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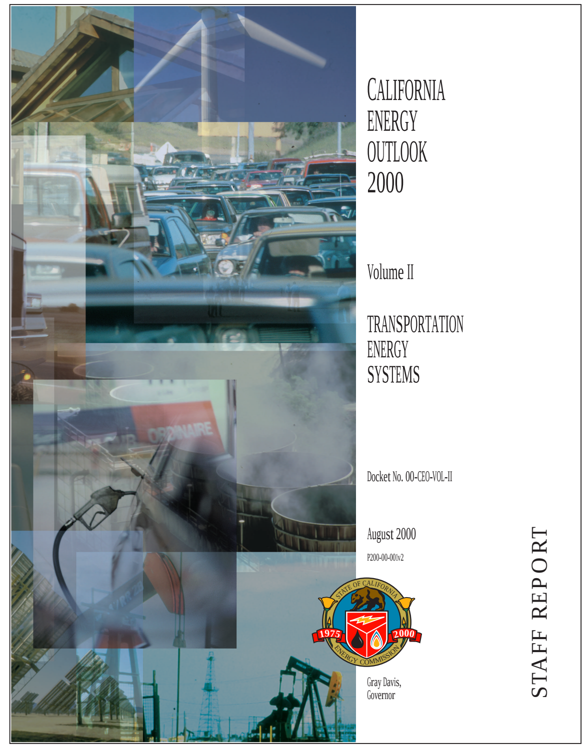

CALIFORNIA

Dan Fong,
Sue Kateley,
Project Managers

Nancy J. Deller,
Deputy Director
ENERGY
TECHNOLOGY
DEVELOPMENT
DIVISION

H. Daniel Nix,
Deputy Director
ENERGY
INFORMATION
& ANALYSIS
DIVISION

Robert L. Therkelsen,
Deputy Director
ENERGY
FACILITIES
SITING &
ENVIRONMENTAL
PROTECTION
DIVISION

Steve Larson,
Executive Director

ACKNOWLEDGMENTS

FUELS AND TRANSPORTATION COMMITTEE

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Chuck Mizutani	Thom Kelly
Manager, Technology Evaluation Office	*Manager, Demand Analysis Office*
	Robert L. Therkelsen
	Deputy Director, Energy Facilities Siting and Environmental Protection Division

PROJECT MANAGERS

Dan Fong	Sue Kateley

CONTRIBUTING AUTHORS

McKinley Addy	Chris Kavalec	Gareth Occhiuzzo	Gordon Schremp
David Ashuckian	Tom MacDonald	Jim Page	Leigh Stamets
Robert Cervantes	Dave Maul	Pat Perez	
Nancy Hanson	Mike McCormack	Nan Powers	

TECHNICAL CONTRIBUTORS

Brian Covi	Kate Sullivan

EDITOR	**COVER PAGE GRAPHICS**
Elizabeth Parkhurst	Sue Foster

LAYOUT AND GRAPHICS

Vincent S. Vibat

SUPPORT STAFF

Gigi Tien	Valerie Burns

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EXECUTIVE SUMMARY

As California s population and economic output continues to grow, our demand for transportation services also grows. If current trends continue, gasoline use is projected to increase by approximately 40% over the next twenty years. Our already strained in-state refining industry will not be able to keep pace with the forecasted growth without major changes in industry operations. Sudden price increases for both gasoline and diesel fuels as a result of unscheduled refinery outages will be more frequent, and higher prices are likely to be sustained for longer time periods.

California cannot continue to rely nearly exclusively on petroleum-based fuels if it desires a stable transportation fuels market in California, particularly because projections indicate that world petroleum production levels will peak and begin to decline in the mid- to long-term. Eventually, California must begin to transition from petroleum as its predominant source of transportation energy to other energy sources. The challenge is to make this transition in such a way that the petroleum-based system continues to function while alternatives are introduced, gain acceptability and become cost-competitive.

In addition to serious concerns over the adequacy and affordability of traditional fuels, public health and environmental concerns also shape our strategies. Increasing numbers of vehicles on California s roads will require further measures to reduce tail-pipe emissions as part of an overall strategy to achieve clean air. Governor Davis directive to phase-out MTBE from gasoline and to use Phase 3 Reformulated Gasoline, beginning in 2003, will help meet environmental concerns and reduce health impacts from vehicle emissions. Further tightening of specifications for diesel fuel is also underway. This will reduce its environmental impact and allow its continued use in engines that are typically more energy efficient than gasoline-fueled engines.

Ninety percent of Californians live in areas where the air is periodically unhealthy to breathe. The California Air Resources Board (CARB) and U. S. Environmental Protection Agency are mitigating these problems through performance standards and through technology innovations developed by the fuels and automobile industries in response to those standards. Growth in vehicle-miles-traveled, however, erodes these gains and attainment of healthy air quality calls for continuing improvement in fuels and end-use technologies.

Issues surrounding global climate change warrant continued attention. Global climate change strategies must address transportation energy use, a major contributor to California s inventory of green house gases.

Independent decisions by federal, State, and regional governments on transportation infrastructure and growth, particularly on land-use planning, will compound California s increasing transportation energy consumption. Land-use policies that encourage development farther from established population centers that force reliance on the automobile for basic mobility embed a level of transportation energy demand for decades to come. This outcome adds to an already increasing trend in energy consumption and reduces flexibility in managing future energy demand.

The federal Corporate Average Fuel Economy (CAFE) standards created vehicles with increasing levels of fuel efficiency. As consumers purchased new vehicles and retired older cars, the average vehicle fleet efficiency increased. The recent consumer trend toward sport utility vehicles (SUVs), with their large size and lower fuel economy, has reversed the increase in overall fleet efficiency. For the first time since 1980 overall vehicle fleet efficiency has declined. Actions that increase average vehicle efficiency can have an important impact on the demand for gasoline, and can conceivably lower demand to the point where existing refinery capacity can meet California s needs with a production capacity margin. This may be important, in turn, to break the cycle of refinery outages, price shocks, and high fuel prices that eventually drift downward, until the next refinery event.

Opportunities to meet transportation energy needs include building new refinery capacity, expanding pipelines and terminal facilities and other actions that would extend the availability of petroleum-based fuels and tend to ease the tight supply and demand situation that exists in California. An especially important near-term action to improve flexibility for refiners to provide adequate supplies of gasoline is a waiver for the Federal requirement of blending oxygenates in reformulated gasoline. Strategies that reduce demand for transportation energy include increased vehicle fuel economy through a combination of government regulations and incentive programs. Increasing the federal Corporate Average Fuel Economy (CAFE) standards and extending their applicability to SUVs, for example, would have a significant impact on future transportation fuel demand. Demand side opportunities also include sound land use planning and flexible work arrangements that reduce the need for travel.

To reduce demand and displace petroleum fuels requires investment in energy efficiency measures, alternative fuel vehicles and other measures. For example, electric vehicles, hybrid electric vehicles, natural gas vehicles, ultra-efficient gasoline and diesel vehicles and fuel cell vehicles are being evaluated as part of the overall vehicle mix. To develop market demand for some of these technologies may require government support in the early years to mitigate their higher initial costs. This is particularly important in light of the amount of time it takes for technologies to penetrate the marketplace.

Developing cultural acceptance of cleaner, more efficient vehicles and creating a fueling network that addresses consumer concern about convenient access to fueling are crucial milestones. The California Air Resource Board (CARB) recognizes the need for non-petroleum based fuels in its Low Emission Vehicle regulations. Through joint efforts between CARB and the Energy Commission, the State is pursuing opportunities to achieve both the energy and environmental benefits of new transportation technologies.

