-wide pricing, pay-as-you go insurance, and fixed per kilometer-driven pricing. One or more of these variants have been used in San Diego and other cities to reduce congestion; however, comprehensive road pricing policies to reduce externalities are rare.

Of these variants in road pricing, two road pricing policies exist or have existed in San Diego County, peak period variable congestion pricing on Freeway I-15[136] and toll for the South Bay Expressway and Coronado Bridge.[137] The tolls were imposed to finance the building of the road and bridge. We do not have tolls for interurban travel and if we were to, and if these tolls can be avoided by taking other types of roads, there may be no effect on transport energy use. Thus toll pricing is also considered a second best instrument.

The I-15 congestion charge and the HOT (High Occupancy Toll) lanes, which allow free passage for high occupancy vehicles and charge for single occupant vehicles in the HOT lanes, has the side effect of reducing GHGs by two means – an effect on smoother traffic flow and thus reduced fuel use (see Section 4.2), and by its carpool-inducing effect, thus reducing total VMTs. The GHG reducing effect of both of these effects have been modeled for this report (see Section 4.3) up to 2020. Eventually, however, if growth continues, research indicates that congestion will increase again, and in the medium term of 15-30 years, will play a neutral and then negative role in reducing GHGs.[138] In an early empirical study done for SANDAG on the I-15 HOT express lanes before congestion pricing was introduced, it was shown that simply due to separated express lanes, peak period traffic flow increased on all lanes and increased air pollutants.[139] Many studies and practical experience[140] have validated the power of even token pricing signals to influence behavior, change traffic patterns, and reduce congestion, especially if carried out over the long term and over greater areas. However, the effectiveness of road pricing based on congestion is greatly increased when coupled with transit improvements and extensive area use.

VMT pricing is considered a modern road pricing system, and is very much present in all sustainable transportation discussions.[141] Although some countries have implemented kilometer pricing on certain types of roads, such as the freeway charges on all Swiss freeways,[142] few cities or regions have

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[136] U.S. Department of Transportation Federal Highway Administration, I-15 Congestion Pricing Project Monitoring and Evaluation Services Task 13 Phase II Year Three Overall Report, *available at*, http://ops.fhwa.dot.gov/tolling_pricing/value_pricing/pubs_reports/projectreports/interst15_congestion.htm.

[137] Tolls were collected when the bridge opened in 1969. After the bonds to build the bridge were paid off in 1986 – more than a decade ahead of schedule – the fee was eliminated in 2002. Currently there is renewed interest in toll fees in order to finance congestion reduction by other means, such as a tunnel. *See* http://www3.signonsandiego.com/stories/2009/apr/20/1m20tolls22848-bridge-tolls-may-pave-way-ease-traf/?uniontrib.

[138] See Note 104.

[139] Kazimi, C. Supernak, J and Koesoemawiria, I-15 Congestion Pricing Project Monitoring and Evaluation Services Task 3.1.13 Phase I Air Quality Study, August 10, 1998, provided by SANDAG, and subsequent communication with Supernak.

[140] Effect of Gasoline Prices on Driving Behavior and Vehicle Markets, A Congressional Budget Office Study, January 2008, *available at*, http://www.cbo.gov/ftpdocs/88xx/doc8893/01-14-GasolinePrices.pdf.

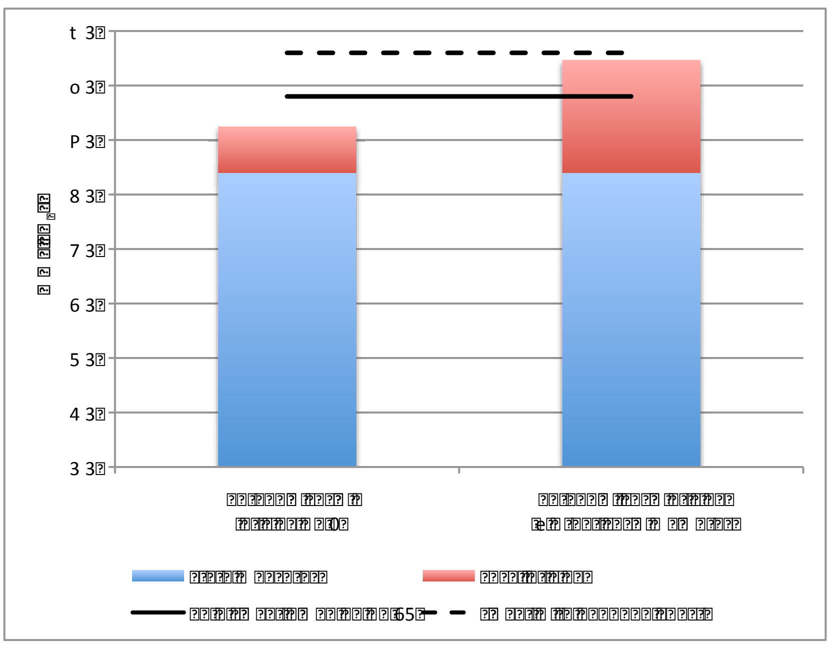
[141] See for example, publications available at the Center for Sustainable Transport, UC Davis, *available at* http://stc.ucdavis.edu/publications/. The importance of sustainable transportation is also expected to be discussed at the December 2009 Copenhagen meeting of the IPCC. See also Bongardt, Daniel, Rudolph, Frederic and Sterk, Wolfgang, Transport in Developing Countries and Climate Policy: Suggestions for a Copenhagen Agreement and Beyond, Wuppertal Papers, May 2009.

[142] Swiss Issues Wirtschaftspolitik – Brennpunkt Road Pricing – eine Option fuer die Schweiz? June 2008. Urban road pricing in Switzerland is politically controversial despite the freeway charges although pilot road pricing

experimented with VMT pricing on all types of roads, or comprehensively, and San Diego county is no exception. Advanced communications technology makes an electronic VMT charge possible with charging systems that are less visually impairing than tollbooths or gantry systems. VMT pricing places the burden of the cost on those who drive most and in addition makes it possible to differentiate the charge according to energy-use and emissions as well as other externalities such as noise, and safety. Currently the only example of a nationwide VMT pricing policy in the process of adoption and implementation is in the Netherlands.[143] In this case, the kilometer charge is planned not only to compensate for the decrease in tax revenues due to the (partial) abolition of the taxes on new cars and on car ownership, but also to regulate GHG emissions. Depending on the amount of the charge, and the other interrelated factors affecting vehicle ownership and use, the Netherlands case is expected to reduce GHGs by 20-40% compared with the existing situation.[144]

The few examples of comprehensive pricing policy in other cities and countries show that significant fuel use reductions can be achieved, between 20-40% of business-as-usual levels. Applying a lower reduction potential (5%) for our region based on the relative lack of mass transit and other non-motorized means of transport, we could still expect to achieve significant GHG reductions through an expanded road pricing strategy. The potential effects of a road pricing policy on its own, and with existing, planned and potential measures, as well as in comparison to the reduction target with the rebound effect are shown in Figure 21.

Figure 21 GHG Reductions from Potential Pricing Strategy



projects have been earmarked for testing by the national government. Switzerland has long charged a fee for the use of motorways (green road signs). The vignette, which is a sticker applied to inside of the windscreen, costs a flat-rate price and is mandatory for motor vehicles and trailers up to a total weight of 3.5 t each. Vignettes can be purchased at customs offices, post offices, petrol stations, automobile associations and railway stations and are valid from 1 December until 31 January of the year after the following year. *See* http://www.ch.ch/private/00081/00083/00228/00229/index.html?lang=en.

