Transportation: Opportunities For Greenhouse Gas Emission Reduction In Sonoma County

Community Climate Action Plan

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Abstract
This paper analyzes the cost and carbon emissions reduction potential of measures in the transportation sector.

Reducing carbon emissions from transportation takes three fundamental paths: (1) using vehicles more efficiently, (2) Reducing the need for trips and average trip length, and (3) using more "carbon efficient" vehicles. Using vehicles more efficiently involves mode share shift. Shifting mode share from single occupant vehicle to walking, bicycling and transit is one of the top objectives of most transportation public policy because of its effect on traffic congestion. Increasing the use of more efficient transportation modes is also one of the most cost effective means of reducing carbon emissions from transportation. This mode share shift generally takes place by employing publicly funded investments in transportation infrastructure.

Reducing the need for trips and average trip length is related to increasing population density in urban core areas. This is an area of overlap between land use planning, the locations of jobs and housing, and how communities can ultimately reduce their reliance on the automobile. These solutions are necessarily longer term in their effect.

However, from the perspective of achieving the level of reduction required by climate science, there must be significant additional mode share shifted from the fossil fuel powered vehicle. This paper proposes a method to make a significant number of non-emitting personal vehicles available on a short term rental basis. These vehicles would include all electric (EV), plug-in hybrid (PHEV) and low carbon fuel vehicles (biofuels, hydrogen). A method for a large scale deployment of low carbon vehicles is given. A program for construction of biofuel manufacturing facilities using municipal revenue bonds is discussed.

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Definitions

Average Distance. Average trip length of a mode, or of all modes.

General policy measures. Measures that tend to have a wide-spectrum effect favoring modes that generate less greenhouse gases (GHGs).

Modes. A mode designates a form of travel, such as walking, or riding in a car. Although many possible modes of travel exist, we limit the number of modes to those that are most relevant to our discussion. Our interest is in shifting from one mode of travel to another to reduce energy requirements while still meeting actual travel needs. From that perspective, seven modes are addressed in this report:

1. Walking including wheelchairs
2. Bicycling including tricycles and electric motor assisted bicycles
3. Transit including trains, transit buses, and paratransit
4. Car driving including light trucks and private vans
5. Car passenger meaning occupying passenger seats in private vehicles[1]
6. Other motorized traveling including motorcycles and motor scooters
7. Non-emitting, which would include all electric, or biofuel powered vehicles

Mode Share. Percentage of all trips via this mode.

Mode Specific Improvement Measures. Measures that *primarily* affect use of that mode. Few measures will not have minor effects on other modes however.

Trip. Although “trip” often signifies a journey from origin to destination, its meaning is slightly different in this report. For the purpose of this report, “trip” means travel on a single mode from beginning on that mode to the point of leaving that mode. In the official language of transit, this is called an “unlinked” trip. As an example of four unlinked trips, a traveler 1) walks to a bus stop, 2) boards a bus, rides to another point on the route, and exits the bus, 3) connects to another bus, rides to another stop, and exits, and 4) walks to the destination.

Trip Generation. Trip generation is the first step in a model of travel usually used for the purposes of forecasting. It refers to a model of the types of trips that are taken and is usually jurisdiction-specific. Other steps in this model of travel are trip distribution, mode choice and route assignment. Trip types and their distribution are normally determined by a travel survey**.**

Vehicle Miles Traveled or VMT. This is the standard measurement for vehicle activity, and the primary metric related to generation of greenhouse gas (GHG). VMT is applied to a standard vehicle inventory on a percentage basis, and then fuel use is calculated based on the average fuel efficiency for each vehicle class in the inventory. VMT is usually an estimate that is calculated from transportation computer models.

[1] Car pool isn't used here because it is somewhat ambiguous. Its intent is captured in the two defined modes, car driver and car passenger, which together are more explicit than “car pool.”

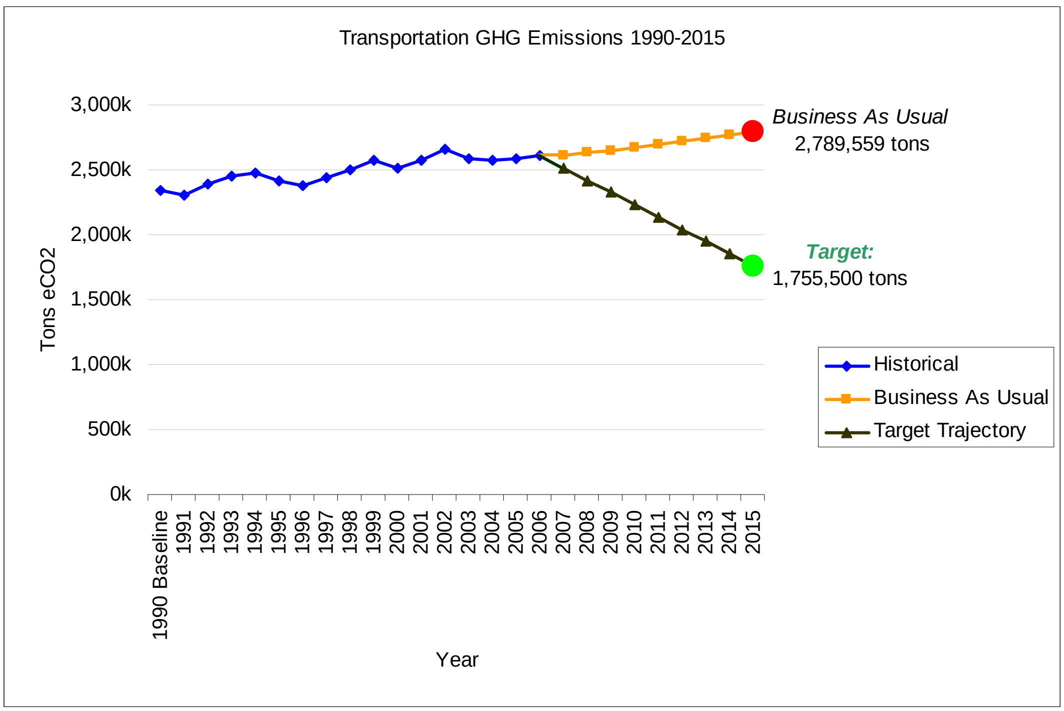
Introduction

Transportation today is responsible for approximately 60 percent of the greenhouse gases (GHG) emitted in Sonoma County. If overall GHGs must be reduced by 25 percent below 1990 levels by 2015, can we reduce transportation system emissions that much, or must the burden be carried disproportionately by other sectors?

Total emissions from transportation in 1990 are estimated to be 2,340,667 tons, based on total annual vehicle miles traveled (VMT) of 3,007 million miles.[2] 75 percent of this level (25 percent below 1990 levels – Sonoma County's target) is 1,755,000 tons. This is the level that should be achieved to avoid impacting other sectors.

The "business as usual" (BAU) VMT for 2015 is projected to be 2,789,559 tons, based on an estimated annual VMT of 4,441 million miles. Reaching the target, then, involves a 37 percent reduction from the projected 2015 BAU level, or a 32 percent reduction from the 2005 level.

Figure 1



To calculate the possible ways to reduce emissions in the transportation sector, we must first look at three transportation parameters:

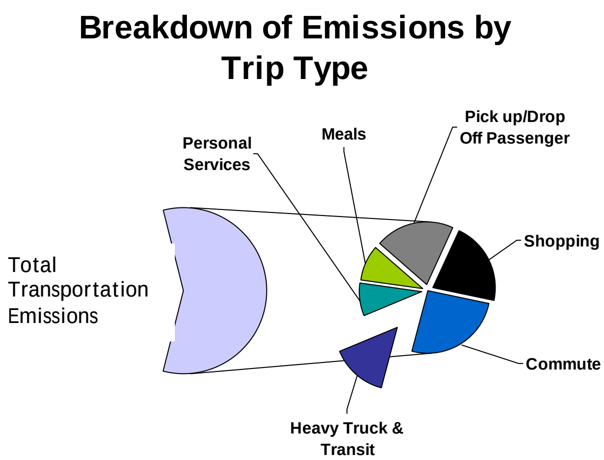
1. Trip generation
2. Mode selection
3. Average trip length

[2] Estimate provided by MTC staff based on Highway Performance Monitoring System (HPMS) data extracted 4/18/2006. Figures confirmed by Sonoma County Transportation Authority staff in private conversation, May 2008.

Trip Generation

The following chart shows the distribution of total emissions among various trip types. This breakdown shows how total transportation emissions are related to trip generation.[3]

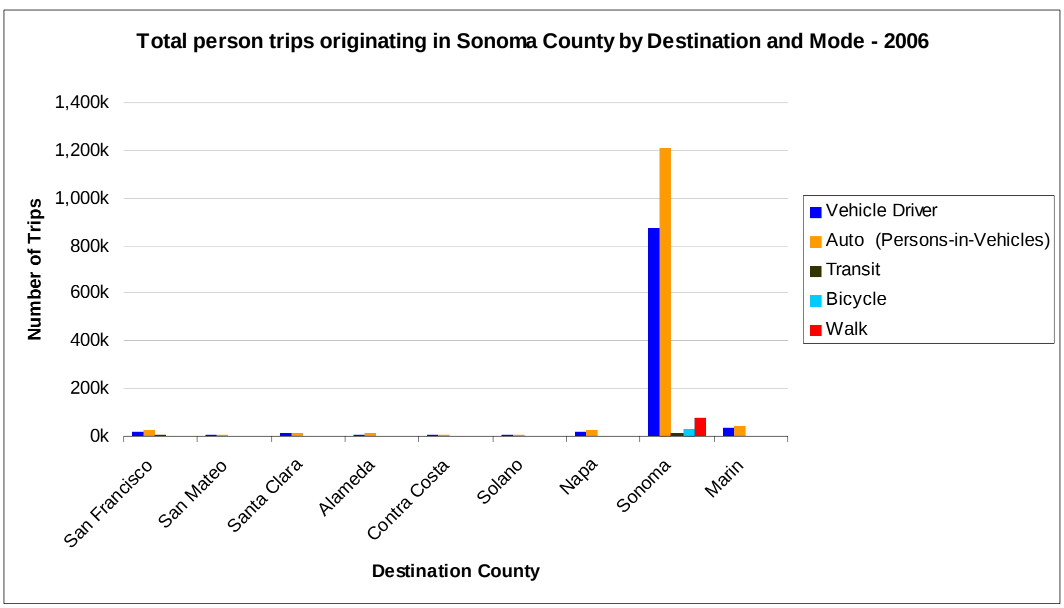
Figure 2



Mode Selection

Figure 3 shows the current distribution of mode selection for travel originating in Sonoma County, with "drive alone" by far the dominant mode.[4]

Figure 3



[3] Based on data supplied in the Travel Forecast Data Summary 2005, Metropolitan Transportation Commission

[4] Data from San Francisco Bay Area Travel Survey 2000 – Regional Travel Characteristics Report, Metropolitan Transportation Commission

Average Trip Length

Average trip length is most influenced by land use. Factors such as “regional accessibility” can affect the total number of miles traveled by an individual, rather than the total number of trips. Overall vehicle miles traveled increase the farther Sonoma County residents live from the 101 corridor.[5] Average trip length is much higher for residents who live in less dense areas of the County.[6]

The number of trips required or “trip generation/production” is also affected by land use. The characteristics of the households in the region of interest also impact trip generation/production. Another way to look at trip generation/production is that “trips are what we need.” Demand for trips or mobility is what drives the transportation system. To the extent that trips can be avoided altogether, GHG reduction can be very cost effective. Trip reduction is similar to conservation in the energy realm, in terms of giving the greatest GHG reduction per dollar. Because the cost of the trip influences trip generation, if the traveler were to pay the true cost of the trip, i.e., including all currently externalized costs, trips generation would be reduced.

