Faculty Research Seed Grant Report
William and Barbara Leonard University Transportation Center
California State University San Bernardino

California's 2050 Travel Demand: Anticipating an Era of Climate Change and Energy Constraints

May 30, 2008

Prepared by:

Richard Willson, Ph.D., FAICP
Department of Urban and Regional Planning
California State Polytechnic University, Pomona
3801 West Temple Avenue, Pomona, CA 91768
(909) 869-2701 FAX (909) 869-4688
rwwillson@csupomona.edu

Research assistance provided by Hilary Mau and Alex Clayton

Table of Contents

List of Tables

List of Figures

Executive Summary

The long-term context for California's transportation systems is one of significant transformation. Neither "business as usual" or slow incremental change are likely to represent the future because of climate change mitigation and energy supply issues. Although uncertainly about these factors makes long term planning difficult, regional transportation planning processes should address these issues head on.

This report is based on a literature review that describes issues in climate change mitigation and energy supply, current initiatives at the state level, and current practice in addressing these issues in regional transportation plans. It then summarizes the 2050 prognosis for California's population, economy, and greenhouse gas mitigation and energy issues. Conceptual models are developed concerning the impact of greenhouse gas and energy issues on personal travel demand and goods movement. Drawing the literature, an alternative scenario for 2050 is discussed. The overall finding is that "business as usual" forecasts may overestimate future demand for personal travel and goods movement.

The report concludes with an overview of issues in long-term forecasts, and develops the concept of robustness and adaptability to guide long-term transportation planning. A variety of long-forecasting tools are available. Their effect is not so much as to correctly predict 2050 conditions, but assist in the assessment of near-term actions that make sense in terms of a wide variety of 2050 scenarios.

1.0 Introduction

The long-term context for transportation systems is changing. Neither "business as usual" or slow incremental change is likely to represent California's transportation future because of the significance of climate change and energy supply. Although the reality of climate change is well established, there is much uncertainty about the responses to climate change (from a technical and policy standpoint) and likely decreases in the supply of conventional fossil fuels (from a technological and economic response standpoint). Uncertainty should not paralyze transportation planning: there are useful tools for planning under uncertainty that should be adopted in California's transportation planning processes.

Greenhouse gas mitigation

Mitigating greenhouse gas (GHG) emissions from the transportation sector is a vital part of a coherent global climate change response. Near-term actions are underway, such as increased Federal fuel economy standards for automobiles and light duty trucks and consideration of mitigation opportunities in California's land use and transportation plans. Assembly Bill 32 (2006) provides a roadmap for greenhouse gas (GHG) reduction actions by the California Air Resources Board (CARB) through 2020. The GHG mitigation 'train' has left the station in terms of both regulations and the development of carbon markets.

Production of conventional oil

Analysis of energy supply indicates that production of readily available liquid fuels, upon which the transportation sector is highly dependent, is likely to decline in the near future. This is commonly referred to as the "peak oil" phenomenon. This will impact energy prices and create pressure for rapid development of alternative energy sources for the transportation sector. High energy prices and lags in the development of alternative fuel sources will place stress on the economic system. The California Energy Commission reports that California is the third largest consumer of transportation fuels in the world, behind the United States as a whole and China, with 16 billion gallons of gasoline and over 4 billion gallons of diesel used per year (California Energy Commission 2007, 20).

Combined impact

The two factors described above are prominent in current public policy dialogues, yet change has not yet occurred at the level of regional plans. Awareness of these problems and their practical impact is growing, but the full impact may be felt in a longer time frame than is typical of long-range transportation plans.

In some cases, there is positive synergy between climate change and peak oil responses. For example, the development of plug-in hybrid vehicles and the emergence of hydrogen fuel (if made with low carbon energy sources) address both issues. On the other hand, development of alternative transportation fuel sources from oil sands and other sources using a fossil fuel-based process would worsen GHG emissions while supplying needed energy for the transportation sector.

Responses in transportation plans

Most regional transportation plans and other long term plans examine a 20 to 25 year time horizon. Going beyond that time frame raises uncertainty about individual trends and the unpredictable ways in which they may interact. The reasons for the 2050 perspective are twofold. First, transportation investments last a long time. If the "business as usual" era is over, then transportation investment should consider long-term scenarios. Ogden (2007) suggests that the time frame for a vehicle innovation to move from R&D to more than a 35% share of the fleet is 25-60 years and that introduction of new infrastructure concepts is on a 30-70 year time frame. Second, the acceleration of GHG mitigation policies and regulations, plus the energy cost pressure associated with expected declines in production of conventional liquid fuels, will be most keenly felt post-2020. In short, a long-term perspective is essential to making rational transportation choices today. Transportation investments that are robust with regard to this long-term future will be most cost effective.

This work has begun in other countries, such as Sweden, where Åkerman and Höjer (2006) ask, "How much transportation can the climate stand?" They created scenarios for the transportation sector under a resource and climate change perspective, concluding, for example, that little new arterial roadway capacity is needed despite significant anticipated population growth. Business groups are looking at 2050 scenarios for transportation energy sources, knowing that the market for their products will be shaped by these factors (World Business Council 2004). Do California's RTPs and other regional and local transportations include such considerations? The general answer is that they do not.

Research approach

The first element of this research is to screen the literature to identify important trends and predictive questions from a 2050 perspective. The scan of the literature is used to develop an alternative scenario to the "business as usual" view of 2050 transportation conditions.

The second element of this research is to explore methods for developing useful long-term forecasts or scenarios. This time frame is outside the realm of traditional econometric forecasting, which predicts the future based on past relationships. There may be substantial economic and social transformations or upheavals by 2050, rendering conventional forecasting techniques ineffective. Long-term forecasting methods such as the Delphi technique or scenario development can be used in developing and assessing scenarios for California's 2050 transportation circumstances.

2.0 Background on Climate Change and Energy

2.1 Global Climate Change

Global warming is the most important environmental issue of our time. The *Intergovernmental Panel on Climate Change* (IPPC) documented the severity of the issue in its 2007 report. The primary transportation-related GHG gas is carbon dioxide (CO_2). Smaller amounts of nitrous oxide (NO_2) and methane (CH_4) are emitted by road vehicles.

Responsibility of transportation in the broad emissions picture

In 2002, 41.2% of California's GHG emissions (expressed as CO_2 equivalents) were from transportation (Caltrans 2006). According to the United States Department of Energy, the transportation sector represented 27.9% of carbon dioxide emission equivalents in 2005 in the United States (USDOE, 2006). Globally, the transportation sector accounts for 23.6% of total emissions (IEA 2005).

The focus of this research is road transport vehicles (cars and trucks), rather than air, rail, or maritime transport. Road vehicles represented 78.9% of total eCO_2[1] in the US in 2003 (U.S. EPA 2005).

Impacts of climate change on California's transportation systems

While the purpose of this report is not to review the adaptation of transportation facilities to climate change, the following provides some examples of direct impacts on California's roadway systems:

- Precipitation-based flooding of roadways and tunnels/erosion of facilities.
- Sea level/storm surge flooding of coastal roadways/erosion of facilities.
- Altered freeze-thaw conditions/heat related buckling of roadway facilities.

Mitigating transportation-related greenhouse gas emissions

There are a variety of methods to mitigate transportation GHG emission. The three main factors are: 1) reducing the amount of transportation activity; 2) changing the transportation mode used toward modes with higher efficiency; and 3) reducing the carbon content of transportation fuels. Table 1 (next page) provides examples in each area.

[1] eCO_2 represents the total of all GHG emissions, tallied in carbon dioxide equivalents. The conversion to eCO_2 reflects the length of life and potency (in terms of radiative forcing) of other greenhouse gases such as methane and nitrous oxide.