[143] Barry Ubbels, Piet Rietveld and Paul Peeters, Environmental effects of a kilometre charge in road transport: an investigation for the Netherlands, Transportation Research Part D 7 (2002) 255–264.

[144] *Id.*

6.3 Road Pricing Policies in Other Regions

The most comprehensive transportation pricing policies in the world have been implemented only in the city-state of Singapore (Table 19). Due to its high population density, there is a natural tendency to implement pricing policies and mass transit measures; however, important lessons can be learned from Singapore has been able to maintain and increase revenues and plan and implement a mass transit system through pricing policies. Singapore started experimenting with transportation pricing policies in 1975 and implemented them gradually at the same time as the gradual introduction of a mass transit system. Since 1998 it has operated a fully electronic system pricing system, which has reduced traffic by an additional 13%, a 6% reduction in travel time. This measure has enjoyed high political acceptance amongst the population.[145] As a result of these transportation pricing measures, and associated mass transit developments, Singapore has been congestion-free and transport energy use per capita low (see Table 2, High Income Asian Cities) for decades despite economic growth.[146] The mass transit modal split was 46% in 1974 and over 60% today.

Table 19 Comparisons of Pricing Policies, Singapore – San Diego

Pricing Policy	Singapore (based on purchase price of $20,000)	San Diego County (example purchase price $20,000)
Vehicle Registration Tax	$140	$31
Additional Vehicle Registration Fee	110% of purchase price ($22,000)	None
Vehicle Excise Duty	45% of purchase price ($9,000)	State vehicle license fee 0.65% of purchase price increasing to 1.15% of purchase price from 2009 ($230)
Vehicle Goods and Services Tax	5% of purchase price ($1,000)	None
Vehicle quota system (Certificate of Entitlement)	Growth of vehicle fleet vs capacity, willingness to pay (auctioned)	None
Road Tax	$1000/year for example Toyota Corolla – based on engine capacity, fuel type, type of vehicle (car, motorcycle)	None
Electronic road pricing (gantry system, now considering GPS system)	For peak hours – time of day, zones, type of vehicle	None
Fuel cost (fuel sales tax in CA is dedicated to transportation projects; in other countries is general revenue)	50% of pump price	About 21% if gasoline price is $3/gallon
Mandated Tire Costs	State mandated annual replacement	None
Vehicle: population ratio	1:7 (2010) about 100 vehicles/1000 persons	About 800 vehicles/1000 persons
Mode Split	60%, (from 46% in 1974) 70% at peak hours	3-5%, 12% at peak hours
Population	5 mi	3 mi
Population density	17,648/mi2 (2008)	700/mi2 (San Diego City 2000/mi2)

[145] See note 47.

[146] Christiansen, Gregory B., Road Pricing in Singapore after 30 Years.

Several cities have implemented one or more road pricing measures. Switzerland has freeway pricing, London has its congestion charge, Oslo has cordon pricing,[147] and Stockholm also has congestion pricing. Each of these has led to positive environmental effects.

In London a congestion charge has been imposed since 2003 with the aim of redirecting and reducing traffic. [148] Annual operations costs are $207 million but revenues of $493 mi are collected annually. Vehicular CO_2 emissions are reported to have dropped 19%, and rush-hour ridership on buses is up 37%. London mass transport procures 20% of its electricity from renewable sources, up from 16% in 2003. In April, a flat fee of 35 pence was added to taxi fares to fund the cost of taxi CO_2 abatement.

Toll pricing provides 40% of all road infrastructure funds in Norway. Oslo introduced cordon pricing (toll ring) in 1990 and with low fees of $2.8 per trip the effects on traffic reduction of about 5% are low. Bergen was the first European city to introduce road pricing (not for public transport) in 1986 to finance roads and with $27 million in operating costs and $13 million in revenues this has reduced volume of vehicles by 6-7%.[149]

Toll pricing for long distance travel has been common in Europe and is found in some places in the US, including on I-94 in Irvine, CA, where it has been mostly used to offset the cost of building the road. The City of San Francisco is studying the feasibility of imposing congestion pricing similar to that used in London – more like cordon or area-based pricing.[150] Passing such a measure seems unlikely, but if approved, such pricing would make San Francisco the first American city to charge cars a fee to enter certain neighborhoods at certain times. A similar proposal in New York failed in 2008.[151]

6.4 Pricing Parking

According to the Victoria Transport Policy Institute, parking pricing typically reduces parking demand by 10-30% compared to unpriced parking but it is unclear without more research how it affects GHG emissions. Research suggests that pricing parking affects commuters and leisure travelers differently.[152] Where access to desirable areas is regulated by parking management and pricing, there could be a high turnover of vehicles and possibly no reduction in GHG emissions. Where employee parking is priced instead of being free, this can encourage carpooling and therefore GHG reduction. Research suggests that about 90% of commuters who drive to work in California do not pay parking fees and it is estimated that employee parking charges of $1 to $3 per day could reduce VMT, trips, and pollutants by 1-3%.[153] Without knowing the overall effect of pricing on VMT reduction in urban

[147] Se-il Mun, Ko-ji Konishi, Kazuhiro Yoshikawa, Optimal cordon pricing, Journal of Urban Economics, Volume 54, Issue 1, July 2003, Pages 21-38.

[148] Ladina Purtschert Credit Suisse Economic Research Brennpunkt Road Pricing – eine Option für die Schweiz? June 2008, *available at,* www.credit-suisse.com/research.

[149] Ieromonachou, Petros, Potter, S. and Warren, J.P. A Strategic Niche Analysis of Urban Road Pricing in the UK and Norway, EJTIR, no 1 (2007), pp 15-38, *available at*, oro.open.ac.uk/7312/1/2007_01_02.pdf.

[150] Malia Wollan, San Francisco Studies Fees to Ease Traffic, January 3, 2009, *available at*, http://www.nytimes.com/2009/01/04/us/04congestion.html?_r=1.

[151] Danny Hakim and Nicholas Confessore, Albany Rebuffs City Traffic Plan, July 17, 2007, *available at*, http://www.nytimes.com/2007/07/17/nyregion/17congestion.html.

[152] Victoria Transport Policy Institute, Parking Pricing – Direct Charges for Using Parking Facilities (July 22, 2008), *available at*, http://www.vtpi.org/tdm/tdm26.htm.

[153] E. Deakin and G. Harvey, Transportation Pricing Strategies for California: An Assessment of Congestion, Emissions, Energy, and Equity Impacts, Research Note 98-1: Topic = Use of Transportation Pricing Strategies for Reducing Emissions, California Environmental Protection Agency/Air Resources Board, June 1998, *available at,* http://www.arb.ca.gov/research/resnotes/notes/98-1.htm.

areas or places of employment it is not possible to quantify further the effect of pricing parking on GHG in our region.

In general, parking supply management applies to downtowns, employment, and residential areas. Where land prices are cheap, parking supply management plays only a minor role and increases in importance with greater population density. Each city should study the need for parking supply management in cooperation with adjacent cities. Where smart growth allows reduced parking, parking ordinances can be modified to allow or not allow minimum and maximums. In downtown San Diego, parking prices are already high and may lead to high flow-through of vehicles. As downtown becomes more desirable for residents and visitors alike, parking prices will naturally increase, especially with the mix of public-private structures or road parking availability. Variable pricing can be used to attract people to parking areas that are less used but further away from the desired destination (low price) and to reduce congestion and increase turnover at very desirable locations (high price).