New Initiatives and Next Steps

As noted previously, policy-makers face the challenge of maintaining adequate and affordable fuel supplies for Californians, while gradually transitioning away from a transportation energy system that is dominated by petroleum. A tight balance between fuel production and demand currently exists because the State s refineries are operating at nearly 100 percent capacity most of the time. Because California is relatively isolated (by distance and time) from other fuel producing regions in the U.S., augmenting our fuel supply cannot be accomplished very quickly. These conditions invite increased price volatility whenever in-State fuel production is disrupted. Price spikes are higher and persist longer whenever substitute supply is not readily available to moderate market volatility. Indeed, increased fuel diversity and higher transportation energy efficiency can be justified on the basis of near-term need alone.

While the State of California has a responsibility to act in the public s best interest to sustain a reliable and affordable transportation energy base, government s ability to control prices is limited in a free market economy, particularly when some of the factors are outside the reasonable control of the State and Federal government. Nevertheless, the State can exercise leadership to develop workable strategies to enhance energy supplies, reduce demand and seek reasonable alternatives to petroleum. The transition from a petroleum-based energy supply for transportation is inevitable, but the precise timing is unknown. If the transition is abrupt or no alternatives appear ready, the market response could be chaotic. Government policies and actions designed to ease the gradual transition away from petroleum-based fuels appear to be prudent. Taking responsible action in a transition from petroleum-based fuels, knowing that petroleum supplies will decline, yet not knowing when or how quickly, is a policy-making dilemma.

There are many strategies to remedy the fuel supply and demand dilemma and other societal issues that arise from California s transportation energy use. It is important to both increase California s supply of conventional fuels while at the same time taking steps to moderate demand. The latter does not necessarily imply doing without. Reductions in demand can be achieved through a variety of actions including increasing the efficiency of the future vehicle fleet, and introducing non-petroleum-fueled alternatives. A combination of strategies that affect all dimensions of our transportation energy system, including the demand side of the market, along with successful development of non-petroleum based alternatives, can open opportunities for breakthroughs in improved public health and environmental protection.

Strategies to address near-term supply issues while gradually transitioning away from oil fall within four broad categories:

- **Petroleum Fuel Supply**. Strategies to increasing supplies of petroleum-based fuels to constrain price volatility in the near-term (i.e., 1 to 3 years);

- **Fuel Use Efficiency.** Measures to improve fuel use efficiency and to reduce petroleum demand;

- **Fuel Diversity and Choice.** Ways to stimulate market competition and to enhance consumer choice;

- **Environmental Quality, Sustainability and Internalizing Externalities.** Steps to address California s long-term transportation energy needs without sacrificing environmental quality and sustainability while accounting for the external or indirect costs of transportation energy use.

Solutions that provide relief for the State s near-term fuel supply and demand issues will also contribute to a gradual transition from petroleum-based fuels. Petroleum-based fuels will continue to be the dominant energy source that fuels our transportation system for decades yet to come. No single strategy will be the panacea to solve all of California s transportation energy challenges. Rather, a combination of strategies should be thoroughly evaluated and selected.

To that end, the Energy Commission Staff has prepared a matrix of options that includes ideas developed by the Commission and by members of the public. The Energy Commission will conduct a public workshop to collect comments on these options to spur public debate on their strengths and weaknesses.

Based upon this public dialogue, the Energy Commission will recommend a variety of strategies to address growth in demand for transportation fuels, supply of transportation fuels, public health and environment costs associated with the continued use of petroleum-based transportation fuels, and an orderly, long-term transition from petroleum-based transportation fuels.

CHAPTER 1
TRANSPORTATION ENERGY DEMAND

Introduction

To understand transportation energy demand requires information and knowledge about key factors such as demographic characteristics of the California population, vehicle purchase behavior of households, the influence of economic activity, regulatory measures, and trends in energy consumption. Energy Commission staff use these factors to develop energy demand forecasts in order to examine potential future alternative scenarios and help anticipate future areas of concern.

One major concern is that California may be facing inexorable growth in on-road transportation gasoline use. This, when combined with constraints on supply, suggests that refineries in the State may face major problems in meeting future demand. After providing a description of the current state of California transportation energy use, this chapter examines future transportation energy demand, an analysis that indicates that this concern is indeed warranted. The chapter concludes with a summary and a discussion of the implications of the analysis presented here.

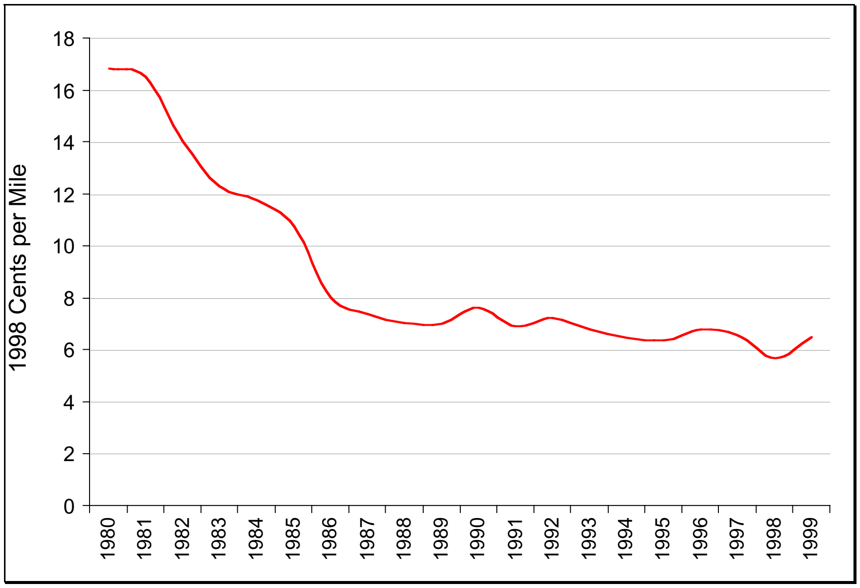
Today s On-Road Transportation Energy Use

Two categories of vehicles, light-duty vehicles and heavy-duty vehicles, account for the majority of California s on-road transportation energy use. The light-duty category is composed of automobiles and light trucks (pickups, vans, and sport utility vehicles). These vehicles, most of which use gasoline, represent nearly all of California s on-road passenger movement. Heavy-duty vehicles include medium- and heavy-duty trucks and buses. Most of these use diesel fuel and these vehicles provide on-road freight movement. A much smaller amount provides passenger transport in the State.

Demographics and economic growth are major characteristics used in developing trends in on-road transportation energy use. From 1980 through 1997 California s population grew at an average rate of 1.9 percent per year. During the same period, the number of on-road vehicles grew at nearly the same rate. Due in part to rising, real per-capita income in the State, total on-road travel increased at a higher rate, an average of 3.4 percent annually. At the same time vehicle fuel efficiency increased significantly during this period, so total gasoline and diesel use increased at a lower rate than travel, an average of 1.7 percent per year.

In addition to population and economic growth, relatively low fuel costs per mile have encouraged growth in light-duty vehicle travel. Since 1980, the real cost of a gallon of gasoline has dropped while fleet-average fuel economy has nearly doubled.[1] The result is that the average fuel cost per mile for light-duty gasoline vehicles is around one-third of what it was in 1980. Figure 1.1 shows the average fuel cost per mile (in 1998 cents) for a gasoline light-duty vehicle from 1980-1999.[2]

Figure 1.1 Average Fuel Cost per Mile, Gasoline Light-Duty Vehicles, 1980-1999



NOTE: Estimated by dividing average price per gallon of gasoline by fleet-average mpg. 1999 value is based on partial year data.