Table 1. Alternative Methods of Reducing Greenhouse Gas Emissions from Transportation

	Person movement	**Goods movement**
Reducing the volume of transport activity	Telecommunication substitution of travel, e.g., work-at-home, on-line classes, teleconferencing. Compact cities: dense, mixed-use development in cities and restricted suburban expansion.	Relocalization of the global economy. Vertical integration of production. Increased local food production.
Reducing vehicle energy consumption per person mile traveled (PMT), or tons of goods moved	Switching to modes that carry more people per vehicle (transit and carpooling). Non-motorized transportation. Reducing congestion while controlling latent demand. Higher fuel economy for vehicles.	Minimizing energy consumption per ton of good moved (load efficiency) Improved fuel efficiency in trucks. Mode switching from trucks to more efficient modes.
Reducing the carbon content of transport fuel	Replacing or augmenting fossil fuels with algae-based fuels, cellulose-based ethanol, hydrogen derived from renewable energy, and other low-carbon fuels.	Replacing or augmenting fossil fuels with algae-based fuels, cellulose-based ethanol, hydrogen derived from renewable energy, and other low-carbon fuels.

2.2 Transportation Energy Supply

California's transportation system is 8th lowest in energy intensity in the U.S. for gasoline consumption, but because the state's population and economy are so large, the absolute level of consumption is very large. Table 2 compares these data for the largest three states (California Energy Commission 2004).

Table 2. Annual Gasoline Consumption in California, Texas, and New York

	California	**Texas**	**New York**
Population	35,893,799	22,490,022	19,277,088
Gasoline consumption per capita	414.4	532.7	293.4
Total gasoline consumption	14,874,390,305	11,980,434,719	5,655,897,619

Energy sources

California is reliant on sources of crude oil and refined petroleum products from outside the state. The role of Alaska in providing oil has declined, with more the 45 percent of crude oil supplies from Saudi Arabia, Ecuador, Iraq, and Mexico (California Energy Commission 2007, 21). California's refining capacity is not keeping up with demand, which is projected to increase at 1 to 2 percent per year (California Energy Commission 2007, 20). Marine terminals, storage facilities and pipelines also require expansion.

California's transportation sector is subject to global competition for oil resources. Costs will rise for a number of reasons:

- The demands for oil by emerging economies such as China and India.
- Declining productivity of established oil fields across the global (the peak oil phenomenon).
- Higher costs for extracting remaining oils, in terms of drilling technology, other production costs, environmental impact mitigation, etc.
- Possible carbon taxes on petroleum use.

Timing of the peak oil phenomenon

There is considerable debate in the literature as to when the peak of conventional oil production will occur. Some say it has already happened while others predict sometime in the next few decades. In a detailed global simulation, Greene, Hoson and Li (2003) predict total world conventional oil production to peak somewhere between 2020 and 2050. The key variables used in making the prediction are the extent to which higher prices stimulate more exploration and extraction of oil resources, technological innovation in oil extraction, and the minimum reserves-to-production ratios that producers will tolerate.

As the supply of conventional oil diminishes, it will be replaced by non-conventional oil, such as heavy crude, oil sands, shale oil, and oil production from natural gas or coal. These options are certain to be more expensive and currently have a poor ratio between the units of energy used to develop the fuel and the units of energy realized.

Biofuels have potential to replace some conventional oil, especially in the form of cellulose-based ethanol, biodiesel, and algae-derived "green crude". Current ethanol production has put upward pressure on corn prices and other agricultural products and highlighted tradeoffs between energy production and food supply. Ethanol from corn is not a good solution to greenhouse gas emissions because of the carbon-based fuel used in producing the corn, processing the fuel, and delivering it.

2.3 Change Cycles and Inertia in Transportation Systems

Transportation systems develop over long time frames in relation to technology, population, economic structure, and land use. Transportation facilities such as roads and rail networks have long functional lives and offer limited flexibility. Although travel behavior and goods movement are derived from the choices of individuals and firms, transportation infrastructure strongly shapes those decisions. As a consequence, changing transportation-related GHG emissions and energy use is a slow process. Compared to energy policy, where a strategic decision to invest in renewable energy can be made, comprehensive change in transportation system requires changes to infrastructure, vehicle production and fleets, land use patterns, and the economic organization of society.

The magnitude of the challenge to reduce transportation carbon emissions is illustrated by Caltrans' prediction that CO_2 emissions associated with gasoline consumption will increase 30% in the next 20 years if current trends continue (Caltrans 2006, p. 3). Not only must policy halt the rise, but it must reverse it to achieve 1990 emission levels.

2.4 California's Responses

California is a leader in greenhouse gas mitigation and energy conservation and planning. The follow briefly summarizes initiatives in each area.

Greenhouse gas mitigation

AB 32 created a program that involves emissions reporting rules, creation of a 2020 emission cap set at 1990 emissions levels, creation of a framework for evaluating measures, identification of early implementation measures, use of regulatory and market measures, and development of a long-term plan. Governor Schwarzenegger's Executive Order S-3-05, which predated AB 32, established the direction for AB 32 and created a Climate Action Team to implement the State's strategy. It also set GHG emission targets for 2050 that are 80 percent below 1990 levels. Executive Order S-20-06 further directed state agencies to begin implementing AB 32.

Actions by the State Attorney General are requiring consideration of GHG issues in both long-term plans (transportation and land use) and project impact analysis (California Environmental Quality Act). In 2007, the State Attorney General sued and reached a settlement with the County of San Bernardino regarding its proposed General Plan. Challenging the plan under CEQA, the settlement provides that San Bernardino will inventory current GHG emissions, make projections for 2020, and seek mitigation measures attributable to internal operations and discretionary land use decisions (Environmental News Service 2007).

Caltrans has two main strategies for reducing GHG emissions. The first is to reduce trips and congestion levels using land use policy, intelligent transportation systems (ITS), demand management, value pricing, and market based strategies. The second is to increase energy efficiency in transportation operations, including strategies such as "greening" the fleet, incorporating GHG considerations in transportation facility planning, and reducing cement use in concrete. Since 2005, the State has been seeking to limit GHG emissions from vehicles (Pavley, AB 1493). The U.S. EPA did not grant approval for California, but the State took this to court and prevailed. The outcome of this effort remains undetermined at this time.

Energy

The California Energy Commission's *Integrated Energy Policy Report* (2005) outlines a series of strategies to address energy supply for all sectors of the economy. The strategy places as first priority in the transportation sector mandated improvements in the fuel economy of vehicles. This would reduce gasoline and diesel consumption per vehicle mile traveled. The Pavley bill is the State's primary initiative to reduce greenhouse gas emissions. Although greenhouse gas emissions are the primary focus of the Pavley bill, increases in fuel economy standards directly reduce transportation fuel demand. At the time of this writing, it is not yet clear if the state will be able to implement its own fuel economy standards, as the new CAFÉ standards adopted by the Federal government prohibit states from setting more stringent standards. Even if the Pavley standards are not implemented, the new CAFÉ standards will reduce transportation energy consumption per VMT, requiring a 35 mpg average for passenger vehicles and light trucks by 2020.

The Integrated Energy Policy Report considers other strategies to reduce fuel demand, including increased use of hybrid electric, plug-in hybrid electric, and light-duty diesel vehicles in California. It also considers initiatives in low-rolling resistance tires, anti-idling regulations for trucks, and truck stop electrification. Finally, land use and transportation initiatives such as Smart Growth that would reduce VMT per person mile traveled (PMT).

Increasing use of non-petroleum fuels is another major element of the Integrated Energy Policy Report. The report recommends that 30% of fuel content be non-petroleum fuels by 2030, but notes that this is an aggressive goal and a substantial increase from the 6% level that existed in 2005.