While parking management through pricing assists in reducing congestion, increasing traffic flow for more single use vehicles likely does not reduce overall GHGs. Improving access to downtowns only makes the downtown more desirable and will only reduce GHG emissions if the amount of SOV driving can be reduced on the whole. While reducing parking supply is the major aspect of parking management that will impact GHGs, no aspect of parking can be properly managed without either restricting access by private vehicles or unless access can be significantly improved in other ways.

6.5 The Effect of Financial Incentives and Subsidies on Vehicle Miles Traveled

Financial incentives and subsidies can promote VMT reduction by increasing alternative commute modes; however, such incentives have the disadvantage of being at the discretion of the current state and federal governments and may suffer the same ups and downs as have incentives for renewable energy such as wind and solar power. Research has shown that unless long-term (20 year) commitments are made, such incentives have the effect of only reducing GHGs during the period of availability of the incentives. In addition, such policies choose specific strategies that may not be based on environmental benefits and turn out not to be the best choice.

Further, some incentives available through the federal government may conflict with others (see Table 20). At the same time as financial subsidies are provided for employers for employee transit participation, the federal government also provides subsidies to employers for parking. How the employer chooses which to provide and this may be an area for study. In any case, the very availability of such contradictory incentives may cancel the benefits of each other.

All the qualified transportation benefits come under the IRS U.S. Code 26 section 132 (f) that provides the monthly pre-tax contribution and reimbursement limits on Parking and Transit Expenses. In 2009, the limit for Parking Expenses is $230 per month for all of 2009 and $120 per month for Transit Expenses from January 1, 2009 through March 31, 2009. The American Recovery and Reinvestment Act of temporarily increased the amount of the Section132 Transit Benefit to $230 per month for the remainder of the calendar year. Therefore bicycle, transit or vanpool qualify for transportation fringe benefits ($120/month normally but $230/month from April 2009 until December 2009 for transit and vanpools are pre-tax, $20/month for bicycle taxable income) when used in connection with travel between the commuter's residence and the place of work. At the same time the parking subsidies are normally $230/month (pre-tax) and were not raised under the Stimulus package. The cost to the federal government published in 2007 is provided below.

Table 20 Federal Parking and Transit Subsidies[154]

	Fiscal Years (Millions of Dollars)										
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Mass Transit and Vanpool	274	295	314	334	354	374	395	415	437	458	481
Parking	4,345	4,454	4,562	4,672	4,770	4,875	4,979	5,078	5,176	5,273	5,369

Based on the data in Table 20, parking subsidies are 15.8 times more than those for transit and vanpooling. This ratio will decrease to about 11 in 2017.

6.6 Policy Implications of a Pricing Strategy for Regional and Local Government

We cannot consider GHG reduction without also looking at congestion reduction and revenue sources and generation for existing infrastructure. Local governments have some jurisdiction over the following pricing measures:

- County air quality abatement fee, fixed, up to $6 at registration of a vehicle
- Goods sales tax (applies to vehicle and fuel taxes)
- Congestion pricing
- Toll pricing
- Parking pricing, depends on owner, public or private

There are other limitations to either the county or municipal jurisdiction that depend on which measures are being considered. This is outside the scope of our report; however, it appears that a road pricing policy provides a more immediate method of achieving GHG reductions at least in the short term of 5-10 years, the same as other measures evaluated in this report. We may not need all the pricing policies implemented, for example, in Singapore, because of our much lower population densities. But this should not be used as an excuse to avoid pricing policies in order to reduce GHGs, reduce congestion and maintain revenues for existing infrastructure and develop alternative transport forms. The challenge is to determine which measures are appropriate to the mix of problems we face in San Diego County. Given the increased attention on transportation emissions in climate change mandates this might be an opportunity to assess and model combinations of possible pricing policies, in order to quantify the GHG reductions possible through these second-best economic options.

- The research suggests the following policy considerations for regional governments:
- To date we have implemented just one pricing policy in one area of our roadway system, congestion pricing. The feasibility of adopting multiple road pricing policies, including VMT charges, and their interactions should be examined as well as the GHG reduction effects.
- The parking supply and demand and its effect on transport energy use should be evaluated.
- It should further be assessed how an increased air quality abatement fee may be used to contribute to measures to achieve GHG reduction.
- The feasibility of pooling financial resources from cities to achieve reductions being considered at each city level for GHG reduction measures should be assessed.

[154] Letter from Joint Committee on Taxation, US Congress to Senator Wyden on tax expenditures for commuters, especially bicyclists, dated February 13, 2007. Provided by Walter Finch, League of American Bicyclists, April 2009.

- Future research on pricing for San Diego County should evaluate more closely the adoption process, legal issues and implementation issues of VMT pricing policies in other jurisdictions.[155,156]

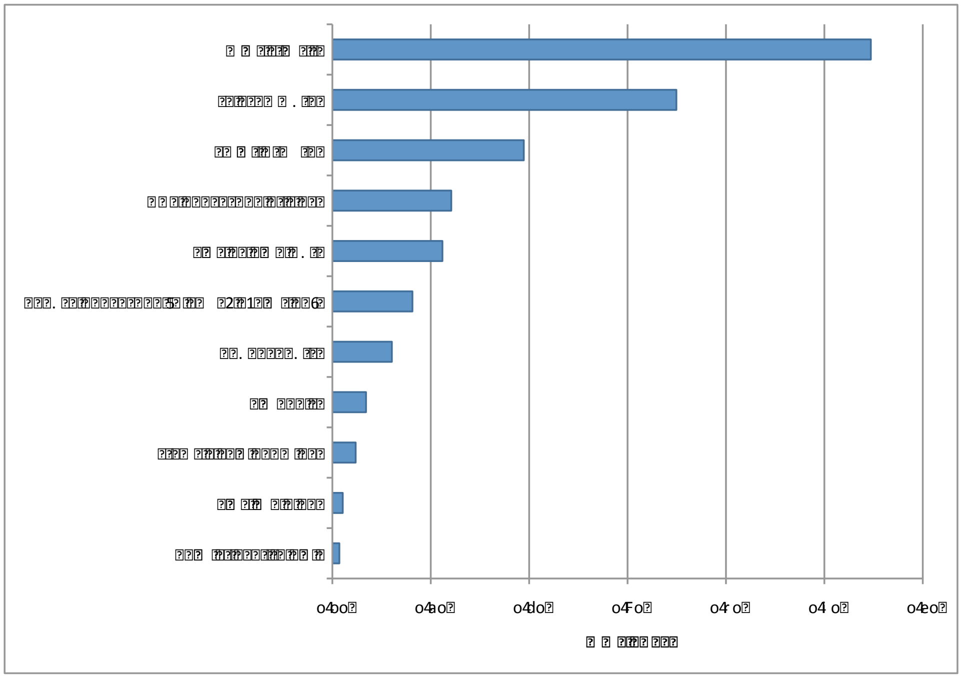
[155] The Dutch Ministry of Transport has detailed on-going descriptions of adoption and implementation of this policy, *available at,* http://www.verkeerenwaterstaat.nl/english/topics/mobility_and_accessibility/roadpricing/index.aspx.

[156] The Victoria Transport Policy Institute has a summary of various pricing policies used throughout the world, their successes and failures,. Germany and Austria have a limited version of national road pricing for trucks charged according to their emission levels and number of axles, though without elimination of other fees and taxes.