Accounting for Trips and Passenger Miles

The way travel behavior is accounted for relies on art as well as science. Local travel surveys are rarely undertaken because they are very laborious and hence expensive. The Decennial Census long form from the National Household Travel Survey (NHTS) and the National Personal Travel Survey (NPTS) provides actual data. Experts use this information to develop travel models, playing with various parameters until there is a cohesive picture – at least according to the model. The model then becomes the representation of travel behavior. Extrapolations based on the model fill in gaps where directly observed data does not exist.

[5] “Greenhouse Gas Emission Inventory for all sectors of Sonoma County, California,” 2005, http://climateprotectioncampaign.org/news/documents/AP_INVEN.PDF

[6] Using Residential Patterns and Transit To Decrease Auto Dependence and Costs by John Holtzclaw, June 1994

Overview

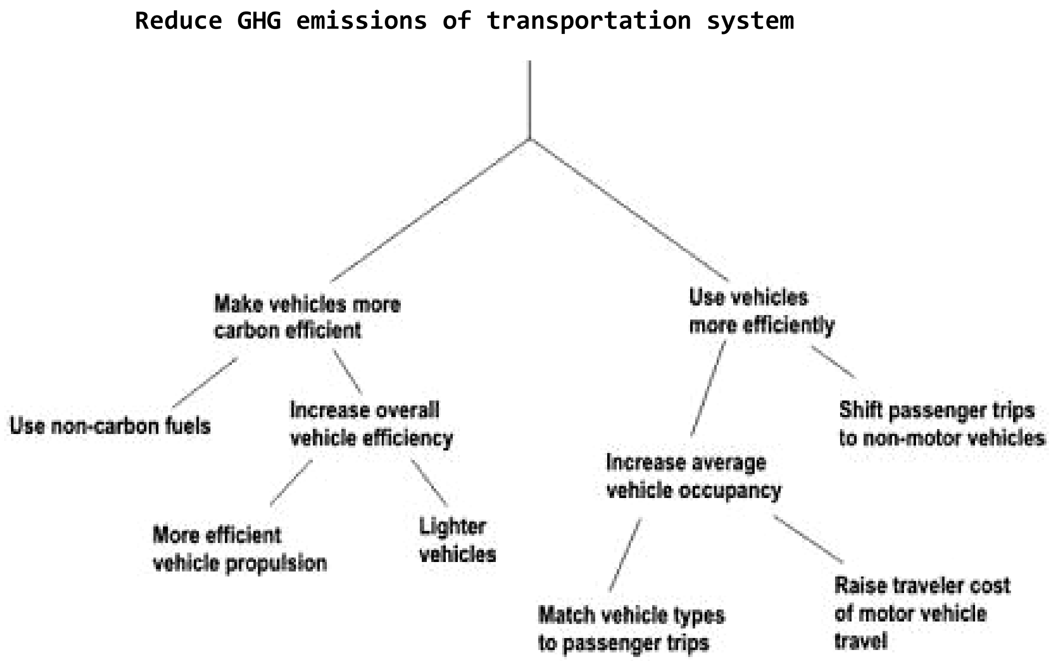
There are three basic ways to reduce the amount of GHG produced by the transportation sector:

1. Reduce the number of trips taken and/or reduce the average length of trips
2. Improve the efficiency of propulsion
3. Shift travel from less efficient modes to more efficient modes.[7]

Logic Framework for Efficiency and Mode Shifting

A logic framework for understanding general measures for efficiency and mode shifting follows.

Figure 4



Estimates for the amount of travel in Sonoma County and for the amount in each modal category are shown in Table 1. Also shown are the corresponding modal percentages that might exist in 2015, the target year, and if we are to be on track for solving our GHG problem. Table 2 shows modal percentages that have actually been achieved in locales that lead the nation in reducing GHG emissions from transportation.[8]

[7] The efficiency of a mode is measured in terms of the amount of energy required per mile of passenger movement. The mode efficiency has two components: (1) efficiency of propulsion; (2) number of miles of passenger movement per mile of vehicle movement.
[8] Table 1 data on possible modal distribution from private international study conducted by Joel Woodhull. Data on modal distribution in US jurisdictions provided by Chris Barney, Sonoma County Transportation Authority.

Table 1. Mode Share Shifts for GHG Reduction

Mode	Walk		Bicycle		Transit		Car Driver		Car Passenger		Other Motorized		All	
	Current	2015	Current	2015	Current	2015	Current	2015	Current	2015	Current	2015	Current	2015 (1)
Share (%)	3.1	12.0	1.9	9.0	1.0	6.0	74.0	37.0	15.0	23.0	2.0	10.0	97.0	97.0
Av Dist. (Mi)	0.4	0.4	2.0	2.0	5.8	4.0	5.0	4.0	7.0	7.0	3.0	3.0	4.9	3.9

Mode Specific Improvement Measures	sidewalks tree lanes, shade street crossing priority intensified network	path construction better connections priority on narrow streets consistent shoulder widths	construct, operate rail passenger service expand bus services fixed facilities for transit passengers	car-sharing services light truck rental rural service network congestion pricing	facilitate car-pooling ride auctions??	parking conversions to provide favorable spaces
General Policy Measures	Land use changes favoring shorter trips New tax policies, e.g. local gas tax, with revenues applied to favor GHG reductions when shifting mode shares General reduction of road speeds to promote energy reduction and safety of all road users Expansion of delivery services Telecommute programs to reduce numbers of trips Manage parking with pricing					

NOTES
Transit includes bus and train.
Car includes light trucks, vans.
Other Motorized includes scooters, motorcycles
(1) Mode shares add to 97% because school bus trips aren't accounted for. They may carry about 3% of trips.

Table 2. Mode Share In Other Jurisdictions

Mode	Walk	Bicycle	Transit	Car Driver	Car Passenger	Other Motorized	All
ACS 05	4.0		2.0	75.0	11.0	**US Census American Community Survey 2005 Data**	
SF2000	19.7	1.0	17.2	62.2		**San Francisco Mode Share #s**	
SF2025	18.7	1.0	19.6	60.8			
MTC2000	9.2	1.5	5.6	71.0	13.0	**MTC 9 County Bay Area Mode Share #s**	
MTC2030	9.2	1.4	6.6	68.1	13.9		
BOULDER03	18.6	14.0	4.6	39.0	23.5	**Boulder, CO Mode Share #s**	
PORTLAND05	6.6	1.1	4.0	58.3	30.0	**Portland Ore, Metro Mode Share #s**	
PORTLAND2035	7.5	1.2	5.5	53.2	32.6		
CP LOW 2015	**6.6**	**6.9**	**5.0**	**57.5**	**19.0**	**5.0**	
	2005 Portland Mode Share %	5% easy shift to bike	4% easy shift to transit		4% easy shift to car/vanpool	telecommute/other	

Even in the best case scenario, if Sonoma County's non or low emitting modal percentages were to exceed what has been achieved elsewhere, transportation's contribution to Sonoma's GHGs would be 80 percent of what it is today. The projected level of achievable emissions reduction is approximately 12 percent below the 1990 level. This is less than halfway to our goal of 25 percent below the 1990 level.

Public Transportation for GHG Reduction

At the local level, the right side of the tree in Figure 4, "Use vehicles more efficiently," is most straightforward to accomplish via public sector actions. The importance of enhancing walking and biking infrastructure and increasing the public transportation system cannot be overstated. These fall within the purview of public transportation agencies, i.e., Sonoma County Transit Authority and the Metropolitan Transportation Commission, that have developed and continue to develop these transportation options.

While upgrading these modes is mandatory for reducing GHG emissions, the rate and scale of improvements are limited by the availability of taxpayer dollars, a political matter beyond the scope of this report to fully address. As policymakers and the public recognize the connection between enhanced public transit infrastructure and GHG reduction, more funding may become available.

This report identifies options to encourage shifting from single occupant, fossil fuel-powered automobiles to more efficient modes. Public sector options, such as those identified above, tend to have greater cost effectiveness in terms of the cost per ton of GHGs reduced. But because these options rely on funding from tax revenues, the ability to achieve the optimum level of mode share shift is highly uncertain.

Role of Personal Transportation

The total GHG emission reduction that can be expected as a result of the mode share shift to public transit, walking and biking is not sufficient to reach the target in the transportation sector.[9] Thus this report also examines the impact of the left side of logic tree in Figure 4, "Make vehicles more carbon efficient." To the extent that low-cost access to high efficiency vehicles can be provided, a mode share shift can be significant. This report describes a funding mechanism and a technology to give drivers and passengers an alternative to owning and depending upon a private automobile.

Findings of 1997 Sonoma County Transportation Study

In the past, transportation studies focused primarily on relieving congestion. However, a 1997 report known as the Calthorpe Study[10] presented some conclusions that are consistent with the goal of reducing GHG emissions. The team that developed report was tasked with determining "how to most efficiently spend public money on transportation improvements and how to create a pattern of land use that can most efficiently take best advantage of transportation options while maintaining a high quality of life for Sonoma and Marin County residents."

The approach the team took is described as follows:

> *In order to determine the best and most efficient transportation network and urban form for the North Bay, five transportation and two land use scenarios were evaluated. These scenarios included a wide range of potential improvements such as High Occupancy Vehicle (HOV) lanes, reconfigured freeway interchanges, improvements to state highways and local roads, the introduction of commuter rail service, improvements to the existing bus transit system, and bicycle and pedestrian improvements. The land use analysis explored the effects of focusing some new mixed-use development in locations with good access to transit.*

The findings of the Calthorpe study most relevant to transportation and GHG reductions are as follows:

No Scenario Will Substantially Change Fundamental Travel Behavior — The increment of population growth projected between 1995 and 2015 is not large enough to change the fundamental character of the North Bay; future County

[9] Reductions from expected mode share shifts are quantified in the Appendix.
[10] *Sonoma/Marin Multi-Modal Transportation and Land Use Study*, June 6, 1997, Calthorpe, et al.

residents will likely continue to have a strong propensity to drive due in part to the semi-rural nature and dispersed population density of the County.

Rail Works — All of the Scenarios with rail transit had projected more ridership than expected. Rail can be implemented with a relatively low cost, because the major element of its infrastructure is already in place and publicly owned.

Bus/HOV Lane is the Least Cost Effective Transit Investment — A continuous Bus/HOV lane is more expensive than the rail system on a net cost per new trip basis.

Benefits of HOV Lanes Vary Along the Corridor — The HOV lane is of variable effectiveness at relieving congestion on Highway 101. For example, the section between Cotati and Petaluma is relatively uncongested in all the Scenarios and would not benefit from an HOV lane.

Compact Land Use Policies are Not Necessary Everywhere — Some Opportunities Areas are less effective at reducing traffic impacts on Highway 101 and improving rail ridership than others, such as those in Cloverdale and other outlying areas. Also, some Opportunity Areas may not be politically viable.

The goals and methodology of the Calthorpe study were similar in many respects to this evaluation of transportation solutions for reducing GHG emissions. The conclusions of this study, in terms of its focus on the set of potential improvements, echo those of the Calthorpe study. The only exception, perhaps, is the assessment of additional HOV lanes. Although Calthorpe concluded they were less cost-effective than other options, they were still proposed as a congestion management option. From a GHG emissions perspective, the addition of HOV lanes represents roadway capacity increase, which leads to an increase in VMT.[11] Because increasing VMT increases GHG emissions, HOV lanes are not a viable option for this report.