SOURCES: Fuel prices are based on averages in the Bay Area and Los Angeles regions. Fleet-average mpg estimates are from the California Department of Transportation and the Energy Commission.

California On-Road Vehicle Characteristics

There are about 22 million gasoline vehicles and 400,000 diesel vehicles registered in California. Smaller fleets of liquefied petroleum gas, natural gas, alcohol, flexible fuel, and electric vehicles also operate in California, cumulatively totaling less than 60,000 (or less than _ of 1 percent of the vehicle population). In 1999, Californians purchased 994,000 new cars and 828,000 new light-duty trucks. Commercial fleet vehicles account for about one-third of these sales.

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[1] Note that fuel cost per mile is equal to the price per unit of fuel divided by fuel efficiency (miles traveled per unit of fuel).

[2] Gasoline price increases during the year 2000 have raised fuel cost per mile from about 6 cents per mile in 1999 to over 8 cents per mile. However, current costs are still one-half that in 1980.

The overall fleet-average fuel economy of gasoline-fueled light-duty vehicles has steadily increased since the mid-seventies, from about 12.6 mpg to today s 20.6 mpg. However, the trend toward light-duty trucks, particularly minivans and sport utility vehicles, has led to a leveling off of fleet-average fuel economy; for the first time since 1973, fleet-average fuel economy for gasoline vehicles is staying constant or declining slightly.

There are approximately 350,000 heavy-duty vehicles (heavy-duty vehicles are generally defined as those vehicles that weigh over 14,000 pounds), about 90 percent of which use diesel. They use approximately 2.5 billion gallons of diesel fuel annually.

Trends in Key Factors: Population and Economic Growth

California's population is expected to grow at more than 1 percent annually over the next 20 years. The California Department of Finance projects average annual population growth of about 1.4 percent while the *UCLA Anderson Forecast of 1999* projects growth of 1.6 percent annually[3]. These growth rates translate to approximately 12 to 14 million more Californians by 2020, but are slightly below the average annual rate during the last 20 years (around 1.9 percent). The lower growth rate projections, relative to historical values, reflect the aging of the large baby boomer generation [4].

The Anderson Forecast projects unemployment in the State to remain relatively low (around 5 percent) over the next 20 years. Real income per household is projected to grow at an average annual rate of almost 2 percent. This growth rate is roughly double that of the past 20 years, owing in large degree to the impact of the economic recessions in the early eighties and early nineties.

Transportation Energy Demand Forecasts

The Energy Commission forecasts on-road transportation energy demand (including gasoline, diesel, electricity, and natural gas), vehicle miles traveled (VMT), and vehicle stock in California for cars, trucks, buses and light-rail transit. The forecasts presented in this chapter include a base case and alternative scenarios that examine the effects of higher fuel prices and of increased use of alternative fuel vehicles. Gasoline demand projections include freight, transit, and light-duty vehicle (LDV) use. Diesel projections include on-road freight and transit use. The following sections present the assumptions behind, and the main results of, these forecasts. Appendix C provides descriptions of the methodology and data inputs of the model used to generate these forecasts.

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[3] *The UCLA Anderson Forecast for the Nation and California*, September 1999, B-3 to B-6.
[4] The term baby boomer refers to Americans born between the end of World War II and 1960.

Base Case Forecast

The base-case forecast assumes no significant penetration of alternative fuel vehicles, nothwithstanding existing incentive and regulatory programs to encourage and/or require their use. As will be seen later in this chapter, this assumption is not critical for an accurate forecast of gasoline demand as California s current alternative fuel vehicle programs do not have a significant impact on fuel demand. The base case also assumes no increase in new LDV fuel economy for any class of vehicle beyond 1999 levels, reflecting the current lack of incentive to buy (or for auto manufacturers to make) more efficient cars and light-trucks. In addition, the Energy Commission forecast assumes gasoline prices will return to relatively low levels beginning in 2001 ($1.50, in 2000 dollars, from this year through the end of the forecast period). Finally, the Energy Commission forecast assumes sport utility vehicles (SUVs) continue to increase as a percentage of new LDV sales through 2010, at a rate matching that of the last 10 years, roughly 1 percent per year.[5] This means that SUV penetration of new sales would reach 28 percent by 2010 and remain relatively constant thereafter.[6]

Base case projections for electricity and compressed natural gas demand (CNG) include transit applications along with the current number of light-duty vehicles (about 1,300 for electric and 16,000 for natural gas). The transit portion of the CNG demand forecast is derived from information provided by various transit districts.

In the base-case forecast for the State, on-road gasoline demand is projected to increase from 13.9 billion gallons in 1999 to 19.9 billion gallons by 2020, while diesel use is projected to increase from 2.4 billion gallons to 3.4 billion gallons over the same period. On an annual basis, gasoline demand is projected to rise by an average of about 1.8 percent and diesel demand by about 1.5 percent. LDV fleet-average fuel economy is projected to drop by almost 6 percent over the forecast period, from 20.5 mpg in 1999 to 19.3 mpg in 2020. Figure 1.2 shows the projected as well as historical (since 1980) demand for on-road gasoline and diesel.

On-road VMT (light-duty vehicles, freight, and transit) is projected to increase in California from 293 billion miles in 1997 to 401 billion miles by 2020. On an annual basis, VMT is projected to increase by an average of 1.5 percent per year. Light-duty vehicle VMT, which makes up about 95 percent of the total, is projected to increase from 279 to 382 billion miles over the forecast period, also at a rate of 1.5 percent per year.

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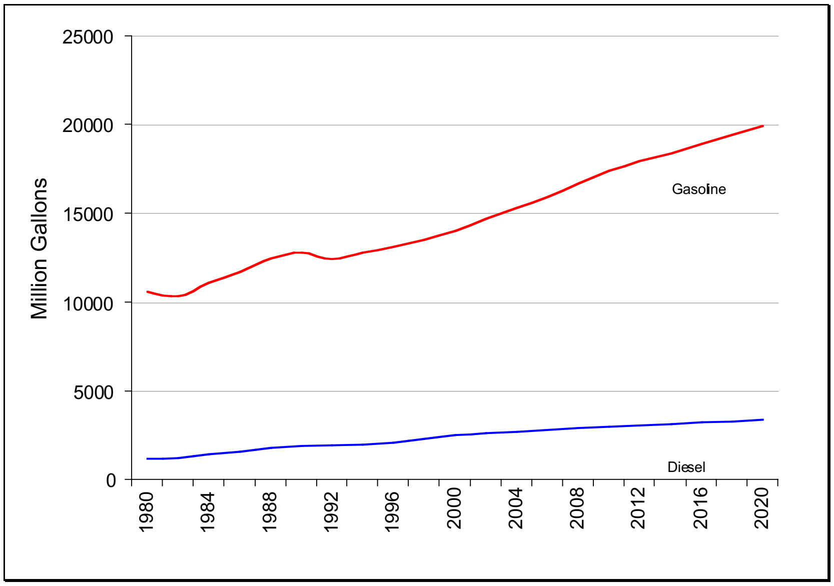
[5] 2010 was chosen as the final year of increase since it is the year in which the baby boomers begin to reach retirement age. Some evidence suggests that drivers 65 and over are less likely to choose an SUV for their next vehicle than those in their forties and fifties (from staff analysis of the *1995 National Personal Transportation Survey*, sponsored by the U.S. Department of Transportation).

[6] Some of the major factors driving the increase in SUV penetration over the last few years (changes in taste, safety concerns, status, etc.) could not be incorporated in the CALCARS model used to forecast LDV demand and usage. Therefore, an exogenous trend variable was introduced to increase SUV penetration rates in the forecast.