7 EFFECT OF COMBINATIONS OF MEASURES ON GHG REDUCTION

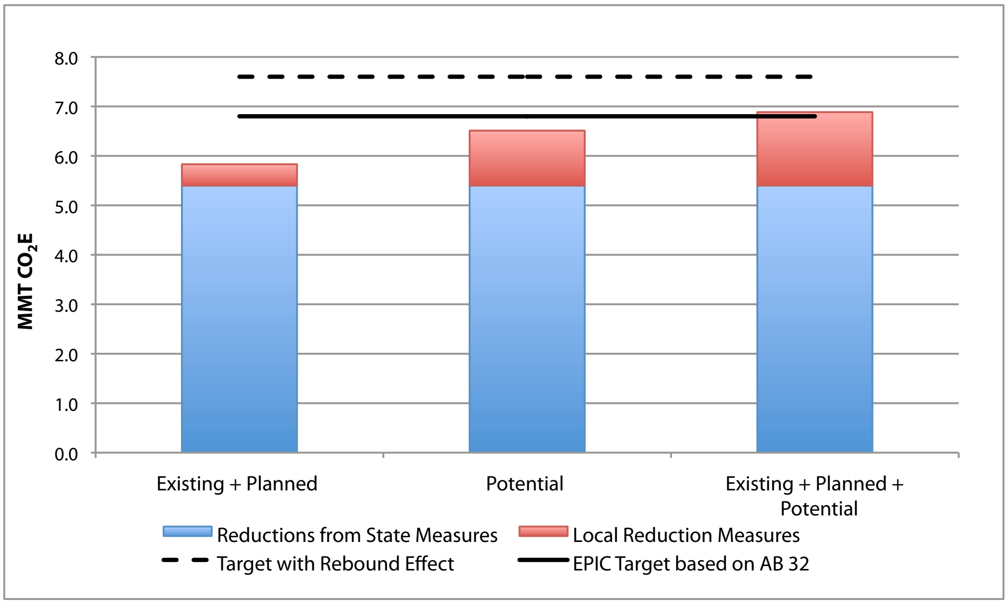
The relative GHG reduction effect of the eleven potential local fuel use reduction and VMT reduction policies is shown in Figure 22.

Figure 22 Existing, Planned and Potential Local Policies to Reduce GHGs



Combining the GHG reductions possible from several fuel use and VMT reduction measures may allow us to reach the target reduction amount (Figure 23). However, as mentioned before, research has shown that both fuel efficiency standards and the promotion of subsidized alternative fuels can cause an increase in VMT. A 10% increase in fuel efficiency could increase VMT by 2-4%. For every 10% reduction in GHGs due to alternative fuel use, there could be a 3% increase in VMT. Applying these elasticity relationships to our region, we may have an average increase in VMT of 6% due to the rebound effect of state measures. A 6% increase in VMT would mean that we would require an additional 0.8 MMT CO_2E reduction from local measures. This is about 50% more than our previous estimate of the reduction amount needed from local VMT measures. If the rebound effect in fact occurs by 2020, the total GHG reductions estimated from existing, planned and potential measures could fall short of the adjusted target of 7.6 MMT CO_2E. In this case, the role of local government would increase and more aggressive or a greater number of local policies might be needed.

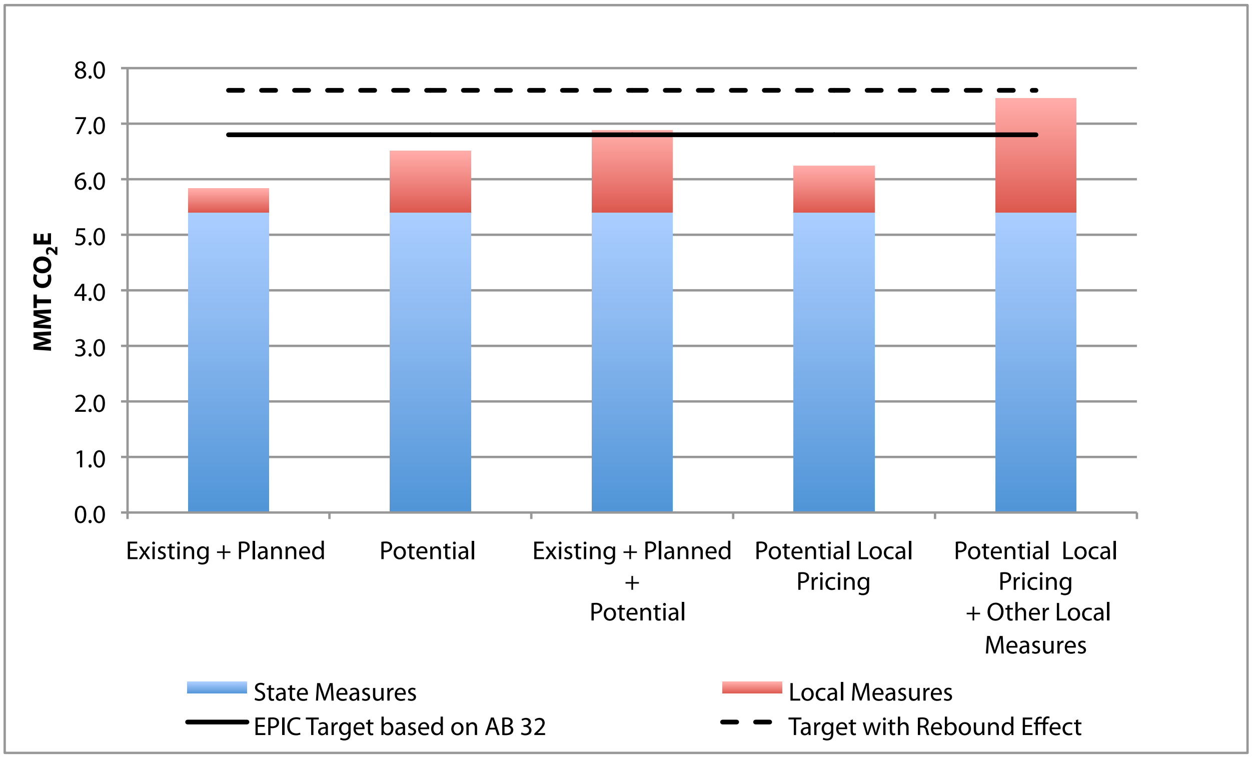
Figure 23 GHG Reduction from All Local Fuel Use and VMT Reduction Measures



Nonetheless, transportation agencies and local cities can create effective combinations of strategies to provide significant GHG reductions in the region from on-road transportation. For example, more aggressive application of the potential fuel use and VMT reduction measures assessed, with federal and state could yield at least the estimated reduction target of 6.8 MMT CO_2E. Alternatively, a comprehensive pricing strategy together with existing, planned and potential fuel use and VMT reduction measures could reach the reduction target, even with the effects of the rebound effect of state measures on local measures. The rebound effect in the latter combination of measures may be remedied by a more aggressive pricing policy.

A summary of the effects of several combinations of policies is shown in Figure 24.

Figure 24 Summary of GHG Reductions from Combinations of Measures



8 THE ROLE OF ALTERNATIVE FUELS

The CA Low Carbon Fuel Standard 2009 requires providers of transportation fuels (regulated parties) to show that the mix of fuels they supply meet the LCFS intensity standard of 10% reduction in carbon intensity by 2020 within set compliance periods. Parties will earn credits when the supply exceeds the standards and deficits when not. Credits can be earned or bought but only within the transportation fuels market. Exempt are racing fuel, interstate locomotives, ocean going vessels, aircraft and military tactical vehicles. Non-exempt are intrastate locomotives and harbor craft. The LCFS is expected to bring reductions of about 15.9 MMT CO_2E statewide and about 1.6 MMT CO_2E within San Diego County (Table 21).

