Reducing Greenhouse Gases from On-Road Transportation in San Diego County

An Analysis of Local Government Policy Options

October 2009  |  Executive Summary
Acknowledgements

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Table of Contents

Key Findings .......................................................................................................................... 2
Report Overview ..................................................................................................................... 4
San Diego Greenhouse Gas Inventory .................................................................................. 4
VMT Reduction Measures ...................................................................................................... 6
Fuel Use Reduction Measures .............................................................................................. 8
  Traffic Signal Retiming ....................................................................................................... 8
  Roundabouts ....................................................................................................................... 8
  Limiting Congestion by Highway Expansion .................................................................... 9
A Pricing Strategy .................................................................................................................. 10
Effect of Combinations of Policies on GHG Reduction ......................................................... 11
Cost Considerations ............................................................................................................. 13
The Role of Alternative Fuels .............................................................................................. 14
Conclusions ............................................................................................................................ 16

Table of Figures

Figure 1 Greenhouse Gas Emissions, San Diego County, 2006 ................................................. 5
Figure 2 Fuel Cost Savings of Traffic Light Retiming ............................................................... 8
Figure 3 GHG Savings from Fuel Use Reduction Measures .................................................. 10
Figure 4 GHG Reduction from Potential Local Pricing Strategy .......................................... 11
Figure 5 Existing, Planned and Potential Local Policies to Reduce GHGs ............................... 11
Figure 6 Effect of All Local Fuel Use and VMT Reduction Measures .................................... 12
Figure 7 Summary of GHG Reductions from Combinations of Measures ............................ 13

List of Tables

Table 1 Estimated GHG Reductions from Broad Strategies ..................................................... 5
Table 2 Existing and Planned VMT Measures Effect on GHG Reduction ............................... 7
Table 3 Existing and Potential Local VMT Measures ................................................................. 7
Table 4 Fuel Cost Savings from Roundabouts ......................................................................... 8
Table 5 Fuel Cost Savings from Planned Highway Expansion for Congestion Relief ............ 9
Table 6 Cost Issues of Local Policy Measures Assessed ......................................................... 14
Table 7 GHG Potential Reduction of Electric Vehicles ............................................................ 15
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$_2$E by 2020.

  - Federal vehicle fuel economy standards and state measures to reduce tail pipe emissions are expected to provide a 3.2 MMT CO$_2$E reduction;
  - The state-wide low carbon fuel standard (LCFS) would contribute 1.6 MMT CO$_2$E;
  - Other state measures for heavy duty vehicles would contribute 0.6 MMT CO$_2$E; and,
  - The reduction of VMT locally by 10% by 2020 is expected to contribute 1.4 MMT CO$_2$E.

- 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 occurs in our region, the reduction target of 6.8 MMT CO$_2$E could increase to 7.6 MMT CO$_2$E, highlighting the role of local governments in reducing GHGs from on-road transportation.

- Implementation of federal and state measures could reduce greenhouse gases by 5.4 MMT CO$_2$E, about 79% of the total reduction needed (6.8 MMT CO$_2$E) to achieve the 2020 target in our region.

- 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 in addition to reductions from federal and state strategies.

- 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$_2$E. The combination of these local measures with expected implementation of federal and state measures could reduce GHG emissions by 5.8 MMT CO$_2$E, about 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$_2$E).

- 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$_2$E, about 5% of the total reduction amount (6.8 MMT CO$_2$E) needed. Without planned smart growth policies, the reductions achievable are just over half this amount.

- Existing measures to reduce fuel use by limiting congestion (highway expansion) could reduce GHG emissions by 0.1 MMT CO$_2$E, 1 % of the estimated reduction amount needed (6.8 MMT CO$_2$E).

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1. These values are rounded off for readability, please refer to the tables for the actual numbers and percentages calculated.
• The combination of potential (not planned) local measures evaluated in this report, existing and planned local measures, and federal and state policies can achieve nearly all of the 6.8 MMT CO$_2$E reduction target, or 89% of the target adjusted for the potential rebound effect (7.6 MMT CO$_2$E).

• 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$_2$E;
  - A telecommute policy for 20% of commuters by 2020, 2 days a week, that could reduce GHGs by 0.3 MMT CO$_2$E, and
  - A parking cash-out policy with 12% commuter uptake by 2020 that could reduce GHGs by 0.1 MMT CO$_2$E.