Figure 1.2 Historical (1980-1998) and Projected (1999-2020) On-Road Gasoline and Diesel Demand for California; California Energy Commission



By 2020, the number of on-road vehicles is projected to reach almost 30 million in California, up from about 21.8 million in 1999 (of which over 98 percent are light-duty vehicles), an average growth rate of 1.5 percent per year (matching the growth rate of VMT). Primarily due to the continued growth in the penetration rate of sport utility vehicles, light-duty trucks are projected to continue to increase as a fraction of LDV vehicle stock in California, making up over 46 percent by 2020, up from 37 percent in 1999.

Alternative Scenarios

Commission staff also examined the effects of higher gasoline prices and of a much higher rate of alternative fuel vehicle (AFV) penetration. The first alternative case is the same as the base case except the price of gasoline per gallon is assumed to be $2.00 (up from $1.50) beginning in 2001 through the end of the forecast period. In the second alternative case, electric and natural gas vehicles are assumed to begin to substitute for gasoline LDVs at a much higher rate than in earlier years (with all else the same as in the base case). Electric vehicles were assumed to reach penetration levels consistent with the California Air Resources Board (CARB) Zero-Emission Vehicle mandates: around 2.5 percent of new LDV sales[7] in 2003 and about 4 percent thereafter.[8]

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[7] The Zero-Emission Vehicle mandates specify a definition of light-duty vehicles slightly different from that used by the Commission: cars plus light-duty trucks with a loaded vehicle weight of 0-3,750 pounds. Approximately 50 percent of all light-duty trucks (as defined by the Energy Commission) fall into this category, based on the DMV Unladen Weight Report. The percentages assumed here, 2.5 and 4, use the CARB definition and therefore electric vehicles would make up a smaller percentage of Commission-defined LDVs and reflect the use of both multiple and partial ZEV credits in early years by automakers, as allowed by the current regulation.

[8] These percentages are based on comments received from the California Air Resources Board.

Table 1.1 Effect on Gasoline Demand, Travel, and Light-Duty Vehicle Fuel Efficiency of Two Alternative Scenarios (Percent Change relative to base case forecast)

SCENARIO	VARIABLE	YEAR			
		2001	2005	2010	2020
Higher Gasoline Prices ($2.00/gallon)	Gasoline Use	-4.0	-4.5	-4.8	-4.9
	VMT	-3.6	-3.6	-3.6	-3.6
	LDV FUEL EFFICIENCY	+0.3	+0.8	+1.1	+1.1
Alternative Fuel Vehicle Substitution	Gasoline Use	--	-0.8	-1.3	-1.3
	VMT	--	+0.2	+0.6	+1.3
	LDV Fuel Efficiency	--	+1.0	+1.9	+2.7

Table 1.1 provides a comparison of these two scenarios with the base case forecast for 2001 (except in the AFV case), 2005, 2010, and 2020. In the higher gasoline price case, the percentage drop in gasoline demand relative to the base case is increasingly higher throughout the forecast period as average light-duty vehicle fuel economy rises in response to the higher price. The drop

Understanding Vehicle Population and Consumer Trends

With co-funding from the ARB and Caltrans, the Commission has developed a much-in-demand capability to analyze and provide data on the California vehicle population using the DMV vehicle registration database. Vehicle population information is a key ingredient in a variety of transportation analyses. Transportation forecast simulation models such as those employed by the Commission cannot operate without such data as the vintage and class of the vehicles. Accurate vehicle counts and descriptions are needed in the analyses of energy demand, infrastructure needs, and air quality issues. Data are received semi-annually from DMV to allow updating the database and monitoring changes in the fleet.

The vehicle information serves not only as an important element to understand and plan for the State s transportation energy needs, but also affects the work of many other key government agencies. Although originally the project was to meet the vehicle population needs of three agencies, the program now responds to more than 30 requests annually, including many referrals and requests from DMV. Examples of requests include data on 4-wheel drive vehicles for the Department of Parks and Recreation, vehicle counts by size and model year for the Southern California Association of Governments, truck counts by fleet size for the Metropolitan Transportation Commission and commercial fleet counts for the South Coast Air Quality Management District.

Appendix A displays tables of the vehicle data categories addressed by the analysis of the DMV data and Appendix B graphically highlights some of the vehicle statistics supporting the transportation energy demand forecasts presented in this Chapter.

in VMT is relatively constant.[9]

In the AFV scenario, average fuel economy rises for light-duty vehicles at a more noticeable rate as, by 2020, highly efficient electric vehicles make up around 2.6 percent of total light-duty vehicle stock while CNG-fueled cars and light-trucks make up around 1.7 percent. On-road electricity demand would more than quadruple compared to the base case by 2020 (from 746 million up to 3,387 million kWh) while CNG demand would almost double (from 87 million to 173 million therms). AFV ownership at this level would result in more than a one percent decrease in gasoline demand by the end of the forecast period, relative to the base case and VMT increases.

Summary and Implications

Forecasts project California s population will increase by more than 1 percent annually over the coming years and that the economy will remain strong. The Energy Commission forecasts that, at the same time, the cost of travel per mile in gasoline light-duty vehicles will remain relatively low. The Energy Commission forecasts that, as a result of relatively low cost in travel per mile, vehicle miles traveled on-road in the State will increase by over one-third by 2020. The Energy Commission forecasts that these factors, along with the expected continued popularity of light-duty trucks, yield a projected average annual rate of growth for gasoline use of 1.8 percent, with annual demand for gasoline to reach 17 billion gallons by 2010 and almost 20 billion gallons by 2020.

There is currently little incentive for California vehicle owners to buy more efficient vehicles nor for auto manufacturers to make them. The current trend toward sport utility vehicles is in fact reducing fleet-average fuel efficiency, further increasing gasoline demand. The current CARB Zero-Emission Vehicle requirements will help as would use the continued use of CNG-fueled vehicles. However, unless the penetration of alternative fuel vehicles increases significantly over time due to new initiatives, the Energy Commission projects that growth in gasoline demand would be only minimally reduced. Although higher gasoline prices in the State would reduce demand growth, it would appear that prices would have to increase substantially to have a significant effect. Even with a 50-cent per gallon increase over base-case price projections, annual on-road gasoline demand is still projected to increase from 14 billion gallons today to almost 16.5 billion gallons by 2010 and 19 billion gallons by 2020. Programs to increase the vehicle fleet efficiency, such as higher CAF standards or vehicles with high fuel economy would help to reduce demand.

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[9] Vehicle owners respond to a gasoline price increase over time by buying more fuel efficient vehicles. This effect would tend to reduce the percentage decrease in VMT; however, the Energy Commission projects that fleet-average fuel efficiency will continue to drop even with higher fuel prices. This leads to an opposite effect: over time fuel cost per mile (price/mpg) increases, which tends to (all else equal) increase the percentage reduction in VMT. In this case, the two effects effectively cancel each other out.

CHAPTER 2
TRANSPORTATION FUEL SUPPLY AND PRICE

Introduction

This chapter reviews crude oil supplies, non-petroleum fuels, refinery capacity and upcoming changes that are anticipated as a result of the phase-out of MTBE and transition to a new set of gasoline specifications by 2003. The reduced flexibility and fungibility associated with the federal minimum oxygen requirement and expanded use of ethanol are described, along with the costs of the transition. The chapter concludes with the causes and potential mitigation strategies that may be used to combat future fuel price spikes due to the occurrence of major unplanned refinery outages coupled with California s geographically isolated and delicately balanced fuels market.