Table 21 Low Carbon Fuel Standard GHG Reduction Effect in San Diego County

Strategy	Estimated GHG Reduction by 2020 (MMT)	Percentage of Total On-Road Transportation Reduction Potential	Percentage of Total EPIC Target Based on AB 32
Low Carbon Fuel Standard	1.6	24%	12%

Scenarios that might make this possible are suggested in the LCFS.[157] Most scenarios envision a high percentage of ethanol substituting for gasoline (and biofuels substituting for diesel) with a minimum 9% of the fuel provided through electricity (Table 22).

Table 22 Potential Alternative Fuel Scenarios for Gasoline Fuel for Low Carbon Fuel Standard Compliance by 2020.

	Percent of Reduction Provided by Each Fuel Type Substituting for Gasoline in 2020			
Fuel Type	Scenario 1	Scenario 2	Scenario 3	Scenario 4
CA Low-CI Ethanol	2	2	2	2
Cellulosic Ethanol	44	43	38	28
Advanced Renewable Ethanol	43	41	36	27
Sugercane Ethanol	0	3	3	3
Electricity	9	9	18	35
Hydrogen	2	2	3	5

In July 2009, SANDAG produced a comprehensive report on alternative fuels, vehicles and infrastructure in San Diego County that examines how SANDAG can help local governments in the region to accelerate the deployment of alternative fuel vehicles and develop the associated infrastructure.[158] Although the LCFS envisions most alternative fuel scenarios to be high in ethanol, there are several issues related to ethanol that may make it less promising as an alternative fuel than

[157] CA Energy Commission, *Low Carbon Fuel Standard*, *available at* http://www.energy.ca.gov/low_carbon_fuel_standard/.

[158] SANDAG, Environment – Energy – Regional Alternative Fuels, Vehicles, and Infrastructure Report, *available at*, http://www.sandag.org/index.asp?projectid=339&fuseaction=projects.detail.

electricity. The issue of food security and ethanol is as yet unresolved. The lessons from Brazil with respect to ethanol fuels shows that when the price of oil is low, ethanol flex-fuel vehicle users will switch to gasoline, thus reducing the GHG effect of ethanol. In addition the distribution of existing alternative fueling infrastructure in San Diego County is largely electric.[159] Therefore, the following questions may be of interest to local jurisdictions with respect to alternative fuels:

- What percentage of market penetration by HEVs or EVs is feasible by 2020?
- What would be the effect on GHG emissions if various percentages of passenger vehicle VMTs were traveled by HEVs or EVs in 2020?
- How much electric energy would be required if various percentages of VMT were traveled by HEVs or EVs in 2020?
- What is the effect on GHGs of replacing the bus fleet based on diesel with the alternative cleaner CNG?
- How does replacing the passenger vehicle fleet with diesel affect GHGs?

8.1.1 Market Penetration by Hybrid Electric Vehicles

Table 23 shows the number of gasoline-battery electric hybrids needed per year at 20% annual growth rate in order to achieve at least 9% market penetration by 2020. It was shown above that, provided the economic recession eases, and based on the sales of HEVs between 2005 and 2007, more than 20,000 HEVs per year on average could be sold in the county, and that therefore at least 9% share of total registered HEVs appears feasible.

Table 23 Number of HEVs needed by 2020 to achieve 9% market penetration

	Registered vehicles (EMFAC projections)	HEVs needed to achieve 9% market penetration in 2020	Vehicles retired annually (3.3%)	Vehicles retired under existing state programs	AFV statewide rebate sales 2007-2009 scaled to San Diego County
2008	2,096,281	24,929	69,177	2,905	
2009	2,115,346	29,915	69,806	2,932	63
2010	2,134,578	35,897	70,441	2,959	
2011	2,162,710	43,077	71,369	2,998	
2012	2,191,207	51,692	72,310	3,037	
2013	2,220,074	62,031	73,262	3,077	
2014	2,249,324	74,437	74,228	3,118	
2015	2,278,968	89,324	75,206	3,159	
2016	2,308,988	107,189	76,197	3,200	
2017	2,339,419	128,627	77,201	3,242	
2018	2,370,240	154,353	78,218	3,285	
2019	2,401,473	185,223	79,249	3,328	
2020	2,433,113	222,268	80,293	3,372	

Notes: The number of registered vehicles was obtained from EMFAC model projections. For sales projections, 20 annual average growth rate is used based onpast national HEV sales data. The statewide rate of vehicle retirement of 3.3% was used for San Diego County.

[159] *id.*

8.1.2 Effect on GHGs of Replacing VMT Driven in 2020 with Electric or Hybrid Electric Vehicles

How much could we reduce GHG emissions if we drive various percentages of projected miles traveled in 2020 by conventional passenger cars and light duty trucks with either electric cars, or hybrid-electric vehicles? Using the Tesla Roadster[160] and the Toyota Prius as examples for each, respectively, we compared the CO_2E emissions for this scenario (Table 24). According to the calculations, a Tesla Roadster electric vehicle would produce 125 grams CO_2E/mile (well to wheels, though most emissions are from well to tank) if the electricity were drawn from the California average electricity mix today with a carbon intensity value of 124 grams CO_2E/MJ. The Toyota Prius would emit 258.45 grams CO_2E/mi. The conventional gasoline vehicle with an average fuel efficiency of 19 mpg today emits 610.83 g CO_2E/Megajoule.

Table 24 Comparison of Alternative Vehicle GHG emissions

	Gasoline	Electric Vehicle	Hybrid Electric
Miles per Gallon	19.04 (San Diego County Passenger Fleet Average)	120.75 (Based on Tesla Roadster)	45 (Based on Toyota Prius 2009 City and Highway Average)
Miles per Therm	-	105	-
Watt Hours/mile	-	177	-
Mega Joules/mi	6.37	1.00	2.70
Grams CO_2E/MJ	95.86	124.00	-
(from LCFS)	-	105.00	-
Grams CO_2E/mi	610.83	124.59	258.45
	-	105.50	-

Note: The following values are derived from the LCFS Table ES-8: 124 is the current CA electricity mix, and 105 is the future expected CA electiricty mix with more renewables.

Based on these CO_2E emission values for the two types of electric vehicles, we calculated the GHG reductions possible if various percentages of passenger vehicle miles were traveled by EVs or HEVs in 2020. (Table 25). The potential GHG and energy use reductions by a 100% substitution of the projected passenger car and light duty vehicle miles traveled in 2020 by battery electric hybrid vehicles is significant. However, this kind of market penetration is not feasible. Instead, to achieve the 12.2 MMT CO_2E target (or, the 6.8 MMT CO_2E reduction amount by 2020) from the on-road transportation category, the percentage of HEV would have to reach between 80 and 90%, while the percentage of EVs would have to reach between 40 and 60%.

[160] We are less concerned with the cost of the vehicle but used a worst case scenario of emissions based on the power of the car. The Tesla Roadster is a sports car and represents a worst-case electric car scenario for emissions. The GHG emissions from mid-range electric limousines, and their electricity usage is expected to be lower.