Another state strategy to reduce petroleum energy use for the transportation sector is the *California Hydrogen Blueprint Plan* (2005), which calls for actions to support the introduction of hydrogen fuel vehicles. Hydrogen is an energy carrier, not an energy source, so the fuel demand consequences of such a strategy depend on the source of energy used to generate the hydrogen. Natural gas and electricity are the common fuels used, but renewable energy or biomass could be used to generate hydrogen.

The potential of hydrogen to reduce petroleum demands by California's transportation sector rests with a series of technical innovations in fuel distribution and vehicle technology, but these factors are overshadowed by the progress in generating on-site electrolysis from renewables and central gasification plant using biomass.

2.5 Regional Transportation Planning Responses

The 2050 transportation context is beyond that currently anticipated by long-range transportation plans. For example, the Southern California Association of Government (SCAG) 2030 Regional Transportation Plan did not address GHG emissions. The latest 2008 Regional Transportation Plan, which considers the period through 2035, does address climate change and energy availability, but in a cursory fashion. Three pages of text are devoted to the subject, primarily summarizing State initiatives and indicating that there is uncertainty in these areas. The 2008 version makes no commitments on GHG reduction and states that energy issues are "recommended for additional study and deliberation prior to development of the next Regional Transportation Plan" (SCAG 2008, page 73). Table 3 (next page) summarizes RTP treatment of these issues across the state.

Table 3. Regional Transportation Plan Treatment of Energy and Climate Change

Entity	Policy Statements	Alternative Energy & Price Scenarios	GHG Regulation & Mitigation Scenarios
Smaller regions	Plans mention energy conservation, but rarely address climate change, GHGs, alternative fuels, or sustainability; peak oil is not addressed.	Not addressed	Not addressed
Southern California region (SCAG, SANDAG)	Both MPOs address global warming/GHG emissions, though neither presents a strong policy statement.	The only definitive provisions are SANDAG's alternative fuel infrastructure toolkit for local governments.	Plans address coordinating various modes of transportation to reduce VMT, and thus GHG emissions, but there are no specific regulation scenarios.
Northern California region (JPC, MTC, SACOG)	All plans address climate change/GHG emissions; only the Joint Policy Committee's (JPC) Joint Climate Protection Strategy promises more than what AB32 outlines.	SACOG provides an alternative fuel infrastructure toolkit, while the JPC discusses the future of gasoline-powered vehicles, but does not address implementation mechanisms for alternative fuels.	JPC and MTC plans both address a menu of taxation and fees to reduce VMTs, encourage people to get out of their cars, and fund climate change efforts to tackle GHGs and associated global warming. SACOG discusses promoting energy conservation in selecting contractors and provides for education on global climate change, but does not introduce regulation scenarios.

In regard to climate change and energy supply, it appears that the State of California is ahead of Metropolitan Planning Organizations throughout the state. Although some aspects of these issues are beyond regional control, there remain significant strategy areas such as land use policies where regional action is vital. Responses to energy issues and climate change will be more effective if the regional and state agencies are working in partnership. In bringing in the land use side of the transportation equation, participation by local governments will be necessary. The authority of local, regional and state agencies concerning land use and transportation may require a comprehensive review.

3.0 Literature Scan Concerning 2050 Trends

This section summarizes the findings of the literature review concerning long-term trends that affect transportation demand and transportation planning.

3.1 California's Population

The State Department of Finance projects that California's 2050 population will grow to almost 60 million residents (CA Department of Finance 2007). Their population projection technique uses fertility, mortality and migration assumptions. The following describes the method:

> Applying the fertility assumptions to the women of childbearing ages creates new cohorts. The population ages with time, as the gender-, race/ethnic-, and age-specific survival rates are applied to the population at risk. In addition, the overall migration assumptions by race/ethnicity are distributed using the assumed gender and age proportions. The process is carried forward for 50 years from 2000. Special populations are then added to produce total population projections. (CA Department of Finance 2007, web page accessed http://www.dof.ca.gov/html/DEMOGRAP/ReportsPapers/Projections/P3/P3.php)

Migration rates are based on historical patterns. The difficulty of this approach is that it does not consider the impact of climate change and energy issues on California's growth. These are complex and difficult to quantify, but relate the impact of these factors on in- and out-migration. These, in turn, have to do with the differential impacts of climate change and peak oil on the California economy as compared to other states, neighboring countries, and global economic organization.

The level of population growth anticipated can easily outweigh increases in energy efficiency in the transportation sector or land use changes that reduce travel. However, it may be that long-term resource constraints lead to slower growth than that predicted by the extrapolation of "business as usual" conditions.

3.2 California's Economy

The Economic Research Unit of the California Department of Finance prepares estimates of the growth of the California economy. The most recent detailed forecast looks only two years into the future, to 2010. It projects growth in total wages and salaries from $856 billion in 2008 to $939 billion in 2010, a 10% increase in two years (California Department of Finance 2008). Data on economic activity from 2004 to present show continuous growth.

Longer-range economic forecasts sometimes use an annual percentage growth rate. For example, McCarthy, et al (2005) use a 2.5% per year growth rate for gross state product in generating a 2050 scenario to test energy demands. While there may be historical precedent for such increases, there are likely based on post-war expansion in an era of rapidly expanding energy supply. Given the likely increases in the cost of liquid fuels and the expected actions to respond to GHG emissions, projections based on past trends may not offer much insight into future conditions.

The California Department of Finance web site (2008a) provides a summary of economic events for each year. Scanning the list of economic events back to 1999 produced only two references to energy prices and no references to climate change impacts as economic events. The 1999 energy reference was:

November 17, 1999	Crude-oil futures hit an almost nine-year high, rising 90 cents to $26.60 a barrel.

With current prices over $125 per barrel, consumers and producers are in the midst of significant economic adjustments.

California also has a *Dynamic Revenue Analysis for California* (DRAM) model that is used to perform revenue analyses for major legislation (California Department of Finance, 2008b). The model considers consumption, production, trade, investment, labor supply, and migration. All these factors could conceivably be influenced by energy prices and climate change mitigation.

Economic modeling of the impact of greenhouse gas mitigation has been completed with a 2020 timeframe by the state's Climate Action Team. Two economic models were used to forecast baseline growth through 2020. The models forecast an increase in real state output of 62% from 2003 to 2020 (Climate Action Team 2007, pp. 33). The assumptions used in this model for future energy prices (in 2006 dollars) are that crude oil will be $38.17 per barrel in 2020 and gasoline prices will be $2.21 (Climate Action Team 2007, pp. 15) based on a 2005 Integrated Energy Policy Report. Said simply, the state's best economists did not anticipate the current energy price situation.

Economic responses to high prices of conventional liquid fuels

The market price of conventional liquid fuels is not the only factor in economic growth and patterns, but it is significant. Strategies for non-conventional oil and fuel substitution are likely to be expensive. In addition to affecting growth, economic organization may change in response to higher energy prices, e.g., reduction of "just-in-time-production" and diversification of local production. These trends may solve part of the problem without additional government action, but the degree of these market responses is not known.

Rising or unstable energy prices could lead to a downturn in the economy as the increased production costs filter down to the consumer, thus affecting consumption, inflation, and global economic growth. The effect would vary across economies as the balance between the efficiency of globalization and the higher transportation costs of this pattern of economic organization are worked out.

The global economic system has developed into the current highly interrelated organization over many decades, and cannot change quickly. In almost every sector, from agriculture to manufacturing, regions have become more specialized. The possibility of a relocalization of regional economies would affect all sorts of travel demands, ranging from maritime and air shipments to trucking, but it would take decades to occur.