Regional and Countywide Transportation Endeavors

Both the Bay Area Metropolitan Transportation Commission (MTC) and the Sonoma County Transportation Agency (SCTA) have recently incorporated climate protection as part of their planning. MTC's 2035 plan incorporates the targets of reducing carbon dioxide emissions 40 percent below 1990 levels by 2035, and reducing per capita VMT 10 percent by 2035.[12] Similarly, SCTA's Comprehensive Transportation Plan includes as one of its five goals to reduce greenhouse gas emissions.[13]

[11] "Induced Travel Demand: Research Design, Empirical Evidence, and Normative Policies," Robert Cervero, Journal of Planning Literature, 2002; 17; 3.
[12] "Travel Forecasts for the San Francisco Bay Area 2009 Regional Transportation Plan Vision 2035 Analysis Data Summary, November 2007, http://www.mtc.ca.gov/planning/2035_plan/tech_data_summary_report.pdf
[13] SCTA Comprehensive Plan Update, May 2008, http://www.sctainfo.org/pdf/Agenda_Packets/2007/200705_scta.pdf

New Methodology for Estimating GHG Impact of Mode Share Shifts

To date, the impact on GHG emissions of mode share shifts has not been well defined. This report presents a new methodology for estimating both the marginal and total effects of projected mode share shifts on VMT and therefore on GHG production. A method for estimating the GHG reduction impact of a decrease in average trip length is also given.

A model of the sources of GHG emissions in the transportation sector, detailed in Appendix 2, was created to estimate the effects of mode share shifts and generate data for this report. In brief, the model uses data from the year 2000 MTC Transportation Forecast to estimate total vehicle miles traveled in Sonoma County. It uses data on numbers of trips, broken down by trip type and mode share, along with average trip distance. The effects on VMT of shifting mode share from single occupant vehicle to walking, bicycling and transit can be estimated. Total VMT is converted to fuel consumption, based on vehicle inventory and average fuel efficiency for each vehicle category.

Findings

Impact of Mode Share Shifts

One way to illustrate the relationship between GHG reductions and various mode share shifts is as a ratio of percent emissions reduction to percent change in mode. How much emissions reduction will result from 1 percent mode shift?

Results can be summarized as follows:

- 1 percent reduction in average trip length: 1 percent GHG reduction
- 1 percent shift of trips to non-emitting vehicles: 1 percent GHG reduction
- 1 percent shift from car driver to transit: 0.46 percent GHG reduction
- 1 percent shift from car driver to non-motorized transport: 0.38 percent GHG reduction

As travel modes shift from cars toward more fuel efficient alternatives, passenger trips (counted separately each time a unique mode is used) may become somewhat more numerous overall because the average journey will utilize more non-car modes. However, total vehicle miles will decrease markedly and GHG emissions will decrease concurrently.

Opportunities by Travel Mode

The following section describes, in general terms, policies and programs addressing specific travel modes. All estimates given below as "achievable" based on a private global survey.[13] The "likely" estimates were based on U.S. data as applied to Sonoma County.[14] For each mode, the anticipated GHG reduction compared to business as usual is calculated.

Walking

	Mode share shift from SOV	*GHG reduction from BAU*
Achievable	*8.9%*	*4.3%*
Likely	*3.5%*	*1.7%*

Over time, transportation planning priorities have increasingly favored car travel to the disadvantage of pedestrians. Sidewalks have often neglected been over the years, chopped up as roadways are widened to accommodate ever more auto travel, and laden with power poles and pedestrian obstacles. Varying sidewalk standards have resulted in widespread elimination of tree lanes and consequent lack of shade for pedestrians. In both urban and rural areas, pedestrians frequently must walk adjacent to high speed car traffic. As roads have been widened, especially at intersections, pedestrian accident exposure at crossings has increased, while crossing times allotted to pedestrians have diminished.

The road-building programs that often caused the degradation of the pedestrian environment had strong funding mechanisms. Nothing equivalent exists for pedestrians in built out urban environments. Repairing this bleak pedestrian environment will be costly, so well-funded programs must be established. This might be done under the “routine accommodation” concept now being considered as part of road funding.

Bicycling

	Mode share shift from SOV	*GHG reduction from BAU*
Achievable	*7.1 %*	*3.4%*
Likely	*5.0%*	*2.4%*

Bicycling, the most energy efficient travel mode, holds great potential for the United States judging by its use in other developed nations. Even greater potential exists for Sonoma County given its mild climate, beautiful landscape, and relatively flat terrain.

Cycling is limited by some of the same obstacles that hinder walking, particularly conflicts with fast-moving motor vehicles and unsafe and unpleasant accommodations in the street network. Advances are being made as funding is being expanded, and it is happening faster with bicycles than with pedestrian facilities. The greatest shortcoming today may be a lack of recognition of the need for a travel network that is denser than the motor vehicle network. Cyclists are often expected to be content with a sparse network -- a few key safe-routes through the dangerous motorized maze.

To greatly expand bicycle travel we need to greatly expand the network of routes and their safety. This will encourage new riders and accommodate more experienced cyclists over the entire network now available to motor vehicles. In addition to path construction, attention must be given to the connections between routes, to bicycle preference on narrow streets, and to consistent shoulder widths along rural roads. There must be complete and widespread distribution of secure bike parking, and accommodation when possible for bicycles on buses and trains. More discussion of the needs for improving the infrastructure for bicycles is offered in Appendix 3.

Transit

	Mode share shift from SOV	*GHG reduction from BAU*
Achievable	*5.0 %*	*3.3%*
Likely	*4.0%*	*2.6%*

In the shift away from car dependence, transit can be viewed as an adjunct of walking and bicycling, accommodating the longer trips that people make less frequently, so that they won't be compelled to own cars simply to be able to make their longer trips.

There is room on the buses for a lot more passengers, but service has to be intensified to attract them. Fortunately, an increasing return to scale can be expected; doubling the frequency will bring more than twice the riders. Extending the service will also be necessary, although there is little or no scale economy in that direction.

As a nationwide average, the percentage of seats filled on buses is about the same as for cars, primarily because there is a lot of wasted bus service. Most of the waste is in providing service where the demand is insufficient to fill many seats.

The easy answer for why there is insufficient demand is because there is insufficient density. While true, this oversimplifies the situation. Other factors to consider are:

- Route patterns: From the perspective of the traveler they need to be reasonably direct.
- Trip path concentration: Concentration of trip desires along a single path is advantageous for transit and disadvantageous for single occupancy vehicles.
- Price: Price, both actual and perceived, relative to other modes of travel impact travelers' decisions.
- Travel time: Travelers' decisions are also based on the amount of time required from trip origin to destination including wait times.

One factor that many people would put on this list is bus size. It is not included here because it bears little relation to rider attraction. For riders, the best size is a bus with some empty seats. The desire of the non-riders is usually inspired by how few of the seats are utilized, and the wish to have the buses smaller. All else being equal, smaller would be better, but size is limited at the low end by the economics of bus system operation. The key question is how often the passenger load exceeds the number of seats. If there is an answer, it depends on the following factors:

- Route Structure: Can it be changed to reduce the passenger load variance and thereby reduce overloading?
- Fares: Can they be restructured to be in better proportion to distance traveled? Can higher fares be charged for smaller buses?
- Service frequency: Can it be increased judiciously to cope with overloads?
- System operations: Can different size buses be utilized without losing operation and maintenance economies of scale? In an efficient operation buses may shift among lines throughout the day. The more that buses differ within a fleet, the less flexibility they have for line service.

Reorganization of bus services is much needed, based on service policies that will put the services where they are most likely to be used. The contemplated SMART rail passenger system will provide a useful frame element for reorganizing bus services around rail station hubs.

In addition to service expansion, far more attention must be given to the ancillary facilities that serve transit passengers: bus stops and shelters, sidewalks and cross walks near bus stops, secure bike parking, and readily available information on routes and schedules.

The role of school buses in the GHG picture is not clear. They are positive to the extent that they are replacing the need for parents to ferry their children to and from schools. But to the degree that they are providing road safety to children that could otherwise be walking or biking, a more appropriate course might be to make the roads safe for all modes. School siting and school design standards have been major factors in suburbanization, so reforms there should be a consideration in planning for school travel.

The Special Role of Rail in the Transit System

According to the SCTA, Sonoma County has over 2,300 lane miles of city streets and county roads, plus 250 miles of state roads. When the SMART rail system is approved we will also have 50 miles of rail route. The effect of those 50 miles is likely to be far greater than would be implied by its length relative to the rest of the transportation network.

Aside from the relatively modest number of long trips it will carry, SMART will:

- Establish an organizing spine for the entire transit system
- Justify more frequent bus service by providing key bus destinations that will increase bus ridership
- Spark development patterns that lead to far more walking and biking

Long trips determine the need for car ownership, especially when there is no reasonable alternative. People buy cars to make long trips, then use them for their more frequent shorter trips. Rail service with stations spaced 5 miles apart on average, and with service only in a single corridor, would be providing a means of serving those long trips that are most causal for car dependence.

Car Driver

	Mode share shift from SOV fossil fuel powered to non-emitting vehicle	*GHG reduction from BAU*
Achievable	*10.0 %*	*10.0%*
Likely	*Unknown*	*Unknown*

Two primary factors contribute to the car's popularity: Its usefulness and convenience for a great variety of trips, and the public's willingness to accept its exorbitant external costs. In a GHG reduction program, the policy objective for cars should be to eliminate their use wherever feasible while allowing for continued use when essential.

People's commitment to automobiles is largely caused by the way personal costs are structured, i.e., large initial vehicle purchase price, followed immediately by rapid depreciation, but with continuing low costs at time of use. Once the initial buy-in has occurred, there is little to be saved by daily or weekly decisions to use alternate modes of travel, so car usage is essentially locked in. Car commitment can be reduced by restructuring the costs so they are mostly avoidable on a short term basis.

The most comprehensive way of restructuring personal driving costs is through short term auto rental, known as car sharing. Car sharing firms have been formed in a number of western countries, and now operate in many of the larger U.S. cities. To gain a large enough local scale of operation they require fairly high density of users, but over time ways may be found to provide the service in lower density situations. (See section on Public Financing for Personal Transportation below.)

If car-sharing organizations offer a range of vehicle options, such as light trucks for example, people will be less likely to buy specialized large vehicles to meet needs that rarely arise.

Unlike fuel costs, auto insurance costs are borne by the car owner regardless of how much the car is used. Using "Pay-As-You-Drive" (PAYD) insurance to decrease the amount of driving is an idea that has been discussed for perhaps twenty years. Insurance companies oppose the concept because PAYD threatens their business. If drivers have the option of reducing their insurance costs by leaving their car parked, they will do so as often as they can.

This situation creates an opportunity for individual companies offering PAYD insurance. They can gain market share by offering a desirable product to low risk drivers. Progressive, a large auto insurance company has been patenting system technology, presumably so it moves fast and first when the market is ready for PAYD insurance.

Other means of encouraging car drivers to seek alternate ways to travel involve eliminating driver subsidies wherever possible. (See Wide Spectrum Solutions below.)

Measures for encouraging drivers to seek alternatives are most applicable in urban areas because that is where car driving is least necessary, and alternatives most competitive. Nevertheless, because one third of Sonoma County's residents live outside municipal boundaries and have high travel distances, it is important to reduce the car miles generated here, too. The establishment of rural service networks may eliminate some of the errands that people do in their cars. (Please see Private Sector Opportunities below.)

Car Passenger

	Mode share shift from SOV	*GHG reduction from BAU*
Achievable	*7.0 %*	*.9%*
Likely	*4.0%*	*.5%*

Actions taken to promote carpooling have had a mixed record. It is as if the level of riding in the passenger seats goes up or down depending on unrelated factors, e.g. state of the local economy, gas prices, density, etc. Although the emphasis in transportation planning in Sonoma County and elsewhere has been to "encourage" car and vanpooling, the level of uptake has never met expectations. There are excellent programs such as 511.org, which have made an impact, however. Unfortunately, tax advantaged programs such as "Commuter Choice[14]" to encourage car and vanpooling are not implemented by most employers. Incentives for car and van pooling typically take the form of regional, state or federal efforts, because there is little that the local governments can typically do to increase use of these modes. We address the potential for expanding federal income tax incentives for car and van pooling in Appendix 4.