• There are many potential local measures to reduce overall fuel use through advanced technologies or demand management measures:
  - Limiting congestion by highway expansion could reduce emissions by 0.08 MMT CO$_2$E in 2020 but this effect could decrease after 2020 due to population growth.
  - Traffic signal retiming could reduce emissions by 0.02 MMT CO$_2$E.
  - Replacing stop-intersections with roundabouts could reduce emissions by 0.06 MMT CO$_2$E, 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 either hybrid-electric vehicles up to about 80%, or electric vehicles up to about 50%, 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 reducing GHGs 80% below 1990 levels will require more aggressive policies from the on-road transportation category.
Report Overview

In September 2008, the Energy Policy Initiatives Center (EPIC) released the San Diego County Greenhouse Gas Inventory report, which estimated San Diego region’s greenhouse gas emissions and analyzed strategies to reduce regional emissions to 1990 levels by 2020. While a necessary step in the mitigation process, that 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. 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 provide preliminary cost information to help policy makers understand general 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.

This summary is intended only as an overview of the main findings of the study, and no detailed discussion of methods is included. It provides a brief overview of the San Diego County Greenhouse Gas Inventory and its connection to this study, and GHG reductions from fuel use and VMT reduction policies assessed. Detailed analysis for each policy, including cost considerations, examples of use in other jurisdictions, and information about the methods used for GHG emissions savings and costs estimates are provided in the main project report available for download on the Energy Policy Initiatives Center Website.²

San Diego Greenhouse Gas Inventory

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 (Figure 1). This follows the global trend,³ the national trend in most countries (though not the US national trend⁴), and the California state trend. Tackling the emissions from on-road transportation therefore becomes a major challenge to achieve any significant reductions in GHG emissions in the long run.⁵

2. Electronic copies are available on the EPIC Website at http://www.sandiego.edu/epic/ghgpolicy.
4. The US on-road transportation GHG emissions constituted 30% of the total emissions in 2007, however electricity generation contributes most (34%) to the US total due to the dependence on coal power. California generates most of its electricity from natural gas. See 2009 GHG FastFacts at: http://www.epa.gov/climatechange/emissions/usinventoryreport.html.
5. 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 basis of the 80% reduction of GHG targets for 2050 that is also set by California Executive Order S-03-05. http://www.cbc.ca/world/story/2009/07/09/g8-summit-italy-climate-change374.html.
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%. This was true even though the number of passenger cars was greater than those of LDTs. This effect was encouraged by two federal policies adopted in the 1990s: the Corporate Average Fuel Economy (CAFE) standards to increase the fuel efficiency of passenger cars while exempting vehicles of greater weight from fuel economy requirements, and a policy of taxing less fuel efficient cars but not trucks. LDTs became the largest emitting vehicle type in San Diego County in about 2003. Because the CAFE standards have only recently (2009) been increased for both passenger cars and LDTs, these emissions trend differences are expected to continue at least until 2020.

The California Global Warming Solutions Act of 2006, AB 32, does not require individual sectors or jurisdictions (e.g., cities and counties) to reduce emissions by a specific amount; however, 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.

The AB 32 target to achieve 1990 levels means reaching 29 MMT CO2E in San Diego County by 2020. This represents 33% below the business-as-usual-projections for 2020 of 43 MMT CO2E. For the on-road transportation category, we developed four broad reduction strategies to contribute

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Table 1. Estimated GHG Reductions from Broad Strategies

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Estimated Reduction by 2020 (MMT CO2E)</th>
<th>Percentage of Total On-Road Transportation Reduction</th>
<th>Percentage of AB 32 Target applied to San Diego County</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel Use Reduction (CAFE) + Tail Pipe Emissions (AB 1493/Pavley)</td>
<td>3.2</td>
<td>47%</td>
<td>23%</td>
</tr>
<tr>
<td>Low Carbon Fuel Standard</td>
<td>1.6</td>
<td>24%</td>
<td>12%</td>
</tr>
<tr>
<td>Other State Measures</td>
<td>0.6</td>
<td>9%</td>
<td>4%</td>
</tr>
<tr>
<td>10% VMT Reduction</td>
<td>1.4</td>
<td>21%</td>
<td>10%</td>
</tr>
<tr>
<td>Total</td>
<td>6.8</td>
<td>100%</td>
<td>49%</td>
</tr>
</tbody>
</table>

Note: The AB 32 target applied to San Diego County with the rebound effect could increase to 7.6 MMT CO2E.