Economic forecasting models project past relationships between variables into the future. They may have underestimated energy input values, as discussed in the example above. Furthermore, now that energy prices have exceeded all inflation-adjusted precedents, past elasticities between energy cost and economic activity may be not be valid. Taking all this together, forecasters may be overestimating economic activity for the 2020 time frame. Furthermore, the lack of detailed 2050 economic forecasts means that there is no reliable information available about energy and climate change influences on economic activity.

3.3 Energy availability and type

The peak oil phenomenon will bring significant impacts to the transportation sector. If the transportation sector continues to rely primarily on fossil fuels (oil and natural gas), there will be a costly and environmentally damaging transition to non-traditional sources for liquid fuel for the portion of the transportation fleet that requires gasoline or diesel (from sources such as heavy oil, oil sands, shale oil, oil from coal, etc.). There will be competition for natural gas from other sectors, such as agriculture (to support fertilizer production). The price of diesel and gasoline, despite being at inflation-adjusted highs at the time of this report, is likely to increase at a significant rate.

Forecasts of fuel demand

Improved vehicle fuel economy can reduce the pressure on fossil fuels, but growth in VMT could swamp increases in fuel economy or needed GHG reductions from the transportation sector. Using an assumption that transportation fuels will continue to be primarily gasoline and diesel fuel, researchers at the University of California Davis have modeled 2050 energy demand from California's transportation sector. Their analysis suggests that increases in energy efficiency will moderate but not reverse an upward trend in fuel use, expressed as millions of gallons of gasoline equivalents in the 2005 to 2050 period as follows (McCarthy, et al 2005, p. 34):

- Light duty gasoline demand per year: from 15,000 to almost 20,000 million gallons of gasoline equivalents.
- Light duty diesel demand: from an insignificant amount to 3,000 million gallons of gasoline equivalents.

- Non-light duty vehicle (trucks) diesel demand: from 3,000 to 6,000 million gallons of gasoline equivalents.

Overall, McCarthy et al (2005) project a 45% increase in fuel demand through 2050 in a baseline analysis that considered expected increases in vehicle efficiency but not new fuel efficiency mandates.

Alternative fuel sources for the transportation sector

Compared to other economic sectors, the transportation sector is very dependent on fossil fuels. Nonetheless, alternative fuels have the potential to reduce reliance on fossil fuels. Biofuels have potential to help with GHG and energy issues, but some fuels, such as ethanol derived from corn, do not offer greenhouse gas benefits. The advantage of such fuels is that they do not require drastic changes in vehicle technology. Currently there are technical feasibility issues in cellulose-based biofuels and algae-produced oil, scale issues in production, and conflicts over food supply, but it is possible that breakthroughs could occur in these areas.

Electric vehicles have potential if battery technology improves range and lowers cost and if electricity comes from renewable sources. Plug-in hybrids represent a transition to full electric vehicles. For greenhouse gas reductions, however, the source of the electricity must be a form of renewable energy or yet developed coal-based electricity with carbon sequestration. In both these cases, there are significant limitations related to technology and scale, but breakthroughs could occur in these areas.

As discussed previously, hydrogen is a possible energy delivery system, provided that hydrogen is derived from locally developed renewable energy, a low carbon fossil fuel, such a natural gas, fossil fuel-derived electricity with carbon sequestration, or centralized production from biomass. Hydrogen as widespread fuel source for transportation is likely on the longest time frame of the three alternatives, with perhaps a 40 year time period for a full transition.

3.4 Evolution of GHG Regulations and Carbon Markets

New Federal and international initiatives concerning carbon emissions will likely affect the transportation sector in the coming years. This may include mandates for the use of renewable fuels and the use of pricing strategies and/or regulations to reduce the carbon content in transportation.

It is expected that carbon markets will be the preferred method of implementation, allowing travelers and businesses to sort out their preferences for carbon intensive transportation with a set of prices that reflects the carbon emissions and associated global climate change impacts. New regulatory regimes are possible, but the primary move is toward to using pricing mechanisms to internalize the carbon emission damage of transportation decisions by individuals and businesses.

California's initiatives

The early action recommendations of the California Climate Action Team (2007) indicate the range of measures being considered. They include:

- AB 1493, Pavley, Chapter 200, Statutes of 2002, which requires ARB to achieve the maximum reductions through fuel economy standards.
- Tire efficiency.
- Low Carbon Fuel Standard (LCFS).
- Reduction of HFC-134a emissions from vehicle air conditioning systems (MVACs).
- Heavy-duty vehicle emission reductions, efficiency improvements.
- A series of initiatives for diesel vehicles (vessels, trucks, off-road equipment).
- Transportation efficiency - reduced congestion, improved travel time in congested corridors, and coordinated, integrated land use-transportation decisions.
- Smart land use and intelligent transportation.
- Ultra low emission vehicles.
- State flex fuel vehicles.
- Alternative fuels - non-petroleum fuels.

4.0 An Alternative to a "Business as Usual" 2050 Scenario

Very long term forecasts for California are not common, and most of those available are based on the continuation of current trends in demographics and economic growth. They are primarily "business as usual" perspectives that may have served well in the past but do not capture the possibilities associated with climate change and peak oil.

An example is the Department of Finance 2050 population forecast mentioned in a previous section. This forecast, while it reflects issues such as California's aging population, does not address energy resources constraints or climate change as factors affecting the growth of California.

The focus here is to explore whether the resource constraints represented by climate change and peak oil will affect VMT in a significant way. The discussion that follows lays out a scenario in which VMT per capita is significantly lower than current rates and total VMT is less than most current estimates. This is an important question to ask as the state embarks in major infrastructure investments: are we building for a demand that will not be realized?

The following paragraphs develop an exploratory alternative scenario for 2050, with special consideration of factors related to energy issues and climate change regulation. The goal is to identify the implications of the changes identified in the literature review and explore how multiple trends might interact.