Other Non-Car Motorized Modes

	Mode share shift from SOV	*GHG reduction from BAU*
Achievable	*Less than 10 %*	*Probably small*
Likely	*Unknown*	*Probably small*

Spurred by fuel prices, there appears to be a modest trend toward motorcycles and motor scooters. If Italy represents the potential for these vehicles, there could be a huge shift away from cars as we encounter fuel prices of the magnitude long endured by Italians. The trend could be accelerated by parking conversions to accommodate these efficient modes, beginning by designating the most favorable parking spaces for them.

[14]Pre-tax payroll deduction program. Funds can be used to pay for transit, vanpool or parking cash out. See www.commuterchoice.com for more information.

Travel Mode and GHG Impact Summary

	Mode share shift from SOV	***GHG reduction from BAU***
Walking		
Achievable	*8.9 %*	*4.3 %*
Likely	*3.5 %*	*1.7 %*
Bicycling		
Achievable	*7.1 %*	*%*
Likely	*5.0 %*	*2.4 %*
Transit (including Rail)		
Achievable	*5.0 %*	*3.3 %*
Likely	*4.0 %*	*2.6 %*
Car Driver		
Achievable	*10.0 %*	*10.0 %*
Likely	*Unknown*	*Unknown*
Car Passenger		
Achievable	*7.0 %*	*.9 %*
Likely	*4.0 %*	*.5 %*
Other Non-Car Motorized Modes		
Achievable	*Less than 10.0 %*	*Probably small*
Likely	*Unknown*	*Probably small*
Total		
Achievable	*40%*	*11.5%*
Likely	*25%*	*7.6%*

Likely total GHG reductions from mode share shifts fall in the range of 7.6 to 11.5 percent below business as usual. Given that our reduction target is 37 percent below business as usual, wide spectrum solutions must make up the difference.

Wide Spectrum Solutions

Certain policy changes will simultaneously shift all modes in the direction of GHG reduction. For example, establishing equal access policies for transit stations, shopping centers and other major centers of activity can encourage the use of transit, bicycles and walking. To the extent that such centers subsidize access (e.g., free parking in shopping malls) an equal access policy assures that investment is equal for each mode of access, on a per person basis.

Land Use and Development

GHG reduction impact: 1 percent reduction in GHG for each 1 percent reduction in average trip length or number of trips. Average trip (segment) length is currently estimated at 4.9 miles. If this were reduced to 3.9 miles (22 percent), the corresponding GHG reduction would be 22 percent.

Reliance on the car created today's land-use pattern that now relegates Sonoma County to high fossil-fuel dependency. To reverse this, we must explicitly return to land use patterns in place before the car overran us. Otherwise, any near term energy reductions will be wiped out in the long term.

The current effort to increase density in Sonoma County relies primarily on making buildings taller while maintaining a high level of car access. This course will not increase the energy efficiency of our transportation system. In favoring city centered development in Sonoma County, high density development must be tightly coupled with transit access.

More than just density, economic development and activity that relies on long distance car access must be reconsidered. Large regional retail centers accessible only by car undercut the neighborhood vendor and are incompatible with high density development where people are encouraged to live, work, walk, bike, and take public transit.

High Density Development

The loss of density in the urban centers over the years has been attributed by some to the convenience of the automobile, a misconception based on its speed and ease in getting between any two points. The dominant cause was actually the way that space consumption — the auto's great weakness — was kept out of sight and out of mind.

There is a little noted urban/rural asymmetry, which causes the high space cost of automobiles (for both roads and parking) to be borne disproportionately by the urban economy. Urban areas competed with each other economically by offering free parking, to attract increasingly suburban motorists.

The subsidy of free parking was achieved not through direct local government payments, but by using government power of regulation to require development to provide the parking at much higher levels than would have been provided by a free market. The remedy is to adopt free market policies, eliminating requirements for off-street parking and applying free market prices to curb parking. The key to gaining neighborhood acceptance of paid parking is to return most parking revenues to the neighborhoods where the revenues are generated.

Policies and rules should be revised first in the highest density development nodes near the train stations, where the transit service will be most competitive and auto ownership is less necessary.

Low Density Development

Low-density development is inherently weak in transportation options. Cars will continue to be the predominate mode of transportation, but there can be ways of using them more efficiently and introducing other options. Low-density communities can set up rural service districts that would:

- Own and manage car-sharing organizations
- Manage ride-sharing and provide goods delivery depots
- Operate fuel distribution facilities
- Pay for trunk line bus service to connect with major urban centers and rail stations.

Some of these solutions are addressed in more detail in the section on Personal Transportation Options.

Demand Management
Parking management and pricing, speed reduction and local gasoline taxes fall under the category of “demand management”. These are policies that are directed at reducing the demand for trips by raising the cost or lessening the convenience of travel for basic short trips.

GHG reduction impact: 1.05 percent reduction in GHG for each 1 percent reduction in average number of trips.

Pricing for Parking
Few cities have parking rules and policies appropriate for an era of energy reduction. There has been a longstanding powerful urge to make parking free or cheap to the driver, regardless of the actual cost of providing it. This must change if people are to choose transit whenever feasible, because subsidized parking is the strongest incentive they have to drive.

Like land-use changes in general, parking in particular is very much the purview of local government. Municipal governments need to look carefully at what they've been doing, and make some big changes. Don Shoup proposed a change in the normal municipal practices that may seem radical in today's context:

- Stop requiring off-street parking,
- Charge market rate for on-street parking, and
- Return parking revenues to districts where collected.[15]

These are closely coupled rules, which if carried out, would reduce the urban space wasted on excessive parking, reduce the number of car trips, assure that there is always enough parking available where it is most wanted, and produce revenue for neighborhood public purposes. Those purposes could include better facilities for walkers and bicyclists, and better transit services – all achievable when people have fewer financial rewards for driving.

New city parking policies should be guided by these principles:

- The determination of how much parking there should be must always be based on price. It should be a market determined price, which will mean that prices will vary according to location and time.

[15] Donald Shoup. *The High Cost of Free Parking*.

- The cost of parking should be borne by drivers, not the developers or property owners, or by people who aren't driving.
- Parking arrangements should be simple and easy for drivers. As long as drivers are willing to pay the market price, they should not be hassled by inconvenience.
- Physical arrangements of parking should induce efficient use, i.e., high average occupancy of the spaces. This will be achieved only if parking spaces are readily shared. For example, parking for residents should be available to non-residents when residents are not using them. Time-sharing is often inhibited by security concerns, so those need to be addressed.
- Parking costs should not be bundled with the costs for the primary uses of property, whatever the zoning.

Speed Reduction

A general reduction of permitted road speeds will have many direct and indirect GHG reducing benefits:

- Propulsion energy is reduced by lower speeds.
- Safety of all road users is increased as top speeds are brought down.
- If people are using heavy vehicles to increase their own safety while bringing greater risk to others, safety improvements related to speed reduction may be an inducement to choose smaller vehicles.

New Tax Policies

A local gas tax would be more appropriate than sales taxes to finance all kinds of transportation related expenditures because it increases the incentive to use modes with lower fuel requirements.

Although the driver pays the tax, the incidence of the tax is partly shifted back to the producer. If the oil is coming from a foreign country, that country helps pay the tax. In other words, when the tax is levied on top of the price charged, the underlying price goes down somewhat, depending on consumer price elasticity. This principle was long recognized in countries without internal sources of oil. Unfortunately the U.S. never made the adjustment when it became a net importing country.

Localities with higher gas taxes are better insulated against fuel price volatility.

Prices and Costs of Travel Modes

Total motor vehicle costs for the United States are shown in Table 3.

Table 3[16]

Motor Vehicle Annualized Cost Summary (2000 U.S. dollars)

Costs	Distribution	Totals (millions)	Per Capita	Per Vehicle	Per Veh-mile	
Travel Time	Int.-Var.	$840,000	$3,000	$3,818	$0.34	28%
Vehicle Ownership	Internal-Fixed	$600,000	$2,143	$2,727	$0.24	20%
Crash Damages	66% Int.-Var.	$500,000	$1,786	$2,273	$0.20	17%
Non-residential Off-street	90% External	$300,000	$1,071	$1,364	$0.12	10%
Vehicle Operation	Int.-Var.	$250,000	$893	$1,136	$0.10	8%
Roadway Costs	66% Int.-Var.	$120,000	$429	$545	$0.05	4%
Traffic Congestion	External	$100,000	$357	$455	$0.04	3%
Environmental Costs	External	$100,000	$357	$455	$0.04	3%
Roadway Land Value	External	$65,000	$232	$295	$0.03	2%
Residential Parking	Internal-Fixed	$50,000	$179	$227	$0.02	2%
Fuel Externalities	External	$40,000	$143	$182	$0.02	1%
Traffic Services	External	$30,000	$107	$136	$0.01	1%
Land Use Impacts	External	?	?	?	?	
Equity Impacts	External	?	?	?	?	
Totals		**$2,995,000**	**$10,697**	**$13,613**	**$1.20**	**100%**

This table summarizes estimates of various motor vehicle costs.

For Sonoma County, there were approximately 275,000 automobiles, 100,000 trucks and 8,500 motorcycles registered in 2005. According to the table above, the total cost of travel is over $5 billion dollars annually for these vehicles. That cost is over $11,000 per capita, for all internal (80% paid by the user) and external (20% paid by society) costs.

If a traveler had to pay the full cost of travel on each mode, and pay the price at

[16] From Victoria Transport Policy Institute, TDM Encyclopedia.

the time of travel, the transportation system would be far less car dependent, and the suburbs as we know them today would not exist.

Car ownership as well as payments for insurance and license on an annual basis, and maintenance that is paid for only occasionally, all tend to lower the "out-of-pocket" costs of travel, and thereby create loyalty to car use.

Anything done to bring price more into line with cost will likely evoke negative reactions. Those who pay more will protest that they are being "penalized" and those who pay less may not see the potential advantages. Therefore, measures intended to bring transport efficiency should always be coupled with benefits of convenience and other amenities.

Private Sector Opportunities

With a little bit of help from public sector financing sources to provide seed capital, along with the increasing cost of travel by private automobile, some significant opportunities for new businesses are likely to emerge. These opportunities leverage broad-based access to the Internet, along with the increasing integration between television and online services.

Expansion of Delivery Services

Delivery services coupled with online shopping are proven means of enabling people to acquire what they need without travel. However, the attraction of "going to the store to shop" is deeply rooted in the culture of today. The only possible way to promote the alternatives is to simultaneously make car travel to the store more expensive and inconvenient, while making the online option easier and more attractive to use, ubiquitous and inexpensive.

One possible expression of improvement of the online option might be to provide an online shopping experience using video game or "virtual world" technology. Another name for this technology might be "first person shopper." This option would be included as part of cable television services. The first person shopper virtual shopping experience would duplicate the experience of being present in the store, and would give the user the opportunity to "pick up" and examine items, to walk the aisles, talk to sales people, etc. This virtual shopping experience could be linked with local merchants, such that an order placed by a virtual shopper could be delivered from local stores or shipping depots.

Telecommuting

Management of telecommuting workers involves adapting management style to engaging with workers that are not physically present. Rather than being a technological challenge, this is more of a management challenge for managers that are accustomed to working with an onsite workforce. Although a description of management techniques for a "tele-work" force is beyond the scope of this paper, there are associations that have developed training for managers of teleworkers.[17] Further efforts to encourage and incentivize employers and

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[17] For example, see *Home Workplace: A Handbook for Employees and Managers*, by Brendan Read.

employees to develop a teleworkforce might be packaged into a tax-advantaged program similar to the “Car(e)-Free” program described in the Appendix.