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to meeting the AB 32 target for the region in 2020 (Table 1). We estimated that a reduction of 6.8 MMT CO$_2$E would be needed from the on-road transportation category to meet the target of 29 MMT CO$_2$E by 2020. The 6.8 MMT represents 49% of the total reduction (14 MMT CO$_2$E) needed to meet the AB 32 target in our region. Three of the four broad strategies relied on either existing statutes or policy directives then under consideration addressing fuel economy and fuel type and the fourth broad strategy involved a reduction in local VMT.

The federal CAFE standard included in Title 49 of the Energy Independence and Security Act of 2007 is a measure affecting fuel economy of cars and light duty trucks. California’s AB 1493 (Pavley) regulation requires tailpipe emissions reductions without necessarily affecting fuel economy. Together, CAFE and Pavley provide 23% of the AB 32 reductions. The California LCFS was adopted as an early action measure for meeting emissions reduction targets. This can reduce the carbon intensity of transportation fuels sold in California by 10% by 2020 and provide 12% of the total reduction in our region. Finally, we estimated that a decrease of 10% in VMT locally by 2020 could provide reductions of 1.4 MMT CO$_2$E, or 10% of the total reduction possible from on-road transportation.

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$_2$E could increase to 7.6 MMT CO$_2$E.

### VMT Reduction Measures

The San Diego County GHG Inventory estimated that reducing VMT by at least 10% through 2020 could reduce GHGs by 1.4 MMT CO$_2$E. To estimate what local measures could reduce VMT to meet this level, we first estimated the GHG reductions expected from three measures already incorporated in the 2030 Regional Transportation Plan (2030 RTP):

- Continued increase of vanpools at the current rate of increase would reduce GHG emissions by 0.03 MMT CO$_2$E in 2020;

- The I-15 High Occupancy Toll (HOT) lanes induce a certain level of carpooling. The HOT lane system will be expanded to 80 miles by 2020 and could save 0.1 MMT CO$_2$E;

- Planned smart growth projects reported by SANDAG could lead to a VMT decrease from a current 27.65 miles per capita to 27.30 VMT per capita in 2030. We assumed that this VMT decrease will be achieved by 2020 and lead to a 0.2 MMT CO$_2$E reduction.

Together, the three measures provide about 29% (0.4 MMT CO$_2$E) of the amount needed from VMT reduction measures (1.4 MMT CO$_2$E) (Table 2).

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7. HR6, Title I, Section 102.
8. Executive Order S-01-07 on setting a goal for the carbon intensity of transportation fuels in California was the precursor to the state Low Carbon Fuel Standard, see [http://gov.ca.gov/index.php?/executive-order/5172/](http://gov.ca.gov/index.php?/executive-order/5172/)
9. San Diego Association of Governments
10. 2030 Regional Transportation Plan, 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%. 
The existing and planned 2030 RTP measures to reduce VMT are insufficient to achieve significant GHG reductions and leave 75% of the needed GHG reduction to be achieved by either other VMT reduction measures or other means. Three additional VMT reduction measures that are not currently being implemented could have large GHG reduction impacts:

- An expanded mass transit system with a commuter mode split of 16% could reduce GHGs by 0.6 MMT CO$_2$E.
- A region-wide telecommute policy where 20% of all commuters telecommute 2 days a week by 2020 could save 0.4 MMT CO$_2$E.
- A parking cash-out policy, which provides financial incentives for commuters to either work from home, carpool or use mass transit and eliminate the need for parking, could reduce GHGs by 0.1 MMT CO$_2$E in 2020.

Together these three potential policies could reduce GHGs by 1 MMT CO$_2$E in 2020, with mass transit having the largest impact. Table 3 shows the effect of these three potential measures on GHG reduction. The order in which the policies are adopted and implemented affects the magnitude of the GHG reduction possible from each. In the order of implementation of measures shown in Table 3, we assume that those who telecommute are removed from the pool of commuters available to use mass transit. In a different scenario, if the mass transit potential were applied before a telecommute policy, a 16% mode split for commuters in mass transit achieves greater GHG reductions than in the former scenario.