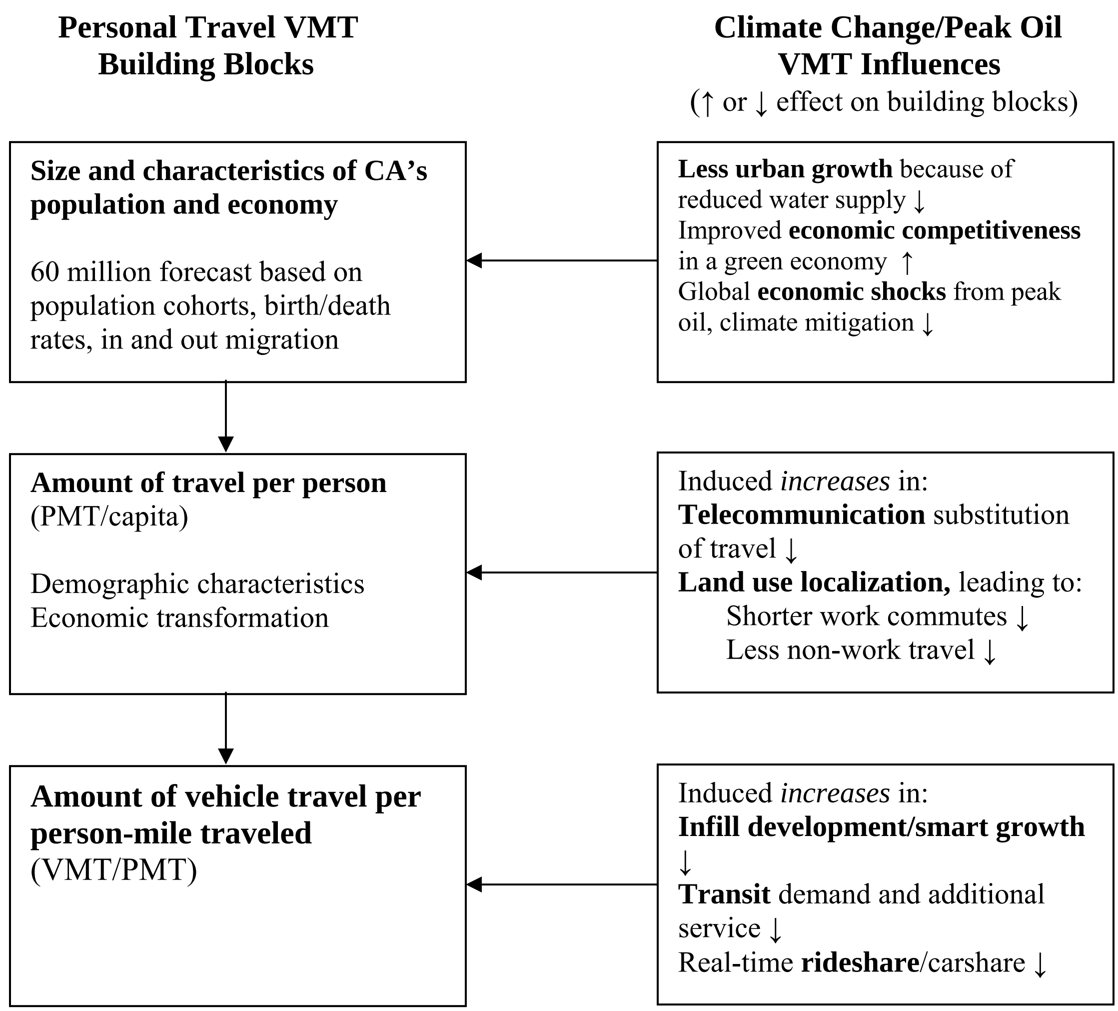
The development of this scenario is not a prediction but an attempt to create a plausible scenario. This is the type of process that might produce a series of 2050 scenarios that reflect different, but plausible, sets of interconnections between the many related issues. It seems prudent that mid-term (20 year) transportation planning should be done with an eye to plausible long-term scenarios. Scenario development can be assisted by Delphi processes that help experts build consensus on plausible scenarios and computer-assisted scenario generation.

4.1 Personal Transportation

The key building blocks of future personal travel demand include the size and characteristics of the population and economy, the amount of travel per person, and the amount of vehicle-mile of travel (VMY) per person-mile of travel (PMT). Conventional four-step regional transportation models take disaggregated population and economic activity from external models and use that information to predict travel and mode choice. Normally, models do not consider scenarios relating to climate change regulations, such as regulatory or pricing constraints on driving alone, or alternative energy supply scenarios,. Indeed, these factors are challenging to assess since many of these possible model input are outside of the range of data used in specifying the model. A good example is energy prices, as the elasticity of demand for gasoline may be quite different at $4.50 per gallon than at $2.50 per gallon.

Figure 1 outlines those key building blocks and provide examples of how climate change and peak oil may affect inputs and the calibrated sensitivities of transportation models. The left side shows the size of the population and economy, the amount of travel per person, and the amount of VMT per PMT. The right side shows a series of possible impacts and an indication of the likely effect on the associated building block. For example, decreases in available water supply could reduce the size of the agricultural economy and the growth rate in urban areas compared to "business as usual" forecasts.

Figure 1: Climate Change/Peak Oil Influences on Personal VMT



The literature review identified possibilities in the 2050 time frame that may change all three areas listed above. The impact of climate change and peak oil on the overall California economy is least clear, since the competitiveness of the State will determine how its economy performs vis a vis other economies that are also impacted by these factors.

Personal transportation is a vulnerable sector with respect to energy availability issues and climate change regulation. The first vulnerability concerns the place that personal transportation will take as society prioritizes that use of fuel against other public priorities, as discussed below. It is vulnerable with respect to climate change issues because of these same reasons, as well as the size of its impact of California's GHG emissions and the long time period to change the vehicle fleet and change land use/transportation relationships.

As petroleum-derived liquid fuels become more expensive and hard to acquire, there will be a sorting among the various uses of those fuels according to those that provide the most essential public goods. The users of liquid fuel that will have a higher priority than personal automobile travel may include water, food production, public safety, national security, construction equipment, and goods movement. The social good of an individual driving a car alone to work or for non-work purposes may rank among the lowest of the possible uses of fuel.

On the climate change side, pressures for reducing avoidable greenhouse gas emissions will rise, through regulations and pricing mechanisms. It is conceivable that a greenhouse gas tax or other fees will be built into fuel prices to internalize this cost for automobile commuters.

The net result of these two phenomena is that there will be downward pressure on the demand for personal travel. A new level of "localization" may emerge. More trips will be short walk, bicycle, low speed electric vehicle, etc. Longer trips are more likely to use transit and other shared ride modes. The three areas of influence shown on Figure 1 suggest less travel – VMT per capita has already largely halted, but VMT per capita may decline and there may be absolute VMT reductions.

Regional governments typically rely on demographic and economic trends and forecasts to predict future travel demand. Ignoring or understudying these issues in their transportation plans may lead to overestimations of VMT. That is good news for future traffic congestion levels, but if energy availability and climate change regulations significantly dampen personal travel demand, then current plans may be calling for an overbuilding of roadway facilities.

Plans based on "business as usual" scenarios may also be underestimating the need for alternatives to individual travel in automobiles. Those alternatives might include telecommunication substitution of travel, new forms of real-time ridematching, dense, mixed-use land use forms that rely on walking and bicycling, conversion of general use lanes on streets and freeways to bus-only use, and enhancements to a variety of forms of transit, including privately provided shared rides.

Of course, technological innovations that increase the energy efficiency of cars powered by oil can help the situation, as can the development of alternative propulsion systems such as electric cars and hydrogen fueled vehicles. The key question is whether that pace of technological innovation and turnover of the vehicle fleet can produce a rapid-enough reduction in oil consumption and GHG emissions by the personal transportation sector. These factors are largely outside the control of regional governments, depending instead on state and federal regulations and innovation by automobile manufacturers.

In the very long term, it is *possible* that that technology will take care of this problem. For instance, we have seen technological innovation produce significant gains in reducing air pollution from vehicles. If improvements in battery technology produce a lower cost, longer range electric vehicle, and if the source of electrical power for those cars is solar, wind or some other renewable source, then perhaps the personal transportation sector can escape the VMT-reducing impacts listed above. Nonetheless, the ability of the electrical sector to supply electric cars may be constrained as it transitions out of oil and natural gas as fuel sources for generation plants. New technologies in electrical production will require massive investments, e.g., solar power, carbon sequestration of emissions from coal fired electrical plants, etc.

This is an area where regional governments face great uncertainty. Having no regulatory authority over how vehicles are fueled or their efficiency, regional governments are dependent on others. Given this situation, and the considerable uncertainty that exists about these technological innovations, it seem plausible to include an alternative in regional transportation plans that assumes that oil availability and GHG regulations produce a significant reduction in VMT per capita.

From an economic competitiveness standpoint, regions that can adapt to these changes will be able to prosper, while those that cannot may suffer disinvestment and decline. Regions should plan to mitigate the lack of economic competitiveness that will exist if they are not capable of providing alternatives to personal automobile travel. A new measure of regional competitiveness may emerge—the adaptability of the region to decreased possibility of personal travel by automobile.

These factors suggest a reprioritization of regional planning concerns. In addition to projecting VMT growth into the future as if energy and climate change constraints do not exist, as is currently the practice, regional governments must consider scenarios in which regional VMT decrease, reducing the need to road capacity expansion and suggesting a reprioritization of funds toward alternative transportation modes. Current Regional Transportation Plans may be anticipating a travel demand future that will never occur.