Crude Oil

Since the mid 1980s, most of the developed countries have reduced their use of petroleum products in the industrial, commercial, residential and electricity-generation sectors by switching from petroleum to other energy sources, and by decreasing energy intensity in those sectors (energy use per unit of economic output). Even so, worldwide demand for crude oil has grown at an average rate of 1.5 percent per year since the mid-1980s. Transportation in the United States and other developed countries remains almost entirely dependent on petroleum products and demand continues to rise.

During the past year or so, OPEC and a few large non-OPEC oil exporters have limited output by almost four million barrels per day in order to raise prices. This decline in production benefited U.S. and California oil producers as strong demand steadily depleted oil and product inventories worldwide. Prices for premium crude oils such as West Texas Intermediate and Brent Blend briefly broke $30/barrel during early March 2000 and again in June 2000. The price of low-quality, heavy California crude oils, such as Kern River, more than tripled compared to prices in early 1999. Figure 2.1 illustrates the change in world crude oil prices over the last three decades. Although OPEC has agreed to increase production to ease prices during the remainder of 2000, most analysts expect prices to remain strong at least through the end of the year due to the depletion of inventories.[10] But even if the crude oil price for 2000 averages out to $28 per barrel, when adjusted for inflation, the price is considerably less than the peak of 1980 — 81.

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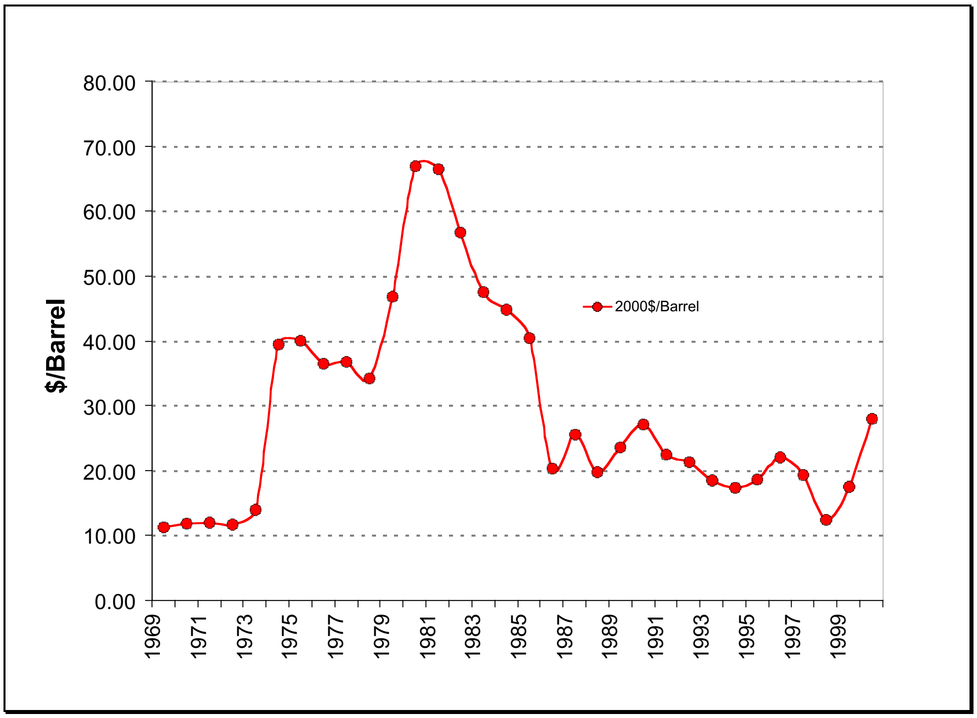
[10] Department of Energy/Energy Information Administration (March 6, 2000). Short-Term Energy Outlook Summary. Washington, D.C.

Petroleum Intelligence Weekly (April 17, 2000). Pundits Expect Prices to Hold Firm This Summer. Energy Intelligence Group, Inc. New York, N.Y.

Gasoline prices are higher today than comparable periods in the recent past primarily due to elevated crude oil prices. In 1999, the crude oil cost component of a gallon of gasoline was about 40 cents, today it is approximately 60 cents. OPEC s ability to increase and sustain world prices to even higher levels is doubtful because substantially higher prices would eventually trigger a move away from crude oil dependence to a greater mix of alternative energy sources by a number of nations.

Figure 2.1 World Crude Oil Prices — Year 2000$ (1969 — 2000)



Substantial petroleum reserves exist in a wide variety of locations. Many geologists see a looming peak and subsequent decline in production of conventional oil. These geologists would further argue that the production peak is likely to occur considerably sooner for non-OPEC countries (in the mid-term) than for OPEC (in the long-term), placing increased market power in a handful of oil exporting countries. This would increase the potential for higher average prices, higher price volatility, or both.

Transportation Fuels

Gasoline and diesel produced from crude oil are the dominant transportation fuels used in California and the rest of the United States. Thousands of motorists and various businesses use alternative fuels in their vehicles, such as compressed natural gas, propane, liquefied natural gas,

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Petroleum Intelligence Weekly (March 20, 2000). BP s Arco Deal Reshapes West Coast US Market. Energy Intelligence Group, Inc. New York, N.Y.

electricity, and methanol, but these fuels currently meet only a small fraction on the State s total fuel demand. Without significant, new State intervention, the Energy Commission expects alternative fuels to remain at or near current levels of use over the near and intermediate terms due to the inertia in the system, the relatively higher direct cost of alternatives, and the need for significant modifications to the existing fueling distribution infrastructure. However, over the long term, crude oil supplies will decline resulting in rising prices that will change the relative economics of competitors to petroleum fuels.

A new cleaner alternative fuel supply made from natural gas is being produced as a possible fuel supply extender for diesel-fueled engines. Recent progress with Fischer-Tropsch technology for converting natural gas into a synthetic diesel fuel is making this fuel source more competitive with petroleum based fuel. Producers believe this synthetic fuel can be economically attractive when crude oil approaches $20 per barrel[11]. In the mid-1990 s process improvements were commercially demonstrated. Today, nearly every major oil company has announced plans to build GTL-Diesel plants. Total production volume (worldwide) of this new GTL-Diesel is expected to exceed 200,000 barrels per day by 2006. While difficult to project, some of this fuel may be imported by California refiners due to its desirable fuel qualities and emission performance in diesel engines.

California refineries process nearly 1.8 million barrels per day of crude oil. In 1999, California sources accounted for 828 thousand barrels per day or 48 percent of the State s total crude oil demand. During this same period, an average of 530 thousand barrels per day (30 percent) was imported from Alaska and nearly 386 thousand barrels per day (22 percent) from foreign sources. The proportion of foreign imports has begun to increase in recent years, however, and will likely continue to grow in the future. But since crude oil is a global commodity, the price of imports is not expected to vary considerably compared to other sources, when adjusted for differences in quality.

The California petroleum industry meets demand for refined products through a combination of production and imports of blending components and finished products. California has been relatively self-sufficient with regard to its supply of petroleum fuels. Imports of finished gasoline and diesel fuel for use in California usually are modest in volume, less than 5 percent of total demand. But imports of gasoline and diesel blending components that are used by refiners to expand production normally account for over 15 percent of total demand. Over the near and intermediate term, the Energy Commission expects the volume and importance of imports to grow due to increasing demand for petroleum-based transportation fuels and due to the phase-out of MTBE.

California refineries have kept pace with gasoline and diesel demand, which has increased 35 and 94 percent, respectively, between 1982 and 1999 (Fig. 2.2). Refiners accomplished this in spite of the significant number of refineries shutting down in California:

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[11] *Gas-to-Liquid News*, page 6, July 1999.