Table 25 GHG Reduction Potential from HEVs and EVs in 2020

Projected Passenger VMT Driven by EVs or HEVs in 2020	HEV Reduction Amount (MMT CO_2E)	EV Reduction Amount (MMT CO_2E)
20%	1.52	2.80
40%	3.04	5.59
60%	4.57	8.38
80%	6.09	11.20
100%	7.61	13.97

The potential for substitution of gasoline by electric "fuel" is already part of the scenario analysis for feasibility of compliance in the LCFS. In all four LCFS scenarios electricity is assumed to penetrate the market from (9% minimum) to 35% (highest rate) by 2020, with ethanol based fuel providing the other large amount of carbon intensity reduction. The potential feasible EV based reductions have therefore already been taken into account in the expected reductions statewide of the LCFS. The question then is whether it is possible to obtain greater than the 9% market share predicted for electric vehicles in the LCFS. The number of passenger cars and light duty vehicles projected for 2020 is over 2.4 million. Considering the number of hybrids on the road from 1996 to 2009 of about 20,000, it would seem improbable that more than 10-20% market penetration of HEVs can be achieved. Over 200,000 battery hybrids would have to be sold in the county annually. Even if the fleet could be completely replaced within 15 years, as projected under a sustained price increase of gasoline, we then could reach the target by about 2025 assuming also that auto manufacturers would continue to build HEVs at the necessary rate. An even more improbable penetration is foreseen for EVs.[161]

Other drawbacks of an all electric or HEV future occurring within the next 10-15 years and large GHG reductions being achieved would not only be that the issue of road maintenance and congestion reduction as a result of continued increase in vehicles but also that revenue from fuel taxes would decrease drastically, and the long term goal for 2050 may still not be achieved. Also, in the case of an all plug-in electric future, we would have to ensure that the capacity needed was available and produced by renewable energy.

8.1.3 Potential EV Infrastructure Needs

SANDAG has carried out an assessment of the regional alternative fuel infrastructure availability and funding mechanisms to assist in the expanded deployment of alternative fuels and vehicles in the region to support the LCFS standard.[162] SANDAG identified 89 existing fueling stations in the region for all types of alternative fuel including electric charging stations, with the largest number being electric charging stations.

[161] A University of California Berkeley study of July 2009 found that the market size for electric cars with switchable batteries, as opposed to plug-in is considerable and the economic and environmental benefits of mass-market adoption. The study shows rapid adoption for electric vehicles assuming the ownership of the battery is separated from the vehicle. adoption rates of electric vehicles with pay-per-mile service contracts that finance the cost of the battery. In previous studies, projected adoption rates have generally been based on electric vehicle sales as stand-alone products. Pay-per-mile service contracts eliminate the additional upfront costs traditionally associated with electric cars. The study predicts that electric vehicles with this type of pricing will account for 64% of light vehicle sales and comprise 24% of the U.S. light-vehicle fleet by 2030. See Electric Vehicles in the United States, A new Model with Forecasts to 2030, Center for Entrepreneurship and Technology, University of California, Berkeley, *available at*, http://cet.berkeley.edu/translational-research.

[162] SANDAG Draft Alternative Fuels and Vehicles Program Report, (May 15 2009).

We assessed the electricity needs for the theoretical maximum EV scenario. The amount of electricity needed for plug-in charging of an electricity-based passenger fleet in 2020 was calculated as 22.7 million Gigajoules in 2020. Based on the annual energy production values shown in Table 26, this would mean over 6,000 GWH of power would theoretically be needed to fuel an all-electric passenger vehicle future in 2020.

Table 26: Electric Energy Needed for All Miles Traveled by Electric Vehicles in 2020

Energy needed for 100% PC, LDT, Motorcycle VMT in 2020 (Million Gigajoules)	22.70
EV Penetration in 2020	100%
Megajoules to Kilowatt hour Conversion	0.28
Total Electric Energy Required (GWh)	6,306

Note: We assume 0.64 Megajoules per miles with 2008 passenger vehicle VMT data.

The GHG emissions calculations were made using the current average CA electricity mix, as well as an electricity average generation mix based on greater renewable energy. Assuming off-peak charging of the 100% passenger EV scenario discussed above (based on the worst case sports car emissions), there will be no need to build additional electric utility capacity.[163] All studies and pilot projects indicate that charging at the optimal off-peak hours will flatten the demand profile *without* the need for increased capacity.[164] As time-of-day charging is the determining factor to maintain the overall capacity strategies are being developed to educate consumers and the public on time-of-use charging. Managing vehicle charging combines well with a smart charging system and will also allow the customer control over costs. Rather than using the average electricity supply's CO_2E emissions, a more accurate GHG emissions estimate can be obtained based on the time of charging of an electric fleet. If, on the other hand, vehicle charging adds demand to peak, this may require additional capacity.

Because the electricity supply sources will determine the GHG emissions from the electricity plant, it is the supply mix providing those off-peak hours of electricity which will finally determine the GHG emissions saved as compared with the GHG emissions for those vehicles had they been gasoline powered. More research is needed to evaluate the time-of-day charging scheme, the electricity supply mix at time-of-day to obtain more accurate GHG emissions data.

8.1.4 Emissions from Diesel Compared to those from Compressed Natural Gas and Gasoline

Two related questions arise in discussions of GHG reduction and alternative fuels: whether the substitution of diesel fuel in buses with the more expensive CNG, for example, leads to GHG reductions, and how much GHG reduction can be obtained from a diesel vs. gasoline vehicle fleet.

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[163] *See also* Electricity Grid, Impacts of Plug-In Electric Vehicle Charging, Christopher Yang and Ryan McCarthy, Air and Waste Management Association (June 16, 2009).

[164] Information provided by SDG&E, June 2009. SDG&E has electric vehicles rates based not on the tiered baseline used today and replaced by time of use charge rates, so that if more of the energy use can be shifted to off-peak or super off-peak hours, such as charging the EV at night, or at times of availability of maximum solar power, the electricity capacity need not increase and it can save money for the consumer. More information on time of use rates is available at http://www.sdge.com/tm2/pdf/ELEC_ELEC-SCHEDS_EV-TOU-2.pdf.

To estimate emissions from CNG buses in comparison with diesel buses, empirical data was obtained from the San Diego Metropolitan Transportation Service (MTS) for the fuel efficiency of the current diesel fuel buses used by MTS as well as of the CNG buses it is replacing the diesels with. For these buses alone, and based on the fuel economies provided, we calculated the GHG emissions based on the LCFS well to wheels analysis CO_2E emissions (Table 27).

Table 27 GHG Emissions from Buses, San Diego County

	Diesel	Compressed Natural Gas
Miles per Gallon	4.29	2.84
Miles per Therm	-	2.23
Magajoules per Mile	31.3	47.3
Grams CO_2E/Megajoule	94.71	75.22
Grams CO_2E per Mile	2968.8	3558.6

Notes: Conversion factors used were provided by CARB. These are 127,464 Btu/gallon, 930 Btu/scf, 1.055 Joule per Btu, and 100,000 Btu per Therm.

It can be seen that, based only on the fuel economies provided, more CO_2E per mile is produced from the CNG bus than the diesel bus so that replacing these diesel buses with these CNG buses does not serve the purpose of reducing GHGs, at least with the existing level of fuel efficiency.[165] MTS is in the process of replacing its diesel buses with environmentally more benign fuels.[166] The main reason for the use of CNG in place of diesel fuel was to reduce other air pollutants, namely particulate matter and nitrous oxide (NOX) emissions. This purpose is still served with CNG-fueled buses.

On the question of diesel versus gasoline passenger vehicles, the background is provided by the fact that in most European countries, diesel vehicles make up more than 50% of the vehicle fleet compared with just 10% of the US fleet. Because some new diesel engines offer roughly 25 to 30 percent better fuel economy than hybrids and have a cheaper price premium—$1,000 to $2,000 instead of $4,000 to $5,000[167] - the European passenger vehicle fleet is significantly more fuel-efficient than the US fleet.