4.2 Goods Movement

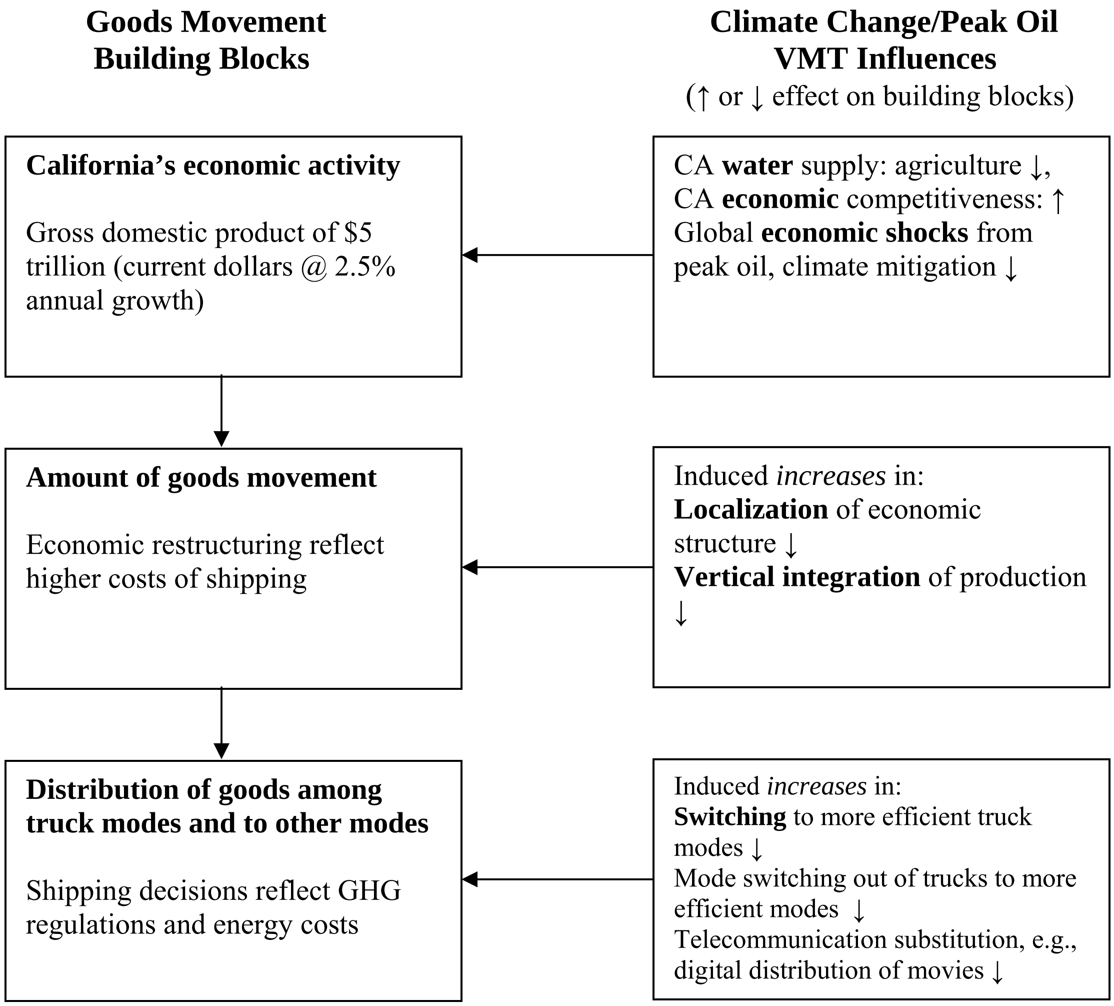
This scenario focuses on the trucking component of goods movement. Historically, major changes in energy prices and regulatory regimes have produced significant economic shocks and induced economic restructuring. The energy crisis of the late 1970's was a contributing factor in recession and inflation. In the regulatory realm, the air pollution regulations imposed by the South Coast Air Quality Management District produced economic restructuring in which certain economic activities relocated out of the region.

The 2050 scenario for California's economy will be closely linked to world economic trends and will be impacted by transformations in the energy sector and greenhouse gas mitigation regulations. In addition, the impact of higher CO_2 concentrations on California's climate, primarily a reduction in water supply, will influence the agriculture industry and may reduce the area under cultivation and affect the type of crops grown.

Global responses to energy issues and GHG mitigation could also *help* the California economy, if California's high tech resources lead the way in alternative energy sources, efficiency initiatives, adaptation strategies, and the like, or if other economies experience greater negative impacts.

Figure 2 outlines key goods movement building blocks and provides examples of how climate change and peak oil may affect inputs to the model and the calibrated sensitivities of the model. The left side shows the size of the economy, the amount of goods movement per unit of economic output, and the distribution of goods movement among alternative modes. On the right side are a series of possible impacts and an indication of the likely effect on the associated building block.

Figure 2. Climate Change/Peak Oil Influences on Goods Movement



The literature review has identified possibilities in the 2050 time frame that may change all three areas listed above. As mentioned previously, the impact of climate change regulations and peak oil on California's economy is hard to predict. Even so, using traditional yardsticks for long-term predictions, such as an annual growth rate, may not be a reliable method. It seems clear that the variety of economic scenarios is broader than would be expected in a "business as usual" scenario.

The impact on the amount of goods movement appears to favor a decrease in shipping per unit of economic output. Whether goods movement would decline has much to do with global growth rates under these conditions and California competitiveness in this environment.

Goods movement would seem to have a high priority in sorting the priority for access to liquid fuel. However, the social good of shipping imported water from around the globe may well be questioned, in the consumer marketplace and in regulatory regimes.

On the climate change side, pressures for reducing avoidable greenhouse gas emissions will increase, through regulations and pricing mechanisms the build emissions costs into product prices. This will give a competitive advantage to carbon efficient products, including products that minimize shipping requirements.

Regional transportation plans may overestimate the demand for goods movement on the basis of the factors described previously. They may also misestimate the demand by the various goods movement modes, e.g., trucking, rail, air shipment, etc.

Technological innovations that increase the energy efficiency of goods movement can dampen the price and regulatory impact. Compared to the personal transportation sector, goods movement innovations appear to have received less emphasis thus far. Issues such as truck fuel economy standards are largely outside the control of regional governments, depending on state and federal regulations and the innovation by manufacturers.

As in the personal transportation case, rather than project goods movement demand into the future as if energy and climate change constraints do not exist, regional governments should consider scenarios in which goods movement demands may moderate, calling for a reassessment of plans for truck-only lanes, port expansions, airport expansions, and the like.

4.3 Conclusion

The point of this exploratory scenario is not to predict 2050 VMT in California, but to point out that Regional Transportation Plans should consider scenarios for different climate change regulatory regimes and energy supply scenarios. Current plans may be anticipating a level of transportation activity that will not materialize and are therefore calling for overinvestment in new transportation facilities. In addition, the modes of travel demanded for both personal transportation and goods movement may shift to the most energy efficient choices among those available.

5. Concepts for Long-Term Transportation Policy Development

This report identifies two important factors that will affect future travel demand in California: responses to climate change and shortages of conventional fossil fuels. Both factors may reduce VMT as compared to "business as usual" projections. In addition, these factors have interactive effects, e.g., the combined effect of increased energy prices and transportation-related carbon taxes produces consumer behavior that reduces VMT more than the separate effect of each factor.

If these were the only trends of concern, the forecasting problem would be formidable. It is considerably more complex, however, because of other socioeconomic impacts of climate change and energy issues that in turn affect transportation. For example, climate change will affect California's water supply, which in turn will affect the structure of the economy. Similarly, energy prices will affect the locational decisions of households and businesses, restructuring regional land use patterns. The development of renewable sources of energy to produce hydrogen for on-road vehicles could stimulate economic growth in California. And finally, public awareness of climate change could produce significant changes in social values and behavior that are outside of conventional model specifications. All these have consequences for future VMT. Clearly, this is a case of transportation policy and program development under deep uncertainty.