Personal Transportation Options

The automobile will continue to account for a significant share of vehicle miles traveled for the foreseeable future. Public transportation improvements are critical for reducing the carbon emissions due to transportation. However, increases in use of the public transportation system, walking and biking options will not account for sufficient reduction of emissions.[18] The best case reduction is less than 15 percent below projected GHG emissions for 2015 for the transportation sector.[19] Since this leaves over 20 percent reduction still required to meet our target, walking, bicycling and transit options need to be augmented significantly with other personal transportation options that are low or non-emitting.

Although some auto use is inevitable, eliminating the market imperfections that underlie its overuse can lessen it. The following solutions mentioned earlier in this document will impact personal choice:

- Create provision of car sharing to obviate the need to own or lease when the need for a car is occasional or sporadic
- Unbundle: Charge separate rents for parking from the rents of both residential and commercial developments
- Shift auto insurance to pay-as-you-drive
- Raise the gas tax in the county

As shown in Figure 4 (see page 5), there are two paths to reducing the GHG emissions of automobile transportation. One path is to use vehicles more efficiently. That is, to increase the number of passengers in the vehicle so that there are more passenger miles per mile of vehicle movement. The other path is to use vehicles that are more carbon efficient. That is, there are more miles of vehicle movement per pound of equivalent carbon dioxide created by that movement.

[18] Relative to the target of 25 percent below 1990 levels.
[19] Based on potential mode share shift estimates from the Sonoma County Transportation Agency.

Table 4

% Change in CC Emissions*		***Technology or Fuel***
- 100		Electric car (renewable source)
- 77		B100 (100% biodiesel)
- 20 to -50		Hybrid car (gasoline)
-32		Electric car (US grid)
-28		B20 (20% biodiesel + 80% diesel)
- 22		E85 (85% ethanol from corn, 15% gas)
- 15		Propane (LPG)
- 13		CNG (compressed natural gas)
ICE	*FCV*	-- *Vehilces using hydrogen* gas
-7	-53	Hydrogen (H_2) from CNG
+138	+21	H_2 from today's US electric grid
-100	-100	H_2 from renewable electricity

*negative CC numbers are good, positive are bad

Ultimately, there must be zero equivalent carbon dioxide emissions created by mobility in any form, either of passengers or cargo. As shown in Table 4, the only zero emissions option currently known is to power the vehicle with renewably generated electricity, or with hydrogen created by renewably generated electricity.

Alternative fuel vehicles may have a very low carbon impact or not, depending on how the alternative fuel is made. Similarly, hydrogen vehicles using fuel cells may have no positive impact on carbon emissions.

The social and economic investment in our present transportation system limits the speed it can be converted into more efficient alternatives, e.g., SkyTran.[20] However, there are many ways of improving the present system and many ways of using the present vehicles in a more effective manner. Future additions to the system can be purchased with the best fuel efficiency and the capability of running on renewable energy.

Improving Vehicle Use

We can gain improvements in three ways.

1. **Use our present vehicles in a more fuel-efficient manner:** Presently, vehicles across all modes of transportation in Sonoma County and the US average 20 to 25 miles per gallon. Many well known ways to improve this exist such as:

    - Carpooling
    - Vanpooling

[20] SkyTran is an innovative, low-cost, mass transit system that uses small “pods” that are dispatched using the same methods used by computer networks for switching and routing. See http://www.unimodal.net/ for full description.

- Increasing the riders on each bus
- Using the smallest, lightest vehicle to do the job (bicycle ,scooter, motorcycle, hybrid car)
- Reducing speed (55 mph speed limit, obeying posted limits)

2. **Convert some of the present vehicles to alternative fuels and electricity:** Some vehicles can be converted to run on electricity and/or biofuels. Many trucks can be run on biofuels and/or converted to Plug-in Hybrid Electric Vehicles.[21] PHEVs run for an initial distance on primarily electricity. This power is taken from the grid and so has the carbon makeup of the grid. These designs can greatly reduce GHG, typically doubling fuel efficiency. Additionally PHEVs lead the way to EVs by creating the infrastructure of convenient plug-in stations.

3. **Purchase new infrastructure, vehicles, and systems that are extremely efficient and run on renewable energy:** Bike lanes and paths can promote perhaps the greatest individual trip savings. Cell phones, GPSs, and the Internet can create more efficient van and carpooling. Hybrids and PHEVs can be purchased. Larger projects such as mass transit can use newer technologies such as SkyTran, an electrically powered magnetic levitation system based on the Internet packet routing concept that use one-tenth the power of traditional mass transit and is much cheaper to build. Electric trolley buses can replace fuel burning buses in suburban/urban areas at a much lower cost than light rail.[22]

With the limited time to make changes to our transportation system and the dangers the current path guarantees, a rapid change needs to occur. More roads are not needed; more occupants per vehicle are. Government agencies and utility companies can lead the way, establishing markets for potentially clean zero-GHG vehicles and transit systems that can run on grid power or other renewably generated electricity.

Public Financing for Personal Transportation

In order to achieve a 20 percent total shift in VMT to low or non-emitting vehicles, between 30,000 and 40,000 of such vehicles would need to be made available on a convenient, low-cost basis.[23] Probably the most viable such basis would be the short term rental, or "car share" described above. In keeping with the overall orientation of the Community Climate Action Plan to frame solutions in terms of public works projects, two principles can be applied:

1. Use of bond financing to acquire the fleet of vehicles
2. Integrate with renewable energy infrastructure

[21] See, for example, www.evpowersystems.com and www.pluginpartners.org.
[22] See, for example, www.tbus.org.uk/home.htm.
[23] These figures are based on a projected annual VMT of 4,440 million miles in the year 2015. Average vehicle mileage for a fully utilized fleet vehicle is assumed to be approximately 24,000 miles/year.

3. Develop "portfolio" of vehicle types that are appropriate for the types of mobility required for different areas of Sonoma County. Another way of stating this is "match vehicle types to passenger trips" as formulated in the Figure 2 logic tree.

The short term rental vehicle fleet should be deployed in areas where population density is not sufficient for economical mass transportation options such as bus or train. The fleet should be used to provide access to transit centers where public transportation is available, or to local destinations that are too far or impractical to walk or use a bicycle.

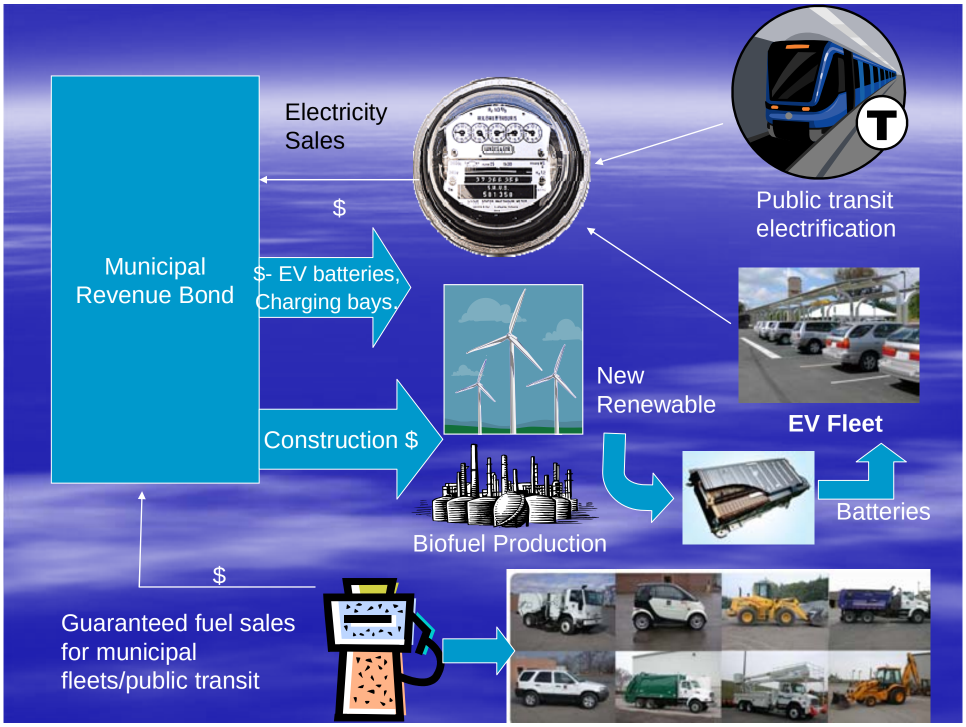
If this rental fleet is integrated with local renewable energy infrastructure, some interesting financial arrangements become possible. Use of card lock technology for access to the vehicles, along with vehicles equipped with "smart metering" would enable tight integration with Community Choice Aggregation (CCA), a description of which is in the Source Material section of the Community Climate Action Plan.[24] The CCA may issue municipal revenue bonds against guaranteed revenue streams associated with electricity sales. Thus, if electricity sold by the CCA is used by a vehicle in the rental fleet, such sales could be used to secure bond financing to purchase and or build the fleet.

Additionally, vehicles batteries and generation capacity for vehicle charging can be integrated into the renewable portfolio of the CCA. As has been proposed elsewhere[25], Vehicle-to-Grid technology can provide battery storage as required for the renewable portfolio described in the Energy Element of the CCAP. The charging bays for the vehicles, using solar PV or other generation technology, can also be put on the grid as elements of the portfolio. In the case of both the batteries and the charging bay power sources, the CCA can purchase these using municipal revenue bonds. The batteries and charging bays can then be leased to the operator of the car share fleet.

[24] Energy Solutions - A Plan to Achieve Accelerated, Scaled & Cost-Effective Greenhouse Gas Emission Reductions in the County's Energy Sector by 2015, Local Power Incorporated, March 2008

[25] "PG&E sees plug-in hybrids as potential profit centers," http://news.cnet.com/2100-11392_3-6174672.html

Figure 5



Smart Meter and Card Lock

For the CCA to issue bonds against electricity sales used for vehicles, each vehicle must be equipped with an electricity meter, just as each home is currently equipped with a meter. However, since the vehicle is mobile, and needs to be able to be charged in locations that might not be served by the CCA, the onboard electric meter needs to be "smart" enough to know when it is being charged by electricity from the CCA. This could be accomplished by specially identified charging ports or stations, or by other means.

Any customer of the CCA that wished to participate in the car share program would be issued a card that would be used to gain entry to a car share vehicle. This card lock system would enable the CCA to bill the customer for the use of the vehicle. The charge for the use of any CCA-owned car share vehicle would appear on the electric bill every month.

In this way, repayment of the revenue bonds used to finance the vehicle fleet can be made through electricity purchases made from operating the vehicles.

Car Share Rental Fleet Portfolio

The car share rental fleet would be composed of a variety of all electric and hybrid vehicles depending on the application and expected use. These vehicles would be deployed in areas of less dense population. Their primary purpose would be to give access either to public transportation or to shopping or personal service destinations where walking or bicycling is impractical. These vehicles could range in size from single passenger, limited range neighborhood electric vehicles

(NEVs), to plug-in hybrid electric vehicles (PHEVs) that carry multiple passengers and have longer range.

In addition, the fleet would include delivery trucks that could be used by local merchants as described in Expansion of Delivery Services.

Walking and Bicycles: Implementation and Costs

Most of the anticipated costs for directly encouraging walking and cycling would be incurred to remedy the errors and omissions of the past. The concept of “routine accommodation” that is now being discussed in the legislature may be the key. It means that whenever roads are built, improved or maintained, all users of the roadway will be considered and provided for, as a matter of routine. Road construction might be somewhat more expensive when all users are considered, but it's a lot less costly than coming back later to fix the omissions.

In the longer term, more comprehensive land-use planning that achieves a more finely tuned distribution of activities and services, and thereby improves convenience of bike and pedestrian access, is probably the least costly approach for these modes.