CARB has estimated that diesel powered passenger vehicles are approximately 14% more fuel-efficient than the equivalent gasoline version for those models available in California. This is based only on the tank-to-wheels emissions. The only trade-off between lower GHGs and fuel use is with respect to one criteria air pollutant – NOx. Except for one diesel model tested by the EPA in 2008, none of the diesel models pass the health-based NOx tailpipe emissions standard in California of 0.07 grams per mile. The European Euro IV model NOx standard is 0.4 grams per mile, and only in 2014 will the Euro 6 model passenger cars reach 0.07 grams per mile NOx tailpipe emissions. Such low emissions will only be possible through more advanced diesel technology or conversion to alternative fuels. Diesel vehicle emissions meet all other air pollution standards for SOx, PM and other hydrocarbons.

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[165] Personal Communication with Kevin Cleary, California Air Resources Board.

[166] In 1999, California created the Moyer Program to reduce smog-forming nitrogen Oxides (NOx) from diesel engines and replace diesel with cleaner alternatives such as natural gas and electricity. The Moyer Program is an incentive program based on AB923 and funded at $140 million per year for 10 years, *available at,* http://www.arb.ca.gov/msprog/moyer/moyer.htm.

[167] Diesel vs Hybrid, Newsweek February 4, 2009, *available at,* http://www.newsweek.com/id/183150.

The policy lesson from this is that diesel passenger vehicles offer significant immediate reductions in GHGs and total fuel use; however, in an air basin classified as non-attainment for ozone, as most air basins in CA, diesel powered vehicles will be unable to meet the NOx emissions standards as yet. IN addition, diesel will delay but not reduce the dependence on fossil fuels in the long-term.

8.1.5 Policy Implications and Recommendations

- Since every incremental measure to reduce GHGs helps and should be pursued, local governments should be aggressive in obtaining and using federal incentive funds.
- The most effective use of federal and state incentives and subsidies is the siting of alternative fueling or charging infrastructure, especially in publicly accessible locations.
- Every local jurisdiction should have a policy of alternative fuel vehicle purchase using federal incentive funds. They should assess not only the cost and criteria pollution emissions reductions but also include actual, not potential such as in the case of flex cars, GHG reductions in the way done for the MTS buses above.
- SANDAG should assess the most suitable type of renewable energy options for the region, whether renewable energy based electricity or biofuels in order to maximize the effectiveness of use of federal and state incentive funds.
- Local jurisdiction should play a role in education of the public, elected officials and marketing of alternative fuels in order to maximize alternative fuel use and penetration.

9 COST CONSIDERATIONS

The magnitude of GHG reduction is a necessary but not sufficient factor in evaluating local policy options. The cost necessary to implement a policy is also an important consideration. To provide orders of magnitude on cost, we developed preliminary cost estimates. The costs for local measures included here are based on a variety of sources ranging from cost of capital investment to costs of fuel saved; therefore we are unable to make a direct comparison of the measures relative to one another in terms of a normalized metric such as dollar per metric ton of CO_2E (\$/metric ton CO_2E). Nonetheless, these values provide an idea of the relative costs based on the relative magnitude of the costs (Table 28).

Table 28 Cost Considerations of Local Policy Measures Assessed

Measure	GHG Reduction 2020 (MT)	Cost in 2020 ($millions)	Cost Basis
Telecommute, first priority	349,606	-$63	Based on US GSA telework cost studies, 2006
Telecommute, second priority	301,382	-$55	Based on US GSA telework cost studies, 2006
Parking Cash-Out	111,849	$3	Based on CARB and Shoup 2005 research data, a range based on cash allowance given out, scaled to San Diego region based on potential parking spots saved in 2020 at 12% VMT reduction. 2008 dollars.
Congestion Pricing HOT Lanes	120,852	$4	From SANDAG, annual operating costs, 1997 dollars, initial HOT conversion cost, annual revenues
Traffic Light Retiming (320)	23,692	$1	Based on research data, capital investment costs vary as the studies dates' vary, SANDAG data on city of San Diego suitability of traffic signals for timing
Smart Growth	193,920	$79	Based on smart growth incentive costs provided in SANDAG 2030 RTP, 2006 dollars
Vanpools	34,219	$78	From SANDAG, vanpool incentives paid at annual nominal value; assume linear increase in number of vanpools, and constant 2009 dollars per van to 2020
Mass Transit, first priority	779,788	$5,800	Based on FTA study capital investment costs of a bus rapid transit system applied to San Diego County, 2006 dollars
Mass Transit, second priority	547,224	$5,800	Based on FTA study capital investment costs of a bus rapid transit system applied to San Diego County, 2006 dollars
Roundabouts (320)	60,480	$1,660	Based on actual Bird Rock, La Jolla capital investment costs for 4 roundabouts, 2005 dollars
Congestion Miles Reduction	82,310	$12,189	Capital investment and operating costs, from SANDAG 2030 RTP Table 4.3, 2006 dollars

Note 1: Telecommute as a first priority results in fewer commuters available for mass transit. Mass transit as a priority removes those commuters available for telecommuting.

Note 2: A negative cost for telecommuting means that within the year of implementation costs are saved.

The largest GHG reduction potential comes from a mass transit system, which had a relatively high cost among the measures evaluated here. Telecommuting could provide the next highest level of emission reductions; this policy also has the lowest cost of implementation. Smart growth and HOT pricing policies could yield similar levels of GHG reductions, though HOT pricing is much less costly. The most costly measure in terms of GHG reduction alone[168] is highway expansion, which also has relatively low potential to reduce GHG emissions.

Although we do not have an estimate for the cost of introduction of HEVs, based on our evaluation of federal incentives for EVs, we can obtain an estimate of cost using the following assumptions:

- An average incentive cost of $5,000 per HEV, as provided by federal regulation through 2014
- This incentive continues to 2020
- 20% penetration of HEVs by 2020, or about 10% more than the lowest in the LCFS range
- Market penetration would not occur if not for the incentives
- 14,000 miles per year per HEV

Under this scenario, the incentives costs would be $1.2 billion for San Diego County alone, which translates to a low relative cost in comparison with the other measures given in Table 22.

On the other hand, a Stanford University GHG cost study of 2008[169] states that the cost effectiveness[170] of introducing plug-in hybrid electric vehicles (PHEV, the same as EVs in this report) is approximately $4/MT CO_2E, with a reduction potential California-wide of 6 MMT CO_2E. We have estimated the reduction potential based on actual market penetration rates in the past few years and showed that only a penetration of about 10%-20% is feasible by 2020, and only for HEVs. At this penetration rate, the upper limit of GHG reduction potential is that already accounted for under the LCFS strategy, or about 1.6 MMT CO_2E in our region. This is a significant portion (26%) of the Stanford study estimated 6 MMT CO_2E state-wide EV potential by 2020. It is improbable, based on the market sales data for HEVs/EVs that the San Diego region could provide such a significant amount of the statewide EV GHG reduction, or without more analysis, how the cost value provided by the Stanford study may be compared with the cost/MT CO_2E that we have derived based only on incentive costs.

[168] Other short-term external benefits of congestion reduction such as reduced air pollution and health benefits, reduced accidents and reduced loss of labor hours have not been taken into account.

[169] Precourt Institute for Energy Efficiency, Stanford University, Analysis of Measures to Meet the Requirements of California's AB 32 (September 27, 2008).

[170] *Ibid.* at 6. A cost effective mitigation measure is defined as: "A greenhouse gas mitigation measure is cost-effective under a given target emission reduction if and only if it costs no more per tonne of emissions reductions than the marginal cost associated with the target emission reduction."