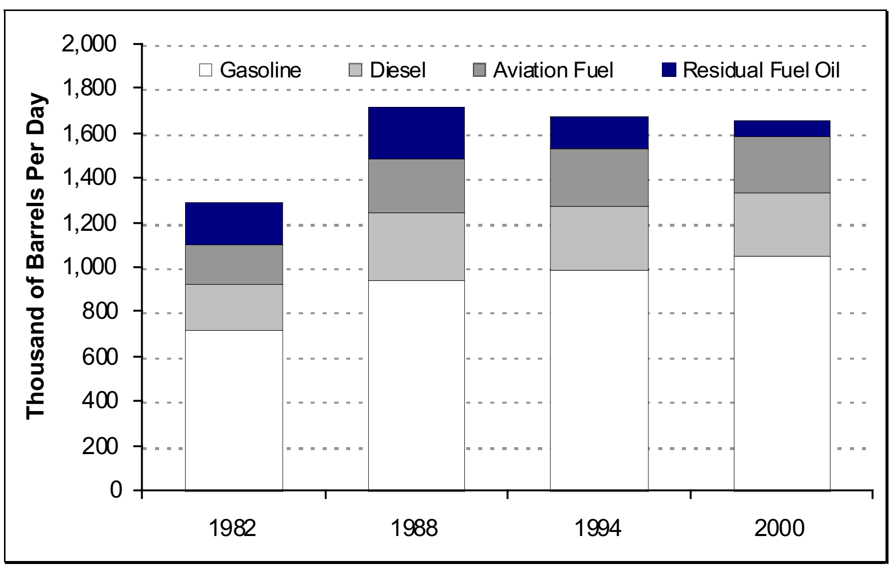
- Refiners are now using what was formerly excess production capacity to increase the amount of crude oil that they process to a level that nearly equals the operational capacity of their equipment. In 1982, the refinery utilization rate was 71 percent.[12] Today, refineries operate at nearly 100 percent of the capacity of their crude oil processing units, allowing them to produce greater volumes of gasoline and other refined products.

- Major modifications were completed to meet the reformulated diesel specifications of 1993 and RFG specifications of 1996, enabling refiners to produce additional volumes of diesel and gasoline from the conversion of less desirable components such as residual fuel oil.

- Refiners gradually increased the processing capacity of key pieces of refinery equipment during periods of routine maintenance. This allowed them to produce more refined products without having to increase crude oil use.

- Refiners have used oxygenates to help meet the Phase 2 RFG regulations and extend their supply of gasoline. The addition of oxygenates, the majority of which are imported from outside the State, increases the physical volume of the gasoline/oxygenate blend compared to the same amount of gasoline without an oxygenate. This has enabled refiners to expand the supply of gasoline by over 10 percent without a corresponding increase in crude oil processing.

Figure 2.2 Fuel Production For All California Refineries (1982 — 2000)



[12] California Energy Commission, *1995 Fuels Report*, publication number P300-95-017, April, 1996, page 18.

MTBE and Phase 3 RFG

Methyl tertiary butyl ether (MTBE) is a gasoline blending component used as a gasoline oxygenate. Initially, refiners used MTBE as a source of octane in gasoline as tetra ethyl lead (TEL) was phased out of use. Beginning in 1992, fuel specifications increased to require higher levels of oxygenate in during the winter months to help control carbon monoxide emissions. But beginning in 1995 and 1996, refiners began to blend with MTBE on a continuous basis because the federal Clean Air Act required a minimum amount of oxygen in gasoline to help satisfy Reformulated Gasoline (RFG) regulations. The concentration of MTBE contained in RFG usually ranges between 11 and 15 percent by volume.[13]

Beginning in the mid-1990s, use of MTBE began to raise concerns because investigators found trace amounts of MTBE in a number of monitoring wells throughout the State. Compared to most compounds found in gasoline, MTBE dissolves more readily in water, travels faster and farther in aquifers, and is more expensive to remediate from a contaminated site. In the fall of 1998, scientists and research specialists with the University of California (UC) completed a health and environmental assessment of MTBE.[14] The authors of the assessment found that there are sufficient risks associated with water contamination from MTBE to recommend consideration of phasing out MTBE over an interval of several years.

Based on the UC study, the Energy Commission s MTBE report,[15] and the potential for MTBE cleanup costs to exceed billions of dollars per year, Governor Davis determined that on balance there is a significant risk to the environment from using MTBE in gasoline in California. The Governor subsequently issued Executive Order D-5-99 on March 25, 1999 calling for the elimination of MTBE by a date no later than December 31, 2002. The Governor also directed the Energy Commission to determine whether the MTBE phase-out timeline could be advanced. In June 1999, the Energy Commission completed its analysis and concluded that, to ensure adequate supply and availability of gasoline for California consumers, the timetable for removal of MTBE from California s gasoline should not be advanced any earlier than the deadline of December 31, 2002.[16]

Directed by the Governor s Executive Order and subsequent legislation, the ARB approved a set of gasoline specifications on December 9, 1999 referred to as Phase 3 RFG. This action requires the removal of MTBE while preserving the real world air quality benefits achieved by Phase 2

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[13] Eleven percent by volume MTBE is used to supply the 2 weight percent oxygen requirement and the US EPA limits the use of MTBE to no more than 15 percent by volume.

[14] University of California, *Health & Environmental Assessment of MTBE — Report to the Governor and Legislature of the State of California as Sponsored by SB 521*, November, 1998.

[15] California Energy Commission, *Supply and Cost of Alternatives to MTBE in Gasoline*, publication number P300-98-013, February, 1999.

[16] California Energy Commission, *Commission Findings: Timetable for the Phaseout of MTBE from California s Gasoline Supply*, publication number P300-99-03, June, 1999.

RFG. Compared to Phase 2 RFG, Phase 3 RFG will have lower levels for both sulfur and benzene, increased flexibility for the distillation temperatures of gasoline hydrocarbons, and a prohibition on the use of MTBE. These new requirements also placed conditions on the use of any oxygenate other than ethanol.[17] Refiners are to implement the new fuel specifications on December 31, 2002, the same date that MTBE is to be removed from gasoline.

Federal Minimum Oxygen Requirement

Current federal regulations limit California refiners options and flexibility for producing Phase 2 RFG, resulting in higher costs to consumers and more extensive use of MTBE than is necessary. As California transitions to MTBE free gasoline after 2002, the federal minimum oxygen requirement will further reduce flexibility for producing Phase 3 RFG and result in a greater impact on the cost of gasoline. This is because refiners will be limited to one oxygenate, ethanol.

Since most areas in California are classified under federal law as severe or extreme non-attainment for ozone, the federal RFG fuel specifications apply to all motor vehicle fuel sold in those areas. This requirement applies to about 70 percent of California s gasoline.[18] However, ARB has petitioned the U.S. Environmental Protection Agency (US EPA) to waive the federal minimum oxygen requirement for such areas and has demonstrated that substantially greater NO_x reductions could be achieved if their request is granted.[19] ARB requires that the State use its own type of RFG. Under California s existing Phase 2 and recently adopted Phase 3 RFG regulations, refiners can produce gasoline that fully complies with State fuel regulations without the use of any oxygenates, including MTBE and ethanol. The petition is currently under consideration. If the waiver of the federal minimum oxygen requirement is granted by the US EPA, some of the fungibility and flexibility difficulties associated with the transition to 2003 could be diminished.