Even with commuter mass transit use much higher than today by 2020, we could achieve only 86% of the needed GHG reduction from the reduction target of 1.4 MMT CO$_2$E; therefore, it is a challenge to achieve the full 1.4 MMT CO$_2$E reduction amount from VMT reduction alone.

### Table 2. Effect of Existing VMT Measures on GHG Reduction

<table>
<thead>
<tr>
<th>VMT Measure</th>
<th>GHG Reduction (MMT CO$_2$E)</th>
<th>Percentage of Reduction Needed (1.4 MMT CO$_2$E)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vanpools</td>
<td>0.03</td>
<td>2%</td>
</tr>
<tr>
<td>Congestion Pricing</td>
<td>0.12</td>
<td>9%</td>
</tr>
<tr>
<td>Smart Growth Planned</td>
<td>0.19</td>
<td>14%</td>
</tr>
<tr>
<td>Total RTP Measures</td>
<td>0.35</td>
<td>25%</td>
</tr>
<tr>
<td>Without Planned Smart Growth</td>
<td>0.16</td>
<td>11%</td>
</tr>
</tbody>
</table>

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

### Table 3. Existing and Potential Local VMT Measures

<table>
<thead>
<tr>
<th>VMT Measure</th>
<th>GHG Reduction Amount (MMT CO$_2$E)</th>
<th>Percentage of Reduction Needed (1.4 MMT CO$_2$E)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vanpools</td>
<td>0.03</td>
<td>2%</td>
</tr>
<tr>
<td>Congestion Pricing</td>
<td>0.12</td>
<td>9%</td>
</tr>
<tr>
<td>Congestion Miles Reduction</td>
<td>0.08</td>
<td>6%</td>
</tr>
<tr>
<td>Parking Cash-Out Potential</td>
<td>0.11</td>
<td>8%</td>
</tr>
<tr>
<td>Mass Transit Potential</td>
<td>0.55</td>
<td>39%</td>
</tr>
<tr>
<td>Telecommute Potential</td>
<td>0.30</td>
<td>22%</td>
</tr>
<tr>
<td>Total Potential</td>
<td>1.20</td>
<td>86%</td>
</tr>
</tbody>
</table>
Fuel Use Reduction Measures

Although federal and state regulations were estimated 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 1), there are many local measures that can contribute to fuel use reduction.

We evaluated three local measures to reduce fuel use, including measures that are already being implemented as part of a regional strategy to reduce congestion and measures that are not currently implemented but are feasible. These are (1) retiming traffic signals, (2) use of roundabouts in place of stop intersections, and (3) limiting congestion through highway expansion.

Traffic Signal Retiming

Inappropriate traffic signal timing contributes to increased congestion, which increases fuel use and GHG emissions. Retiming these signals can be an effective solution to address this problem and contribute to GHG reduction. We calculated the GHG reduction possible based on the average value of savings per intersection reported in the literature for a number of intersections identified by a previous SANDAG study in 1993. GHG savings from traffic signal retiming measures undertaken by individual cities and/or the region could reach 0.02 MMT CO$_2$E in our region. Although the GHG reduction benefits of this measure are relatively small in absolute terms, the resulting fuel savings can quickly recover the capital investment of the measure, even at relatively low gasoline prices (Figure 2).

Table 4. Fuel Cost Savings from Roundabouts

<table>
<thead>
<tr>
<th>Fuel Price ($/gallon)</th>
<th>2.00</th>
<th>2.50</th>
<th>3.00</th>
<th>3.50</th>
<th>4.00</th>
<th>4.50</th>
<th>5.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value of Fuel Saved ($)</td>
<td>40,000</td>
<td>50,000</td>
<td>60,000</td>
<td>70,000</td>
<td>80,000</td>
<td>90,000</td>
<td>100,000</td>
</tr>
</tbody>
</table>

Note: Cost per intersection $500,000; Fuel saved per intersection 20,000 gallons; CO$_2$E saved per intersection 189 MT