10 CONCLUSIONS

In this project, we have sought to deepen our understanding of the GHG reduction effects of policies constituting the broad strategies we estimated from on-road transportation to meet the AB 32 target. We identified and characterized various policy measures chosen from more than 100 measures, based on applicability and feasibility within our region, for each broad reduction strategy.

On-road transportation is not only the largest source of GHG emissions in San Diego County (46%); it also has the potential to provide significant reductions. The majority of transportation GHG reductions (79%) derive from technological changes mandated by the government on fuel efficiency and alternative fuels. However, due to the potential rebound effect of these federal and state mandates, achieving an additional amount of GHG reductions above the estimated amount needed of 6.8 MMT CO_2E locally might be needed and would be challenging. Combinations of policies within local government control are available to achieve the significant reduction amounts. Existing and planned fuel use reduction and VMT reduction measures could allow us to reach the 86% of the total reduction target. Potential local fuel use reduction and significant VMT reduction measures can help increase this amount to 98%. A comprehensive pricing policy alone could achieve 5-10% of the estimated GHG reduction amount. In combination with existing, planned and potential measures, a pricing policy could provide more than the reduction target of 6.8 MMT CO_2E. However, if the rebound effect comes into effect, local measures may have to be more aggressive to achieve additional local GHG reductions.

Practice in the European Union, where GHG and energy use reduction measures have been implemented since 1990, shows that although overall GHG reductions of 7.7 % (429 MMT CO_2E EU-27), 2.2 % (93 MMT CO_2E EU-15) and 25.3 % (337 MMT CO_2E EU-12) below 1990 have been reached, only domestic transportation (mostly on-road transportation) and the maritime and aviation transportation sectors have shown increases and are difficult to control. This serves as a lesson for our region and complements the conclusions based on our analysis of GHG reducing measures applied to our county. Incremental changes to the private and public transport system to reduce VMT and fuel use will not easily allow us to reach the 2020 goal and beyond. To reach the 2050 target of 80% below 1990 levels will require a combination of more comprehensive and/or more aggressive local strategies.

10.1 Summary of Policy Recommendations

Based on the analyses in this report, it is clear that more significant measures than the measures we currently plan for fuel use and VMT reduction would be needed to reach 2020 emissions targets. Even with potential significant measures, it will be a challenge to meet local reduction amounts. The analysis supports the following broad policy measures:

• Implement measures from VMT and fuel use reduction measures discussed;

• Assess, plan, adopt, and implement comprehensive pricing measures;

• Focus on low/zero carbon future for private and public transport.

To support this long-term policy recommendation, the following additional recommendations can be made:

- Develop metrics to assess the energy efficiency of the existing private and public transportation system and track changes over time.
- Develop and track metrics to assess the sustainability of the transportation system.
- Initiate and support education and awareness-raising programs through cities and non-profit organizations, region-wide, to inform city officials, the general public and regional decision

makers on the connection between transportation energy use, GHGs and inefficiencies of the transportation system.

- Develop targets for all modes of mobility with the aim of a more balanced mode share; track these targets.
- Evaluate and pilot test individual and combinations of pricing policies to both raise revenue and provide for a significantly expanded transit system. Evaluate the potential for alternative revenue sources, including an extensive road pricing system or a VMT charge in place, for example, of a gas tax. These possibilities can also be pursued at the state level.
- Evaluate the potential to support an expanded public transportation system that can eventually be based on a zero or low carbon fuel.
- Assess the relationship between electricity needs and a long-term HEV/EV- based private and public transport system.
- Evaluate the most promising alternative fuel source for the region and use the federal and state incentive funds to promote this.
- Support promising local research on alternative fuels and especially the local potential for renewable electricity production for EV.

Policy recommendations for local governments have been made within each broad reduction strategy to complement the above broad strategies as follows:

10.1.1 Recommendations to Reduce VMT

- As mass transit has the potential for the most significant GHG reductions, SANDAG should continue to assess possibilities for an expanded mass transit system that is time competitive with the passenger vehicle and of sufficiently high quality to attract middle-income commuters.
- The state of telecommuting in the county should be assessed and the potential for a region-wide coordinated telecommute policy amongst federal, state, county and city offices should be evaluated.
- The business case for a telecommute policy should be evaluated.
- The business case for an employer parking cash-out policy should be assessed.
- SANDAG should evaluate the cost effectiveness of congestion reduction measures not only in terms of highway safety improvements and labor hours lost but also in terms of GHGs and criteria pollution emissions. The research indicates that the cost is high compared with other measures when considering all these effects.
- VMT reduction should not be considered in isolation of the alternative fuels strategy or the fuel use reduction strategy due to the rebound effect. Therefore, if the rebound effect occurs in our region, the role of local government to reduce GHGs will be enhanced.

10.1.2 Recommendations to Reduce Transportation Fuel Use

Fuel use reduction methods may provide GHG reductions similar to planned congestion reduction measures if carried out in a coordinated way amongst the cities in the region but at a much lower cost. These measures could be considered as low hanging fruit. Therefore the following actions are recommended for local governments:

- Identify traffic signals for retiming.
- Identify new developments that may be suitable for roundabouts.
- The policy of adopting stop signs at every intersection is likely to have similar speed disrupting

effects that increase GHGs and may likewise be reconsidered.[171]

- If additional incremental measures are needed to provide small amounts of GHG reduction SANDAG could evaluate further the effects on fuel use of asphalting roads, implementing advanced traffic control measures, and supporting driver training and vehicle maintenance programs.

10.1.3 Recommendations to Encourage Alternative Fuels

- Since every incremental measure to reduce GHGs helps and should be pursued, local governments should be aggressive in obtaining and using federal incentive funds.
- The most effective use of federal and state incentives and subsidies is the siting of alternative fueling or charging infrastructure, especially in publicly accessible locations. The regional MPO can take a leading role in identifying and establishing such locations.
- Every local jurisdiction should have a policy of alternative fuel vehicle purchase using federal incentive funds. They should assess not only the cost and criteria pollution emissions reductions but also include actual GHG reductions in the way done for the MTS buses above.
- SANDAG should assess the most suitable type of renewable energy options for the region, whether renewable energy based electricity or biofuels in order to maximize the effectiveness of use of federal and state incentive funds.
- Local governments should play a role in education of the public, elected officials and marketing of alternative fuels in order to maximize alternative fuel use and penetration.

10.1.4 Recommendations to Integrate Pricing Policies

- To date we have implemented just one pricing policy that has an effect on GHG reduction in one area of our roadway system, congestion pricing. The feasibility of adopting multiple road pricing policies, including VMT charges, and their interactions should be examined as well as the GHG reduction effects.
- The parking supply and demand and its effect on transport energy use should be evaluated.
- It should further be assessed how an increased air quality abatement fee may be used to contribute to measures to achieve GHG reduction.
- The feasibility of pooling financial resources from cities to achieve reductions being considered at each city level for GHG reduction measures should be assessed.
- Future research on pricing for San Diego County should evaluate more closely the adoption process, legal issues and implementation issues of VMT pricing policies in other jurisdictions.

[171] If replacing stop signs with yield promotes energy use reduction, it may also worsen pedestrian safety in places where there is pedestrian traffic. San Diego residential areas in general have little or no foot traffic and stop signs at nearly every residential intersection. The safety issues may be overcome by driver and public training. Especially in residential areas, use of yield signs in place of stops is not expected to promote vehicle use because of the limited or no additional vehicles using residential zones as travel-through areas.