Bus and Train: Implementation and Costs

Initial cost of the train (SMART) has been fairly well established. Other train costs will be added as growth in ridership occurs. After the initial capital investment, subsequent improvements will come in small increments. Both capital and operating costs will be covered by the sales tax to go before the voters in November of 2008.

Unlike highways and cars, both trains and buses offer increasing returns to scale, as long as scaling up is accomplished by intensification. To illustrate, if a route has had buses that come every half hour, and the buses now come every 15 minutes, it is no longer the same service. It is a better service for the prior riders and is more attractive to new riders.

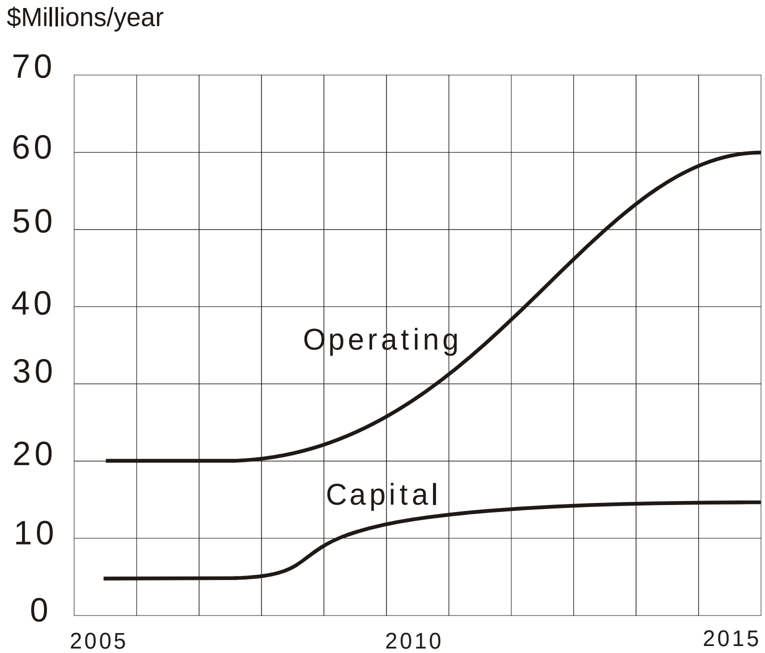
Scheduled bus services in Sonoma County are poorly financed and accordingly very thin. Only about 1 percent of the person trips are on transit. Funding of operations can have greater reliance on fares and local group payment as the system expands and transportation policies are rationalized (i.e., become more market oriented).

An increase in the transit mode share from 1 percent currently to 6 percent in 2015 will require increasing service by a factor of 3 and increasing average loadings by a factor of 2.

The existing 1 percent is accommodated by an annual countywide expenditure of $20 million in operating costs plus $5 million capital costs. The annual expenditures would be something akin to the Figure 6 below.

Although electrification is not part of the initial planning for rail in the County, the municipal bond arrangement could be used to finance it. In the same way that electricity sales for vehicle propulsion would secure bond funding for the fleet, electricity sales to the rail operation would secure funding for electrification infrastructure. The card lock system could also be applied as a “transit pass” on the train. Use of the card to access the train would be billed on the electric bill.

Figure 6:
Approximate Expenditures Required to Meet Transit Mode Share Goal by 2015



Car Share Fleet: Implementation and Costs

As described above in Car Share Rental Fleet Portfolio, the fleet would consist of a set of vehicle types designed to serve the widest variety of individual transportation needs possible. The fleet would be deployed in phases that would coincide with bond issuance. To the greatest extent possible, existing gasoline or diesel powered vehicles would be converted to plug-in hybrid. This could be done very cost effectively using conversion kits being developed today for pickup trucks. Fleet pricing for electric vehicles could bring down the average cost of the vehicle. It is estimated that a vehicle fleet numbering 30,000 EVs and PHEVs could be deployed for between $5,000 and $10,000 per vehicle. This would put the total cost at $300 million. Using 30 year municipal revenue bonds to acquire the fleet would give the lowest possible financing cost. The bond repayment would be made through the charge for electricity used to power the vehicles as described in Public Financing for Personal Transportation.

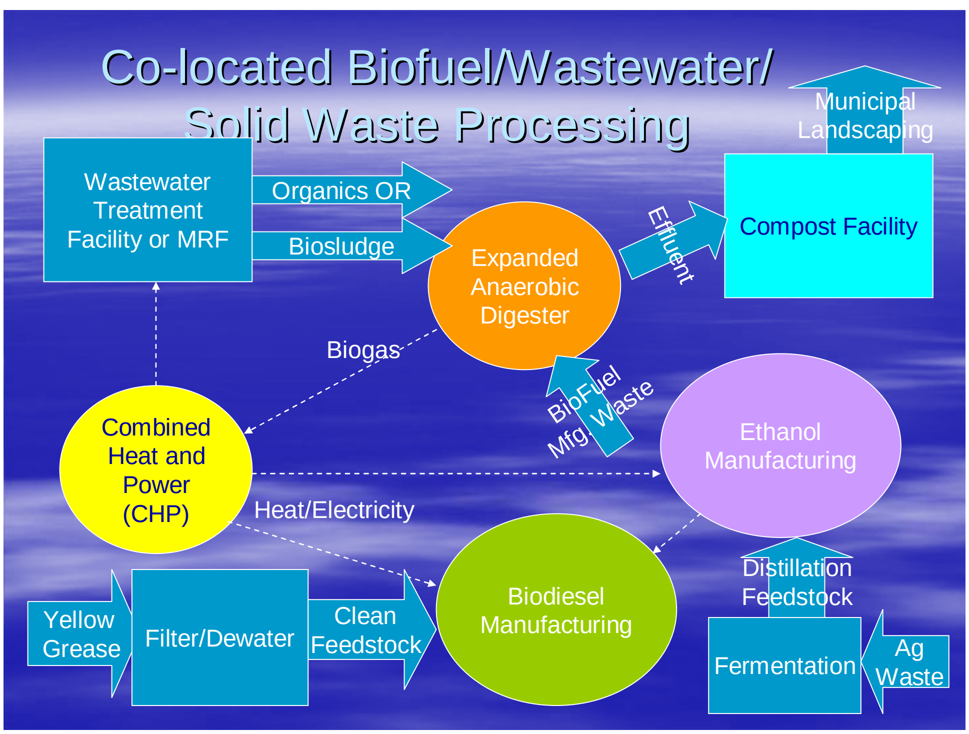
Biofuels

Recently biofuels have been under scrutiny due to controversy over whether they have a net negative impact on carbon emissions. Biofuels made from virgin feedstocks take a slice out of food production as well. However, biofuels made from wastes could make a significant contribution to overall reduction in GHG emissions due to combustion of transportation fuels. As shown in Figure 7, co-located waste processing and energy production facilities have an impact much greater than the sum of the parts. Harvesting both the organic content of the municipal solid waste (MSW) stream, along with agricultural waste and waste from food processing can provide a significant energy/compost/fuel source.

The total magnitude of this source of transportation fuel is somewhat limited however. The current estimate of the waste vegetable oil available in Sonoma County is less than 1 million gallons per year. Total fuel production from waste material, assuming cellulosic ethanol production (or similar low energy production technology) is thus probably in the 2 million gallon per year range. If this fuel was “triaged’ to be used only for public transportation and municipal service vehicle fleets, it would provide the most overall benefit. When and to the degree public transportation and municipal vehicle fleets became electrified, the fuel could potentially be sold to the public or other consumers.

Since the guaranteed biofuel sales to public vehicle fleets would secure revenue bonds, the same financing program used to build renewable energy facilities and vehicle fleets could be used to build and operate the biofuel production facilities.

Figure 7



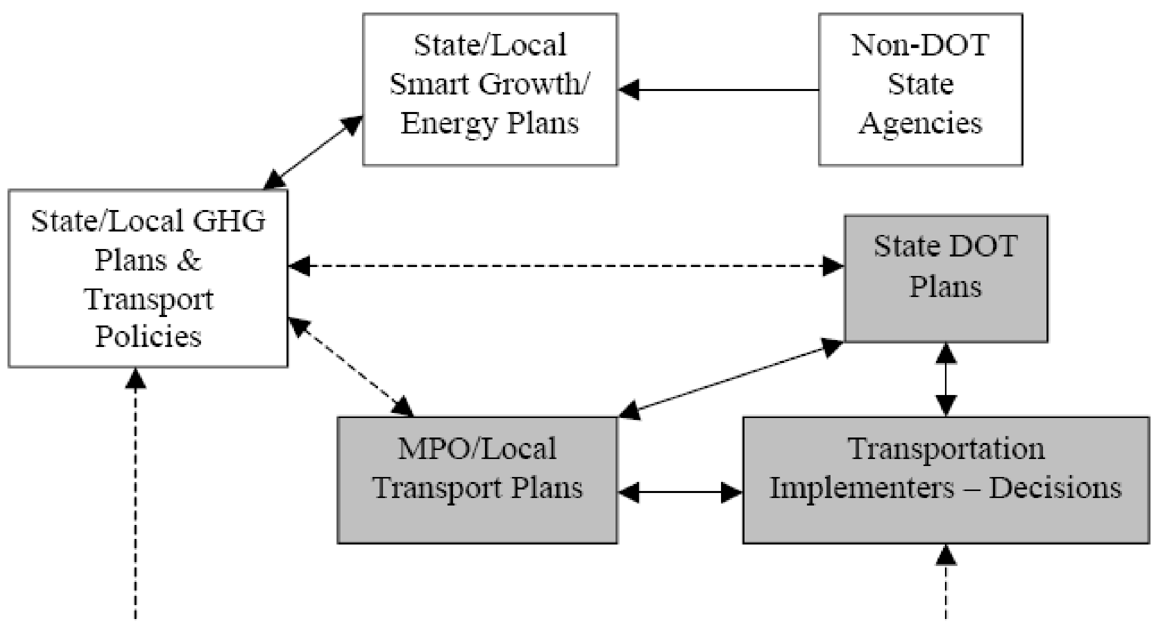
Transportation, Land Use and GHG Planning Integration

Currently, there are gaps in the planning process that make it difficult to create policies that minimize GHG. There is also a need to coordinate local planning processes with state and federal policy-making. Figure 8 below reflects the relationship among the various planning aspects.

Land use, transportation and climate protection planning at the local level should be carried out as an integrated whole. From a policy-making standpoint, the following factors are important:

- Direct linkage between quantified GHG reduction target and land use, transportation and energy planning.
- Involvement of agencies representing other sectors
- Development of a system of metrics and feedback

Figure 8



The following land use factors have a large impact on trip generation:

- Roadway design including signalization and traffic calming
- Pedestrian and bicycle accessibility
- Parking availability, including the size and locations of park-and-ride lots
- Development of energy resources that have an impact on reducing transportation emissions, such as biofuel production and renewable electricity generation. Developing these resources requires dedicated land area.

In general, certain practices increase VMT, such as:

- UGBs that are too large and/or not enforced
- Segregated zoning that increases the distance between residential and commercial areas, or enforces the development of single use areas such as business parks that are remote from housing.

In addition, there are land use policies that may have a direct bearing on local energy production. Although not directly related to transportation, there may be a potential to significantly reduce GHG emissions through co-location of housing and commercial buildings to locally available energy resources such as geothermal, hydro and wind.

Transportation Information Needs

Because the current transportation system is, by orders of magnitude, very climate-unfriendly, approximate data is adequate for analyses that can point us in the right direction. But soon a parallel effort to improve transportation data is needed to ensure the availability of necessary information to make fine scale adjustments and stay on course. We must be able to quickly evaluate the impact of our efforts and expenditures to intervene in a system that currently is taking us in the wrong direction.

The central variables that must be monitored -- and monitored on a highly disaggregate basis -- are VMT and PMT (passenger miles traveled). To a degree this is already being done with transit, but there needs to be a concerted effort to have better data on car usage. Also, we need far better data for walking and bicycling as a measurement of success in shifting modes.