Because ARB regulations for Phase 3 RFG do not require the use of oxygenates, an additional benefit of a waiver is that refiners in California would be able to substantially reduce the volume of MTBE they currently use in gasoline well before the phase-out deadline of December 31, 2002. Since the San Francisco Bay Area is in attainment for ozone, gasoline sold in this region does not require the use of Federal RFG, which contains a requirement for an oxygenate. This is

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[17] Section 2262.6(c) of the California Reformulated Gasoline Phase 3 Amendments. In the future other types of oxygenates could be used if a multimedia evaluation of the use of that type of oxygenate in California gasoline is conducted and the California Environmental Policy Council that was established by Public Resources Code section 71017 determines that such use will not cause a significant adverse impact on the public health or the environment.

[18] It is probable that the US EPA will propose to reclassify the San Joaquin Valley Air Basin from serious to severe ozone nonattainment status within the next two years. This region of the State accounts for approximately 10 percent of gasoline sales, thus the total share of gasoline sold in all severe and extreme ozone nonattainment regions by 2003 could reach 80 percent.

[19] Letter to Robert Perciasepe, Assistant Administrator for Air and Radiation, U.S. Environmental Protection Agency, from Chairman Lloyd of the California Air Resources Board, dated December 24, 1999. Oxides of nitrogen (NO_x) are a precursor for the formation of ozone.

one of the reasons why a number of Northern California refiners are producing a portion of their gasoline without the use of any MTBE.[20] This practice would expand to other areas of the State if the federal minimum oxygen requirement were to be waived, diminishing the use of MTBE by an estimated minimum of 30 percent from the current volume.[21] Since the State used an average of approximately 4 million gallons per day of MTBE during the first quarter of 2000,[22] a 30 percent reduction would be equal to at least 1.2 million gallons per day of MTBE.[23] However, a waiver would not result in an immediate displacement of MTBE since refiners would still require its use until refinery modifications are completed. The permitting, construction, and testing associated with these projects are expected to take over two years to complete.

Expanded Use of Ethanol in California

By 2003, the Energy Commission projects that total volume of oxygenates used in California s gasoline will decline because ethanol contains a greater amount of oxygen. This means that lower concentrations of ethanol are required per gallon of gasoline to meet the federal minimum oxygen requirement. The result is that refiners will need approximately 54,000 to 85,0000 barrels per day of ethanol to replace the 115,000 barrels per day of MTBE that they will phase out by the end of 2002. While the Energy Commission anticipates that oxygenate volumes will decline, exports of certain components that contain undesirable characteristics will increase by 15,000 to 48,000 barrels per day. The net result is that imports of gasoline and blending components will have to increase significantly by the 2003 summer driving season to meet California s increasing demand, absent a significant expansion of existing refinery capacity.

Currently, refiners typically add MTBE to gasoline at refineries before shipping it to fuel terminals located throughout the State where the fuel is temporarily stored. The fuel distribution infrastructure does not have enough storage tanks to allow the gasoline produced by each refiner to be segregated in individual tanks. This is why most of the gasoline shipped through these terminals is stored in community tanks. The cost to segregate and store gasoline production for each individual refinery that will be shipped through the pipeline distribution infrastructure would be prohibitively expensive. In many locations, there is inadequate space to build new tanks even if the costs were reasonable.

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[20] The percentage of MTBE-free gasoline varies among these refiners. Premium grades of gasoline are more likely to contain MTBE to meet octane requirements, while the majority (in some cases) of the regular grade is produced without the use of MTBE or at greatly reduced concentrations.

[21] Even if the federal minimum oxygen requirement were waived, refiners would still be required to sell oxygenated gasoline in the Los Angeles Air Basin during a 4 month winter period because the region has not yet come into attainment for carbon monoxide standards.

[22] California Energy Commission, *Quarterly Report - MTBE Use In California Gasoline*, publication number P300-00-005, vol. I, May, 2000, page 1.

[23] Based on the 4 million gallons per day of MTBE that was used during the first quarter of 2000 and the estimated 30 percent near-immediate decrease in use.

The greatly expanded use of ethanol also reduces the fungibility and flexibility in the distribution infrastructure of California. Limitations imposed by the common carrier pipeline system operators[24], prohibitions against commingling RFG containing ethanol with non-ethanol RFG blends, and compliance with fuel volatility specifications when using ethanol will result in reduced flexibility for refiners when they begin to produce Phase 3 RFG without MTBE. The expanded use of ethanol will create significant changes that will directly affect gasoline blending and distribution practices currently used by California refiners to supply fuel to the State s consumers.[25] Refiners, pipeline operators, terminal owners, State regulators, and other interested stakeholders recognize that steps should be taken to retain the maximum amount of flexibility for refiners, thus minimizing operating expenses and helping to maintain a satisfactory fuel supply.

Monitoring Future Progress

The phase-out of MTBE, greatly expanded use of ethanol necessitated by the federal minimum oxygen requirement, transition to Phase 3 RFG, and continued strong growth in gasoline demand will require modifications to refineries and the transportation distribution infrastructure. The Energy Commission and the Air Resources Board will monitor the progress of these modifications, especially in light of the limited time remaining prior to the transition deadline of December 31, 2002. In addition, the two agencies will report on the adequacy of supplies for both ethanol and key gasoline blending components, identify any logistical constraints emerging in the distribution infrastructure, and determine the implications of an early phase-out of MTBE for a portion of the California market. As warranted by our assessment of information gathered through ongoing meetings with and surveys of various stakeholders, any potential developments that could adversely impact the supply and price of California s fuels will be evaluated and addressed.

Cost Impacts of MTBE Removal and Transition to Phase 3 RFG

In December 1999, the Energy Commission presented an estimated economic impact of phasing out MTBE and moving to Phase 3 RFG specifications. The results of this analysis (illustrated in Figure 2.3) indicate that the average cost to produce gasoline is expected to increase by 3.4 to 6.4 cents per gallon by 2003. [26] The least expensive option would result if refiners were permitted to produce an optimal combination of gasoline containing ethanol and gasoline

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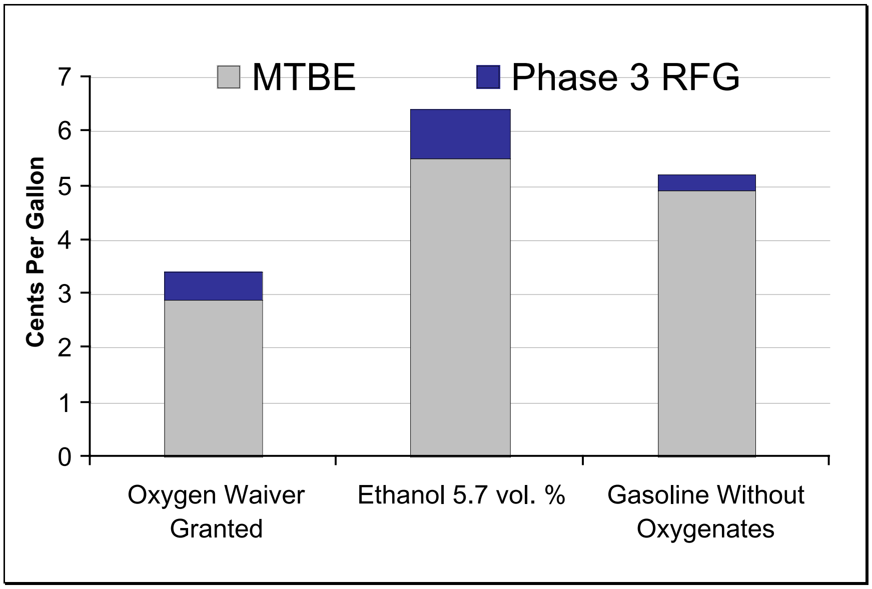
[24] Operators of the common carrier pipeline system in California are expected to limit the concentration of ethanol that can be mixed with gasoline stored in their community storage tanks to a single level. Segregation limitations and the intent to provide the maximum degree of fungibility possible are the primary factors that are expected to result in this limitation.