Roundabouts

Similarly, roundabouts can produce 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 the associated delays. To estimate the potential GHG emission reductions that result from roundabouts, we used the Bird Rock, La Jolla roundabout project as an example of a change from stop sign intersections to roundabouts. In this case, replacing several 4-lane road stop-sign intersections with roundabouts is estimated to have reduced fuel use by 20,000 gallon per intersection. A potential GHG reduction of 0.06 MMT CO$_2$E was estimated for our region. This amount of GHG reductions is significantly greater though more costly than retiming traffic signals (Table 4).
Limiting Congestion by Highway Expansion

The most frequently used mitigation method for congestion reduction in our region has been expansion of the roadway system. While road expansion can reduce congestion in the short run (5-10 years), it has been shown that this 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, CO₂ 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.¹¹

To estimate potential GHG reductions by 2020 in San Diego County from this measure, we used data from existing regional planning documents. According to SANDAG’s Congestion Management Plan Update of 2006,¹² there were 172 miles of freeways, highways and arterials in San Diego County in 2006 that were categorized as level of service (LOS) F, defined as traffic flowing at less than 20 mph with more than 45 passenger vehicles per lane mile. In 2008 LOS F miles were 105. Additional highway improvement measures – mainly additional lanes – are expected to reduce the LOS F miles by 2020 to 91 miles. Based on research studies,¹³ we assumed that such congestion leads to an average 40% decrease in fuel efficiency of passenger vehicles.

The GHG reductions possible from traffic light retiming, roundabouts and planned highway expansion measures are 0.2 MMT CO₂E (Table 5). Highway expansion provides only somewhat greater GHG reductions than potential roundabout installations at intersections.

| Table 5. Fuel Cost Savings from Planned Highway Expansion for Congestion Relief |
|-----------------------------|----------------|----------------|----------------|----------------|
| 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 is 8 million gallons; CO₂E saved is 0.83 MMT


¹³ 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/feq/driveHabits.shtml.
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. Also, some local measures may interact negatively with others and not lead to reductions for a variety of reasons. For example, freeway vehicle speed reduction reduces fuel use; however, actual GHG reductions due to potential reduction of freeway speed in a region depends on the number of total vehicle miles actually traveled at speeds beyond the speed limit as well as the number of miles traveled at congestion speeds of less than 20 mph. Where the number of miles traveled at speeds less than 20 mph is the same as the number of miles traveled at above 65 mph, the emissions at lower speeds are greater than the emissions due to speed limit reduction from 65 mph to a theoretical 55 mph. For this reason, a freeway speed reduction measure cannot be fully quantified for our region without knowing the distribution of speeds on San Diego freeways.

### A Pricing Strategy

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 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.
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 AB 32 target applied to San Diego County with the rebound effect are shown in Figure 4.

Effect of Combinations of Policies on GHG Reduction

The relative GHG reduction effects of the eleven potential local fuel use reduction and VMT reduction policies is shown in Figure 5.
Combining the GHG reductions possible from several fuel use and VMT reduction measures may allow us to reach the target reduction amount (Figure 6). 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% and for every 10% reduction in GHGs due to alternative fuel use, there could be a 3% increase in VMT.\textsuperscript{14} 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\textsubscript{2}E 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\textsubscript{2}E. In this case, the role of local government would increase and more aggressive or a greater number of local policies might be needed.

\textbf{Figure 6. Effect of All Local Fuel Use and VMT 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\textsubscript{2}E. Alternatively, a comprehensive pricing strategy together with existing, planned and potential fuel use and VMT reductions as well as federal and state measures, could achieve the reduction target, even with the rebound effect.

A summary of the effects of combinations of strategies is shown in Figure 7.

Figure 7. Summary of GHG Reductions from Combinations of Measures

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 CO₂E. Nonetheless, these values provide an idea of the relative costs based on the relative magnitude of the costs (Table 6).

The largest GHG reduction potential comes from a mass transit system, which has a relatively high initial investment 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 road pricing policies could yield similar levels of GHG reductions, though road pricing is much less costly. The most costly measure in terms of GHG reduction alone is highway expansion, which also has relatively low potential to reduce GHG emissions.