As discussed previously, the 2050 perspective is outside the time frame of conventional forecasting tools. Existing regional transportation plans in California have 2025 or 2035 as their target dates. For conventional prediction techniques, this is very long term forecasting. In some ways, it is an unfair test to expect regional transportation plans to anticipate 2050 conditions. The potential of misestimating is reduced by the current practice of renewing these plans every four years, however, thereby allowing for a rolling forecast that incorporates new information. For example, the next cycle of RTPs is likely to more formally include energy prices and climate change issues.

5.1 Is 2050 Forecasting Worth the Effort?

One might ask whether a 2050 perspective is even useful, given the uncertainties about trends and their interaction. On this question rests a fundamental perspective about the future of long-term forecasting. One view is that it should provide reliable information on what the long-term future will bring. Given the uncertainty about trends and iterations, and the inability to predict future innovation, one might conclude that 2050 forecasting is not worth the effort. Taking this point of view, short-term incremental actions to move away from current problems could be adopted as an approach.

The challenge that transportation creates for short-term incremental planning is that transportation infrastructure is a long-term investment that will have an economic life that exceeds the 2050 perspective. In addition to long life, some transportation investments (but not all) are inflexible. For example, a rail transit project cannot be rerouted if travel patterns change. Roadway space, while fixed in place, can be allocated between personal vehicles, transit vehicles, or trucks, or some combination thereof.

Drawing on the work of Lempert, et al (2003) a reframing of the expectation for long-term forecasting is as follows: "How can we choose actions today that will be consistent with our long term interests?" (p. xii) Taking this perspective, perhaps a better question is whether current transportation policies and projects are considered *robust* for the wide variety of future scenarios that may occur. In this context, robust means an ability to be useful under a wide variety of future conditions.

5.2 Issues in Long-Term Forecasting

Lempert et al (2003) define deep uncertainty as having three areas where analysts cannot agree. Table 4 summarizes three areas and provides and example for 2050 forecasting for each.

Table 4. Issues in Long-Term Forecasting

Area of Uncertainty	Description	Example from 2050 transportation forecasting
Conceptual models	Models that describe the relationships among the forces that shape the long term future.	Interaction of econometric models used in transportation forecasting with models of political action and public opinion.
Values of key variables and parameters	Probability distributions used to represent uncertainty about the input values to forecasting models.	Predicting the price of oil in 2050, reflecting resource constraint, new exploration, energy efficiency, and competition from renewable energy sources.
Valuing the desirability of alternative outcomes	Will the values of society in 2050 be the same as today? What discount rate should be applied to future costs and benefits?	What priorities will the post-baby boom, internet-native population express through political processes?

5.3 Alternative Long-Term Forecasting Techniques

Table 5 identifies alternative three types of long-term forecasting techniques and discusses their suitability.

Table 5. Alternative Long-Term Forecasting Techniques

Type	How it works	Suitability
Delphi or Foresight techniques and processes	A group of experts is assembled and asked to make estimates about the future. An iterative process is provided to give participants an opportunity to revise their estimates based on those of the rest of the group. The process seeks to find a convergent estimate, based on expert opinion, experience, and intuition.	Helpful for situations in which discussions between a group of informed individuals produces the best estimate. Key issues include the degree to which future costs and benefits are discounted by experts, fallacies in perception, issues of oversimplification, or execution problems.
Simulation models and formal decision analysis	Analytic methods are used to structure the process of considering alternative futures. Such models help correct fallacies that may occur in human reasoning by making relationships, paths and probabilities explicit. Can support long chains of causation using mathematics.	A more quantitative approach to forecasting. Analytic structure allows replication. Not well suited to anticipating surprise. Can lead to error if underlying relationships misspecified or unstable.
Scenario planning	Generates a wider range of alternative futures than conventional forecasting techniques. Emphasizes the importance of multiple views of the future in assessing uncertainty.	Can help identify the transportation consequences of different climate change/energy scenarios for VMT. Widens the consideration of possible futures. Could be misleading in the sense of promoting unlikely scenarios.

Lempert et al (2003) argue for a technique called long-term policy analysis (LTPA). Instead of seeking an optimal set of strategies for a predicted long-term future, it seeks near-term strategies that perform well with regard to a wide range of possible future scenarios. They term these strategies as robust. Policies that are robust for a variety of long range scenarios are also likely to be adaptable. Robust and adaptable strategies are likely to have utility over a wider range of possible futures than strategies that are more narrowly designed over a possible, but uncertain future.

In transportation planning, one of the key distinguishing features of robustness is the distinction between capital strategies (building transportation facilities) and operating strategies (managing the use of facilities through pricing, regulation, providing transportation services, etc.). Among capital strategies, some facilities are more adaptable than others, e.g., a mile of roadway cannot be relocated but can be used for solo driver commuter, transit vehicles, or trucking.

Given that some of the possibilities for 2050 conditions involve a slowing of the rate of increase in travel demand, or even absolute decreases, an emphasis on operating programs and transportation services appears to be a more robust strategy. Emphasizing facility investments could overcapitalize the transportation system in the long run.

5.5 Conclusion

It is rational to seek transportation strategies that are robust and adaptable for an uncertain future. This report concludes that current RTPs do not perform well in this respect. Their time horizon is shorter than the life the investments they propose and most of them recommend strategies without sufficient consideration of climate change or energy supply, two of the most profound policy factors in the early 21st century.

Caltrans has taken a leadership role in promoting Blueprint planning to address the interrelationships between land use and transportation. A similar blueprint approach could be promulgated to address long-term climate change and energy futures beyond the time frame of current RTPs. Although MPOs are being required to address climate change through CEQA analysis, the current 2007 Regional Transportation Plan Guidelines checklist contain no items on greenhouse gas mitigation or energy scenarios.

State agencies could provide research on long-term trends affecting transportation and assist MPOs in developing appropriate scenarios to model. State agencies can also support MPOs in developing long-term forecasting techniques. What is needed is the development of forecasting tools that will allow policy makers to assess the robustness of the choices being made in those plans for a variety of future scenarios.

References

Amador County 2004 Regional Transportation Plan (2004). Accessed at: www.actc-amador.org

Association of Monterey Bay Area Governments 2005 Metropolitan Transportation Plan (2005). Accessed at: http://www.ambag.org/

Butte County Regional Transportation Plan (2008). Accessed at: http://www.bcag.org/Planning/2008-RTP/index.html

Calaveras County 2007 Regional Transportation Plan (2007). Accessed at: http://www.calacog.org/rtp.shtml

California Air Resources Board (2007) "Proposed Early Actions to Reduce Climate Change in California." Access on 5/19/08 at http://www.climate http://www.climatechange.ca.gov/climate_action_team/reports/2007-04-20_ARB_early_action_report.pdf

California Air Resources Board (2008) Amendment to February 25 Technical Assessment, Comparison of Greenhouse Gas Reductions for the United States and Canada under ARB GHG Regulations and Proposed Federal 2011-2015 Model Year Fuel Economy Standards. Accessed on May 25, 2008 at http://www.arb.ca.gov/cc/ccms/reports/final_pavleyaddendum.pdf

California Climate Action Team. (2007). "Updated Macroeconomic Analysis of Climate Strategies Presented in the March 2006 Climate Action Team Report." Accessed on 5/19/08 at http://www.climatechange.ca.gov/events/2007-09-14_workshop/final_report/2007-10-15_MACROECONOMIC_ANALYSIS.PDF

California Department of Finance (2008a). "California Economic Forecast." Accessed on 5/12/08 at http://www.dof.ca.gov/HTML/FS_DATA/dyna-rev/dynrev.htm

California Department of Finance (2008b). "Dynamic Revenue Analysis for California" Accessed on 5/19/08 at http://www.dof.ca.gov/HTML/FS_DATA/LatestEconData/FS_Forecasts.htm

California Department of Finance. (2007). *Population Projections for California and Its Counties 2000-2050, by Age, Gender and Race/Ethnicity*, Sacramento, California, July 2007.