Addressing this topic, the Climate Protection Campaign issued a report, “Greenhouse Gas Emission Measurement in the Transportation Sector: Status, Problems and Possible Solutions.”[26]

Summary and Conclusion

There is no question that significantly reducing GHG emissions from transportation is highly problematic. No one solution is going to produce significant change of behavior or cause widespread use of a particular technology. The effort to reduce GHG emissions from transportation is going to require action at state and federal levels to augment local efforts. However, the overlap between land use and transportation needs is almost entirely under local control. In addition, the public transportation infrastructure, including roads, the walking and bicycling environment and transit, are largely administered by local governments. Policies that have high impact on automobile use such as parking pricing, congestion pricing and gasoline taxes are enacted by local government.

[26] “Greenhouse Gas Emission Measurement in the Transportation Sector: Status, Problems and Possible Solutions,” Jehan Sparks, August 2007, http://www.climateprotectioncampaign.org/reports/jehanrep07.pdf

There is a high degree of certainty that the most cost effective means to reduce VMT and GHG emissions due to transportation is reducing the number and average distance of trips through:

- Increased density through infill development
- Repair and revitalization of walking and bicycling environments through routine accommodation and equal access
- Full funding of transit improvements (including rail) in the most dense areas

Land use planning incorporating GHG emissions reduction assessments is critical for controlling the growth of emissions due to new development.

In conjunction with these measures, demand management strategies can both reduce the frequency of trips, and generate funding for transit and walking and bicycling infrastructure improvements. Parking pricing is one of the most notable methods for reducing the frequency of trips.

Beyond public sector policies and programs, a variety of private sector services and public-private partnerships can be defined and funded using seed capital from public and private sources. These services can provide for the mobility needs of the community, cost effectively, thereby reducing the need for automobile ownership. Ultimately, in order to reduce emissions from transportation to the level required to stabilize atmospheric carbon dioxide at a safe level, the fossil fuel powered automobile will have to be abandoned. This plan is the beginning of that process.

Appendix 1: Required and Achieved Mode Share Shifts

Figure 9

Mode	Walk		Bicycle		Transit		Car Driver		Car Passenger		Other Motorized		All	
	Current	2015	Current	2015	Current	2015	Current	2015	Current	2015	Current	2015	Current	2015 (1)
Share (%)	3.1	12.0	1.9	9.0	1.0	6.0	74.0	37.0	15.0	23.0	2.0	10.0	97.0	97.0
Av Dist. (Mi)	0.4	0.4	2.0	2.0	5.8	4.0	5.0	4.0	7.0	7.0	3.0	3.0	4.9	3.9
ACS 05	4.0				2.0		75.0		11.0	**US Census American Community Survey 2005 Data**				
SF2000	19.7		1.0		17.2		62.2			**San Francisco Mode Share #s**				
SF2025	18.7		1.0		19.6		60.8							
MTC2000	9.2		1.5		5.6		71.0		13.0	**MTC 9 County Bay Area Mode Share #s**				
MTC2030	9.2		1.4		6.6		68.1		13.9					
BOULDER03	18.6		14.0		4.6		39.0		23.5	**Boulder, CO Mode Share #s**				
PORTLAND05	6.6		1.1		4.0		58.3		30.0	**Portland Ore, Metro Mode Share #s**				
PORTLAND2035	7.5		1.2		5.5		53.2		32.6					
CP LOW 2015	**6.6**		**6.9**		**5.0**		**57.5**		**19.0**		**5.0**			
	2005 Portland Mode Share %		5% easy shift to bike		4% easy shift to transit				4% easy shift to car/vanpool		telecommute/other			

Mode Specific Improvement Measures	sidewalks tree lanes, shade street crossing priority intensified network	path construction better connections priority on narrow streets consistent shoulder widths	construct, operate rail passenger service expand bus services fixed facilities for transit passengers	car-sharing services light truck rental rural service network congestion pricing	facilitate car-pooling ride auctions??	parking conversions to provide favorable spaces
General Policy Measures	Land use changes favoring shorter trips New tax policies, e.g. local gas tax, with revenues applied to favor GHG reductions when shifting mode shares General reduction of road speeds to promote energy reduction and safety of all road users Expansion of delivery services Telecommute programs to reduce numbers of trips Manage parking with pricing					

NOTES

Transit includes bus and train.
Car includes light trucks, vans.
Other Motorized includes scooters, motorcycles
(1) Mode shares add to 97% because school bus trips aren't accounted for. They may carry about 3% of trips.

Appendix 2: Transportation GHG Model

The Transportation GHG Model is a method for estimating the GHG reduction from an intervention in the Business as Usual (BAU) scenario. The GHG Model consists of three sections:

1. Intervention Category and Total Mode Shift
2. Trip Distribution and Total VMT Calculation
3. Vehicle Inventory and Total GHG Calculation

Model Overview

The Transportation GHG Model produces an estimate of GHG emissions based on Vehicle Miles Traveled. By modeling the effect of transportation system changes on the mode share distribution or other travel metrics, estimates can be made of the effectiveness of these measures in reducing GHG emissions.

Interventions can change either (1) mode share distribution; (2) average trip length; (3) total number of trips; (4) fossil fuel efficiency of vehicle fleet.

Mode share distribution, average trip length and total number of trips are used in the model to calculate total annual VMT. This total is distributed to vehicle categories based on an “On Road Stock Turnover” model. The “total miles traveled in each vehicle” category is then converted to a fuel consumption figure, based on the average fuel efficiency of vehicles in that category. Finally, total gasoline and diesel fuel consumption is calculated using standard emission factors for each fuel type.

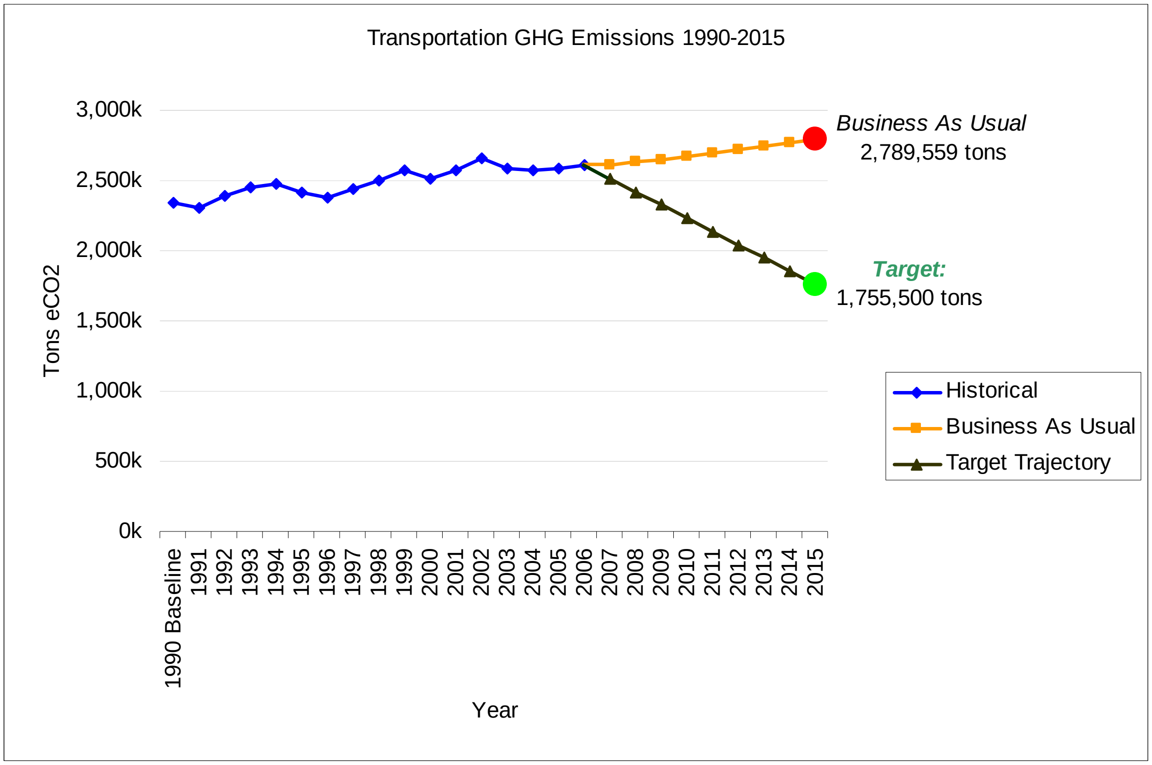
For a .more detailed description of the Transportation GHG Model, please see the section, “The Carbon Model” in the source materials.

Appendix 3: Safe Bicycling Needed to Increase Mode Share

A Really Big Problem

None of us have yet experienced personally the likely effects of climate change, so few of us can imagine that we will soon be desperate to cut back the emissions generated by our fossil fuel guzzling transportation system. The graph below shows what is already planned for Sonoma County, in terms of goals for GHG reduction.

Figure 10



The goal is based on what will be needed if Sonoma County is to meet its obligations as a member of the global community – a 25 percent reduction from the base year of 1990. This graph shows that we expect transportation to make a GHG reduction of approximately 30 percent in 9 years, in the face of having gotten worse nearly every year since the 1990 baseline.

What Can We Do?

First of all, we can try to stop thinking that traffic congestion is the problem, and stop providing the additional road capacity that isn't at all relevant for the "new" problem. The problem isn't really new of course. It's been growing for years, but we've only noticed it recently, just as it is starting to look like a monster.

Since the transportation system is mostly automobiles, automobile driving will have to be curtailed the most. Some of the people now driving cars will have to ride in cars as passengers. Some will be using far more efficient motorized vehicles, such as scooters. Others will be in buses and trains, or biking, or even walking

The more that people make their trips in these other ways, the less road capacity will be needed. Any of the major alternatives – transit, bikes or walking – can move 6 times the volume of passengers through a 10 foot wide space than can automobiles, under typical congested urban conditions and vehicle loadings.

If the conversion has to be done rather quickly – and we think that will be the case – then bicycles could be one of the quickest and most important ways of reducing CO2 generation, for these reasons:

- Most people already have bicycles – they just aren't using them.
- Virtually all the pavement needed is already in place.
- Many of the trips currently taken by car are short enough to be taken by bicycle.
- Bicycling has pizzazz, and many people are ready to switch if their safety is assured.
- There is safety in numbers – injuries per bike rider will fall as more bicycles are seen on the road.

What about Safety?
In Sonoma County there is lots of hoopla and happy talk about cycling, but there isn't much riding. Fewer than 2 percent of the trips in Sonoma County are taken by bicycle, as far as we know. If it's 2 percent on average, then there are lots of streets and areas where bicyclists are rarely seen. To be there on a bike is dangerous, because car drivers see what they expect to see, and they tend not to see cyclists unless there are a lot of them around. Many, if not most, drivers drive too fast for the conditions of the road. They drive unprepared for the unexpected.

Well trained and experienced cyclists understand the shortcomings of the road/auto system, and have usually developed coping mechanisms. But how can inexperienced riders become experienced when they are too scared to start? Cycling advocacy is largely carried on by experienced cyclists. Knowing that the primary reason bicycle use stays at a low level is the fear of being hit from behind by cars, the advocates have focused on separate lanes, and sometimes on separated pathways, even though their own riding encompasses a far wider range of bicycle accommodations.

Considering the dismal state that the bike-riding environment only a few years ago, and the lack of resources for improvement, much has been accomplished in the last decade. But if bicycling in Sonoma County is to rise at least six fold in the next nine years, which will be required, some new approaches must be added to what is already being done.