15. 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.
The Role of Alternative Fuels

While state measures to reduce the carbon intensity of on-road transportation fuels are expected to have a substantial impact on GHG reduction, the role of local government in promoting alternative fuels and vehicles is relatively limited. Therefore in this section we address alternative fuel issues that might be of interest to local government.
The state LCFS is expected to reduce emissions by about 1.6 MMT CO₂E within San Diego County. Most scenarios of alternative fuels envision a high percentage of ethanol (55% to 87%) substituting for gasoline (and biofuels substituting for diesel). However, due to the unresolved issues associated with ethanol, such as food crop use, and the fact that flex-fuel vehicles in practice are used often in the gasoline mode, we focused instead on the potential market penetration by electric vehicles (EVs) and hybrid electric vehicles (HEVs). The LCFS scenarios envision a minimum 9% of the fuel provided through electricity.

According to research by UCLA, the percentage of HEVs in San Diego County based on 2007 data was 0.07-1% of total registered vehicles. The average number of HEVs sold nationwide has been over 20% a year from 2004 to 2007 although this changed in 2007-2008 due to the economic recession in 2008. Assuming an average 20% increase per year through 2020 from 2007 levels it would be possible to achieve at least 9% share of HEVs of total registered vehicles in the county by 2020. We calculated the GHG reduction potential of varying percentages of HEVs and EVs in the passenger vehicle fleet on GHG reduction (Table 7).

Table 7. GHG Reduction Potential of Electric Vehicles

<table>
<thead>
<tr>
<th>Percent of Projected Passenger VMT Driven by EVs or HEVs in 2020</th>
<th>HEV Reduction Amount (MMT CO₂E)</th>
<th>EV Reduction Amount (MMT CO₂E)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>1.52</td>
<td>2.80</td>
</tr>
<tr>
<td>40</td>
<td>3.04</td>
<td>5.59</td>
</tr>
<tr>
<td>60</td>
<td>4.57</td>
<td>8.38</td>
</tr>
<tr>
<td>80</td>
<td>6.09</td>
<td>11.20</td>
</tr>
<tr>
<td>100</td>
<td>7.61</td>
<td>13.97</td>
</tr>
</tbody>
</table>

Note: The HEV model used for the calculation was the Toyota Prius 2007. The EV model used for the GHG calculation as a worst case was the Tesla Roadster.

These calculations show the large GHG reduction potential of an electrified private transportation system. A 100% electric passenger vehicle transportation system would achieve much more than the estimated reduction amount needed from on-road transportation, even with the current carbon intensity of electricity production sources for San Diego region. However, this is unlikely to happen because the rate of annual sales would need to be much greater than projected. There is also relatively little that local governments can do to further promote electric vehicle use beyond encouraging infrastructure. In addition, increased use of electrified private vehicles will not eliminate the need for costly highway expansion. Nevertheless, the potential of a fully electrified private and public transportation system to reduce GHGs even towards the 2050 goal is significant.

16. The experience of ethanol use in Brazilian on-road transportation shows that the use of the ethanol fluctuates according to the price of the agricultural source crop as well as the price of oil. When the price of oil is low, flex car owners switch to gasoline and eliminate GHG reduction benefits from the use of ethanol.
17. California Green Market Geography 2009, 2007 data. Information provided by the author, Dr. Matthew Kahn, UCLA.
18. National HEV sales data is available from the Alternative Fuels and Advanced Vehicles Data Center, at http://www.afdc.energy.gov/afdc/data/
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 CO₂E locally might be needed and would be challenging. Combinations of policies within local government control are available to achieve 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 EPIC reduction target of 6.8 MMT CO₂E. 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 CO₂E EU-27), 2.2% (93 MMT CO₂E EU-15) and 25.3% (337 MMT CO₂E EU-12) below 1990 have been reached, only the on-road and 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 goal and beyond. To reach the 2050 target of 80% below 1990 levels will require more comprehensive and/or more aggressive local strategies.
About the Energy Policy Initiatives Center (EPIC)

The Energy Policy Initiatives Center (EPIC) is a non-profit academic and research center of the University of San Diego School of Law that studies energy policy issues affecting the San Diego region and California. EPIC integrates research and analysis, law school study, and public education to serve as a source of legal and policy expertise and information in the development of sustainable solutions that meet our future energy needs.

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