California Department of Transportation (2006). "Climate Action Program at Caltrans." Accessed on 3/12/08 at http://www.dot.ca.gov/docs/ClimateReport.pdf

California Energy Commission. (2004). US Gasoline Consumption per State. Retrieved on May 23, 2008 from: http://www.energy.ca.gov/gasoline/statistics/gasoline_per_capita.html

California Energy Commission. (2007). 2007 *Integrated Energy Policy Report, Summary.* Retrieved on May 12, 2008 from: http://www.energy.ca.gov/2007_energypolicy/index.html

California Environmental Protection Agency. (2005).California Hydrogen Blueprint Plan. Access on 5/25/08 at http://www.hydrogenhighway.ca.gov/plan/reports/volume1_050505.pdf

California Environmental Protection Agency. (   ) Climate Action Team
Proposed Early Actions to Mitigate Climate Change in California. Accessed on 5/19/08 at http://www.climatechange.ca.gov/climate_action_team/reports/2007-04-20_CAT_REPORT.PDF

California Department of Transportation. (2007). Regional Transportation Planning Guidelines Checklist. Accessed on May 26, 2008 at http://www.dot.ca.gov/hq/tpp/offices/orip/rtp/index.html

Curtis, Fred. (2007). *Climate Change, Peak Oil, and Globalization: Contradictions of Natural Capital.* Review of Radical Political Economics; 39; 385. Retrieved on Oct. 17 from: http://rrp.sagepub.com/cgi/reprint/39/3/385

Environmental News Service. (2007). "San Bernardino Global Warming Plan Settles California Lawsuit" Access on the web at http://www.ens-newswire.com/ens/aug2007/2007-08-21-091.asp on May 7, 2008.

Fresno County 2007 Regional Transportation Plan (2007). Accessed at: http://www.fresnocog.org/document.php?pid=272

Greene, D., H. Hopson and J. Li. (2003) "Running out of and into oil: Analyzing global oil depletion and transition through 2050." ORNL/TM-2003/259. Oak Ridge TN: Oak Ridge National Laboratory.

Humboldt County 2006 Regional Transportation Plan Update (2006). Accessed at: http://www.hcaog.net/docs/RTP.2006/

IEA (2005) Co2 emissions from Fuel Combustion: 1971-2003. IEA Publications: Paris.

Intergovernmental Panel on Climate Change. (2007) *Climate Change 2007: The Physical Science Basis.* Geneva Switzerland: IPPC.

Joint Policy Committee Bay Area Regional Agency Climate Protection Program (2007). Accessed at: http://www.mtc.ca.gov/planning/climate/

Jonas Åkerman and Mattias Höjer. (2006) How much transport can the climate stand?—Sweden on a sustainable path in 2050. *Energy Policy,* Volume 34, Issue 14, September 2006, pp. 1944-1957.

Kern Council of Governments Regional Transportation Plan - Destination 2030 (2007). Accessed at: http://www.kerncog.org/publications.php#transplan

Lempert, R., S. Popper, and S. Bankes. (2003) Shaping the Next One Hundred Years: New Methods for Quantitative. Long-Term Policy Analysis. Santa Monica: The Rand Pardee Center.

Linstone, Harold A. and Turoff, Murray (2002). *The Delphi Method: Techniques and Applications.* New
Jersey Institute of Technology. Retrieved on Jan 2 from: http://www.is.njit.edu/pubs/delphibook/

McCarthy, Ryan W., Christopher Yang, Joan M. Ogden. (2008). California Baseline Energy Demands to 2050 for Advanced Energy Pathways. Institute of Transportation Studies, University of California, Davis, Research Report UCD-ITS-RR-08-07

Mendocino County 2005 Regional Transportation Plan (2005). Accessed at: http://www.mendocinocog.org/regional_trans_plan2005.shtml

Merced County 2007 Regional Transportation Plan (2007). Accessed at: http://www.mcagov.org/publications/trans.html

Metropolitan Transportation Commission Transportation 2035: 2009 Regional Transportation Plan Vision 2035 Analysis (2008). Accessed at: http://www.mtc.ca.gov/

Metropolitan Transportation Commission MTP2035: Draft Final 2035 Regional Transportation Plan (2008). Accessed at: http://www.mtc.ca.gov/

Ogden, Joan. (2007) Visioning Sustainable Transportation Systems: Near and Long Term Options. Presentation at 4th Annual California Climate Change Conference, University of California Davis, September 13, 2007. Presentation accessed at http://www.climatechange.ca.gov/events/2007_conference/presentations/2007-09-13/2007-09-13_OGDEN_JOAN.PDF on May 9, 2008.

Sacramento Area Council of Governments Metropolitan Transportation Plan for 2035 (2008). Accessed at: http://www.sacog.org/mtp/2035/

Sacramento Area Council of Governments Draft Program Environmental Impact Report for MTP 2035 (2008). Accessed at: http://www.sacog.org/mtp/2035/

San Diego Association of Governments 2007 Regional Transportation Plan 2030 (2007). Accessed at: http://www.sandag.cog.ca.us/index.asp?projectid=292&fuseaction=projects.detail

San Joaquin Council of Governments 2007 Regional Transportation Plan (2007). Accessed at: http://www.sjcog.org/Programs & Projects/Transportation_files/Planning-page.htm

San Luis Obispo Council of Governments Vision 2025: 2005 Regional Transportation Plan (2005). Accessed at: http://www.slocog.org/cm/Programs_and_Projects/Regional_Transportation_Plan.html

Santa Barbara County Association of Governments 2004 Regional Transportation Plan (2004). Accessed at: http://www.sbcag.org/publications.html

Shasta County 2004 Regional Transportation Plan (2004). Accessed at: http://www.scrtpa.org/RTplan.htm

Southern California Association of Governments. (2004) Destination 2030: 2004 Regional Transportation Plan. Los Angeles: SCAG.

Southern California Association of Governments 2008 Regional Transportation Plan (2008). Accessed at: http://www.scag.ca.gov/transportation.htm

Southern California Association of Governments Draft 2008 RTP Program Environmental Impact Report (2008). Accessed at: http://www.scag.ca.gov/transportation.htm

Stanislaus Council of Governments 2007 Regional Transportation Plan (2007). Accessed at: http://www.stancog.org/rtp/rtp.shtm

Tulare County Association of Governments 2007 Regional Transportation Plan (2007). Accessed at: http://www.tularecog.org/

Turton, Hal (2006). Sustainable global automobile transport in the 21st century: An integrated scenario analysis. *Technological Forecasting & Social Change.* 73; 607-629. Accessed at http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V71-4HMNFV9-1&_user=10&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=7849c19f238fc4af5b30f87ce725b8c6 on October 17, 2007.

U.S. Department of Energy. (2006) *Emissions of Greenhouse Gases in the United States 2005.* Washington D.C.: Office of Integrated Analysis and Forecasting.

World Business Council. (2004). Mobility 2030: Meeting the challenges to sustainability. Accessed at http://www.wbcsd.org/DocRoot/uu8taBpoTDXkvBiJHuaU/english_full_report.pdf on May 9**, 2008.**

Ziglio E, M. Adler, E. Ziglio. (1996) *Gazing into the Oracle. The Delphi Method and its Application to Social Policy and Public Health* - London: Jessica Kingsley.