Crosscurrents
When cycling advocates encountered opposition from the vast majority of society, they had to limit their objectives. That has meant settling for a safe path across town, rather than safe use of the entire road system available to the automobilist majority. That has meant traffic segregation on some of the major cross-town roads or the wider roads through the countryside. In the process, advocates came to equate bicycle lanes with bicycle safety, because it makes sense on major thoroughfares with fast traffic. But of

late, conflicts have arisen as the segregation concept has been extended to narrower roads.

One source of conflict is a recent trend toward narrower streets advanced as a traffic calming measure, a way to foster pedestrian safety. Unfortunately, narrower streets usually don't have room for both bike lanes and parking lanes, and thus arises the conflict between car parking and bike travel.

Most of the narrow streets are still in the old street networks, where the conflict is even greater because more cyclists are there, and because the need for street parking is more acute. The cyclists argue that a continuous lane for cycling is more important than a continuous lane of parking on the street, and ask that this conflict be resolved by moving the parking off-street. But that proposition runs counter to another, newly evolving conflict: that the proper management of parking is to charge market rate prices at the curb and not to require off-street parking. Another line of thought is that a line of parked cars along the curb acts as a shield to reduce anxiety of pedestrians walking along the street.

Broadening Program for Bike Safety

Assuming that a higher safety level is required to get more travel onto bicycles, can it be improved more rapidly than bike lanes can be acquired? Bike lanes that segregate bicyclists from fast-moving cars are a legitimate need. But what about those fast moving cars?

Speed and Safety

The chance that a cyclist or pedestrian will survive a collision with a car is shown by this table from the NHTSA:

Table 5

(Fatality + serious injury) rates by posted speed limits, by pedestrian age.
(Florida, 1993-1996; pedestrians in single-vehicle crashes)

Pedestrian Age	Speed Limit							Row Total
	<=20 mph (N=1,244)	25 mph (N=1,626)	30 mph (N=4,905)	35 mph (N=3,409)	40-45 mph (N=4,948)	50+ mph (N=1,212)	None/Oth (N=6,271)	(N=24,115)
Ages 14 or less	17.2%	21.7%	26.8%	29.3%	38.5%	58.7%	20.5%	26.3%
Ages 15 - 24	11.5%	21.4%	25.0%	32.0%	43.2%	55.0%	20.5%	29.2%
Ages 25 - 44	13.0%	24.9%	29.5%	43.6%	50.4%	60.2%	26.2%	37.2%
Ages 45 - 64	12.3%	27.8%	34.5%	48.3%	59.9%	68.1%	27.7%	41.8%
Ages 65 +	17.9%	41.8%	42.9%	54.8%	66.6%	82.4%	33.7%	47.4%
All Pedestrians	14.5%	24.4%	29.4%	40.2%	50.5%	61.8%	24.8%	34.5%

In spite of this stark relation of car speed and death rate for cyclists and pedestrians, streets in U.S. urban areas are routinely posted for speeds greater than 30 miles per hour.

Given that such speeds are attained only in fits and starts, and otherwise held down by traffic to an average level of around 20 mph in most cities, why should higher speeds be encouraged by the posted limits, which tend to be treated as “suggested speed?”

There seem to be two primary causal factors at work. One is the U.S. traffic engineering practice of providing a “margin of safety” in street design widths. The other is the arbitrary 85th percentile rule, which prevents effective speed enforcement if the posted limit is disobeyed by more than 15 percent of the drivers. The “margin of safety” acts as an invitation to go faster, and the 85th percentile rule makes sure the tendency to go faster is incorporated in the posted speed limits. Of course neither of these causal factors has anything to do with bicycles or cyclist safety.

Presumably, if numerous bicyclists were magically to appear on a street and consistently ride there, engineering and enforcement would somehow reflect their presence after a while. Unfortunately, the erstwhile cyclists are waiting for safety that never comes.

Hierarchical Streets
In the U.S., and to a lesser degree elsewhere, road networks evolved into a hierarchy of roads specialized by function.

Table 6

Type	Function
Local	Direct property access
Collector	Gather traffic from local streets and feed it to the arterial system
Arterial	Longer distance mobility and not intended to serve as immediate access to properties
Freeways	Fully grade-separated so no signals are required for traffic on the freeway. No direct access from property.

The purpose of a hierarchy is travel speed; longer trips can be made faster, with the car driver moving up the hierarchy and back down during the course of a journey. At each higher level, the street arrangement becomes more complex, as do the intersections.

A consequence of the transition from the simpler urban grids of yore to the hierarchy of streets was congestion on the high level roads. That led to “cut-through” traffic in the residential neighborhoods, which led in turn to a more dendritic or "tree-like" structure to keep the through traffic out of the neighborhoods. Thus the hierarchical street system, intended for having faster, higher volumes in a coarse grid, became plagued by congestion. Cycling was neglected in the quest for long distance speed of motor vehicles.

The means of assuring bike and pedestrian safety in the hierarchical street system will differ within the hierarchy, and will differ in high and low density areas. For transit-oriented development (TOD), space is at a premium and the space requirements of hierarchy are too burdensome. Hierarchy will have to be lessened and more shared use will be required. Speed must be low everywhere within a TOD.

At the other end, in suburban situations, the basic hierarchy will likely remain. Bike and pedestrian safety there will depend on far more attention to the local and collector streets, where the speeds must be curtailed.

Bike Safety on All Streets
By law, streets can't be ruled off-limits to bicyclists, whether or not they have bike lanes or other provisions for bikes. But if the streets are scary enough, they are off-limits by default, which is why most bikes remain in garages, keeping company with all the other things families buy but seldom use. The requisite intensity of bike use will never come about as long as cyclists are effectively limited to bits and pieces of the overall street network. Therefore, all streets need to be made safe. Rather than wait decades for bike lanes, or forever for a set of separated bike paths that duplicates the existing street network, there needs to be a new working policy, expressed in local ordinance thusly: Bicycles have priority on all streets without bike lanes.

How the priority would be realized (e.g., in signage, enforcement, engineering changes) could differ from one street to another. The primary thrust would be to greatly reduce the speed differential between cars and bicycles. Where there are no bike lanes, the complexity of mixed traffic can be made safe if the speeds are slow enough that people have time to react to surprises. This is especially the case in a dense environment.

More Effective Traffic Calming
Traffic calming began in Europe years earlier than in the U.S., so it is reasonable to look there for models of progress. One innovation that came along after the initial focus on individual streets and intersections was “30 Km Zones” where all streets within a bounded area would be limited in speed to 30 Km/hr. (This was later followed by 20 mph Zones in U.K.). These were generally applied at the neighborhood level, and sometimes in larger areas. Their use continues to spread. Their effectiveness depends on using the site-specific physical calming measures and enforcement.

Two very different local sites can serve as examples of another approach to bicycle and pedestrian safety. Both are current subjects of planning activities. One is the prospective urban TOD to be located in the general area around the planned train station in Railroad Square. The other is the Northwest Neighborhood – a suburban archetype where formerly vacant lands are gradually filling in on a random site-by-site basis. It borders the same railroad tracks, but doesn't have a station.

What they have in common are networks of narrow streets subject to a forced choice between lanes for parking or lanes for bicycles. The objective in both cases is to devise a solution based on mixed traffic operations that offer the same level of safety that would be afforded by bike lanes. Perhaps it should not be surprising that a Zone 20 deployment would be a common element in each.

Downtown Station Area[27]
This Transit Oriented Development would be the center of a high density mixed use community that includes the downtown. There will be a strong emphasis on both walking and bicycling. It will be the hub of the Class 1 bike path system, but car access to the train will not be encouraged. Today, with little of that expected development in

[27] Comprised of two adjacent neighborhoods, No. 14 – Railroad Square 5 and No. 32 – West End. Please see Santa Rosa Neighborhoods map:
http://ci.santarosa.ca.us/city_hall/Neighborhoods%20Website/Neighborhood_Org_Map.pdf

place, it has a walk score of 89 on scale of 100.[28] A Walk Score can help people find houses and apartments in walkable neighborhoods. Walk Score shows you a map of what's nearby and calculates a Walk Score for any property. Living in a walkable neighborhood is good for the environment and good for your health.

Northwest Santa Rosa Neighborhood[29]

This neighborhood is nearly uniformly residential in use, and has a fairly typical discontinuous network of streets with numerous cul-de-sacs, overlaid by several continuous collector streets with full direct residential access. It might be characterized as a close-in auto-dependent commuter suburb.

In the all-too-common fashion, an elementary school was sited just beyond the urban edge because the land was cheap, leaving problems of access to be solved by the city. Except perhaps for recreational walking, little foot traffic is likely in this neighborhood even with continuous sidewalks, because of the uniformity of land-use. Its current walk score is only 28. While it is unlikely to become a true walkable community, it could be a bikeable community with proper attention to bike safety.

At approximately a square mile, having a uniform zone speed limit throughout would scarcely add to travel times for people exiting and leaving the neighborhood, but it would still discourage cut-through traffic, if that should become a problem as the neighborhood is built out.

[28] This is one point higher than the White House. See http://www.walkscore.com
[29] Composed of Neighborhood No. 9 – Concerned Homeowners of Northwest Santa Rosa.

Appendix 4: Car(e)-Free: Moving toward Car Independence

One of the glaring problems in our program to reduce emissions from transportation is the lack of viable options to the single occupant vehicle for day-to-day mobility needs. Our transportation analysis reveals that the best that can be achieved through enhancing the public transportation system, including enhancements to walking and biking environments, is a 12 percent reduction in emissions, relative to 2015 BAU. Not, bad, but we have to do better. The land use and train options, while essential, are longer term in their effect. We need a lot more, a lot sooner.

One possible approach to compete with the personal private automobile as the mode selection of choice is to substitute a menu of options for replacing the various functions that a car serves, at a lower cost. This menu of functions would be paid for via a pre-tax payroll deduction.

The program would be called Car(e)-free and might work something like this:
A participant signs up with the plan through work, or through a plan administrator, similar to health insurance. The participant would then get a detailed transportation audit that would assess the total costs of transportation, including automobile, air and other travel. The transportation needs would also be assessed. The participant would then be allowed to deduct the full annualized cost of transportation determined by the audit, pre-tax, to be placed in a fund. The participant would then be entitled to use this fund to pay for a menu of services up to the value of the fund.

Basic services would be:

1. Access to a certified vanpool service similar to the airport transporter that would provide transport to work and school with guaranteed ride home.
2. Access to a certified car share fleet.
3. Enrollment in a certified telecommute training program
4. Broadband/wide area wireless internet access
5. Hardware/Software support for and access to "first person shopper" online shopping, with guaranteed 1 hour delivery for essentials such as food and pharmaceuticals, next day for everything else.
6. Discounted air travel with certified airlines
7. "Universal" public transportation pass, valid in all participating cities, internationally.
8. "Never stranded" guaranteed pick up and drop off using certified taxi fleet for those who don't drive
9. Access to "house call" services for mobile dentist, physician clinic, banking services and miscellaneous repair services.

Alternatively, a participant could use the funds to lease a plug-in hybrid that is charged using the CCA charging bay and uses fuel manufactured by the CCA owned fuel production facility.

In order to be a certified provider, a service provider would have to demonstrate carbon neutral operation, i.e., electric or biofuel powered vehicles in fleet using renewable electricity or carbon-neutral domestic biofuel. The provider would be automatically certified by running vehicles powered or fueled by CCA owned facilities.

The primary condition of entry to this program would be to surrender your automobile and receive the full value as a one-time tax credit. This program could be selectively targeted at owners of SUV/Light trucks. Automobile dealers would be required to offer this program as an alternative to purchase of certain vehicles.

For a program like this to exist, modifications would have to be made to the Federal Income Tax code to expand the existing pre-tax "Commuter Choice"[30] program. However, the idea of providing low cost, convenient options to actually owning a vehicle can be moved along at the local level using the CCA-based car share fleet described in the main text.

[30] IRS Section 132 (f)