[25] These individual scenarios are described in greater detail in Appendix F.

[26] MathPro, Incorporated, *Analysis of California Phase 3 RFG Standards*, publication subcontract number LB60100, December 7, 1999. It should be noted that the work completed by MathPro was in advance of the December 9, 1999 ARB hearing. The actual set of specifications adopted by the ARB was slightly different than those modeled by MathPro. It is estimated by Energy Commission staff that the impact of this change will be to reduce the estimated costs to comply with the Phase 3 RFG specifications to a level of less than 1 cent per gallon. The larger component

Figure 2.3 Average Production Cost Impacts — MTBE Removal and Phase 3 RFG



containing no oxygenates.[27] A waiver of the federal minimum oxygen requirement would allow refiners to use an optimal, rather than mandated, amount of ethanol. Average production cost impacts could then be reduced by 1.6 to 3.1 cents per gallon, compared to the required use of ethanol, saving consumers between $250 million and $485 million per year.[28]

The waiver scenario is less costly primarily because the combined volume of ethanol and gasoline blending components imported into California is less than the amount used in the scenarios mandating ethanol. Another factor is that the energy content of gasoline containing ethanol is lower than gasoline without ethanol. This effectively causes consumers to have to purchase additional fuel to travel the same distance. Refiners will still have to make investments at their facilities, regardless of the extent that ethanol is used in gasoline. Although the types of modifications may vary under the different scenarios, the total investments required at all of the refineries are similar with or without the use of ethanol.

A national phase-out of MTBE will exacerbate concerns about the use of ethanol and gasoline components required to produce reformulated gasolines in California and the rest of the nation.

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of the estimated 3.4 to 6.4 cents per gallon increase in average production cost is directly attributable to the expenses incurred to eliminate MTBE.

[27] The optimal combination result from this report was that 60 percent of the State s gasoline supply contained ethanol at a concentration of 7.8 percent by volume, while the remaining 40 percent of the State s supply consisted of gasoline without any oxygenates.

[28] Savings are calculated based on an annual gasoline demand of 15.67 billion gallons by 2003.

Under such a phase-out, the average cost for California gasoline was estimated in the 1998 MTBE report to increase over the intermediate term by nearly 5 cents per gallon. This increase would primarily be caused by the higher price of ethanol that would result from a national MTBE ban. A national MTBE phase-out will also likely increase demand for clean gasoline components such as alkylate and elevate their prices. The Energy Commission s previous cost analysis did not include this consideration. Therefore, the cost of gasoline for all consumers is expected to be higher under a national MTBE ban. Under this scenario, the need for a waiver from the federal minimum oxygen requirement is more imperative.

Even though the production cost increases associated with MTBE phase-out and moving to the cleaner Phase 3 RFG are modest, the tightening supply picture in conjunction with the federal minimum oxygen requirement creates circumstances that could potentially lead to more frequent and larger price spikes. As Californians have experienced in the past, prices rise suddenly and fall slowly. Thus, with tighter supplies California can expect prolonged periods of higher prices associated with major unplanned refinery outages.

Potential Mitigation Strategies — Temporary Market Imbalances

Petroleum markets throughout the United States and California experience rapid increases in the retail price of gasoline and other petroleum products when supply and demand enter into a period of temporary imbalance. Most of the time, some event or combination of events cause a temporary tightness of supply within some specific geographic region. Supplies can be significantly reduced when production is curtailed by major refinery problems caused by electrical outages, equipment failures, and accidents. Supplies can also be impacted by problems in the distribution system related to such events as product pipeline failures and unavailability of marine vessels used to transport petroleum products.

Unplanned refinery outages can have a dramatic impact on retail prices. A 16 cents per gallon increase in the wholesale price of diesel occurred over a period of three weeks in October 1993. That price spike was mainly due to refinery problems and low inventories that resulted from the changeover to the reformulated diesel fuel during the peak demand period. There was also a surge in demand by market participants in an effort to avoid price increases that were anticipated from a federal fuel excise tax hike and the cost of the new complying diesel fuel. During April of 1996, the Shell refinery in Martinez experienced fires that damaged some key pieces of gasoline-producing equipment, affecting more than 10 percent of the State s production capability. Within a matter of weeks, the wholesale and retail prices of gasoline increased by 26 and 27 cents per gallon, respectively. More recently, a fire at Tosco s Avon refinery in February of 1999 led to the temporary closure of the refinery, prompting another jump in prices for both gasoline and diesel. Prices jumped again following a fire at Chevron s Richmond refinery in March 1999. These two major refinery outages, combined with a number of other refinery equipment problems, reduced gasoline production capability in the State by over 15 percent for a number of weeks. Ultimately, the retail price of gasoline increased by over 52 cents per gallon between February and April of 1999. These events illustrate how sensitive the California market has become to significant production disruptions.

One strategy could be to decrease the time and distance factor by increasing the volume of alternative supplies available within the State. Fuel reserves, flexibility in executing regulatory standards, and pipelines to import fuel have been raised as potential strategies to mitigate the effects of price spikes. The corresponding additional supplies could be used as another resource for refiners that have experienced a severe refinery outage. Such strategies could reduce the amount of time involved to bring additional supplies to market in the State, thus reducing the duration and magnitude of the price spike.

Strategies designed to reduce demand could also have the same beneficial impact by increasing refinery capacity. Voluntary conservation and measures to avoid unnecessary inventory building are some near-term steps that could be undertaken during periods of price spikes. But longer-term reduction strategies would have to be significant enough to decrease demand to levels below that of today, thus increasing the fuel production capacity reserve of California s refineries. However, this approach may not accomplish the desired outcome if the reduction strategies only offset the growth in demand. The State will experience continued exposure to price spikes over a longer period of time if the status quo is maintained. Although average cost to consumers during periods of normal refinery production operation would be lower, compared to a situation of greater dependence on imports, the cumulative impacts of price spikes resulting from major refinery problems could be significant.

Summary and Implications

The combination of strong growth in gasoline demand, phase-out of MTBE, greatly expanded use of ethanol necessitated by the federal minimum oxygen requirement, and transition to Phase 3 RFG could have a significant impact on the delicate balance between supply and demand of transportation fuels in California. The ability of refiners to consistently supply volumes of gasoline to meet California demand will be impaired by the loss of flexibility associated with the phase-out of MTBE with a continued federal oxygen mandate that will necessitate the greatly expanded use of ethanol as an MTBE replacement. This, in turn, is expected to diminish the fungibility of gasoline due to limitations in the distribution infrastructure. All of these factors will pose challenges that must be overcome to produce increasing volumes of cleaner-burning transportation fuels to meet California s demand. . In the near-term, obtaining the federal oxygenate waiver will be of critical importance to meeting these challenges.

Although the State has a responsibility to act in the public s interest to sustain a reliable and affordable transportation energy base, government s ability to influence the marketplace to reduce price spikes has limits. Some factors, such as rapid increases in crude oil cost, are outside the reasonable control of the State or federal government. Nevertheless, the State can exercise its leadership to develop workable strategies that provide benefits to consumers that outweigh market benefits. Chapter 4 contains a more detailed examination of various strategies to increase supply and reduce demand over both near and long term time periods.

California, however, cannot continue to rely nearly exclusively on petroleum-based fuels if it desires a stable transportation fuels market in California. Eventually, California must begin to transition from petroleum as its predominant source of transportation energy to other energy sources. The challenge is to make this transition in such a way that the petroleum-based system continues to function while alternatives are introduced, gain acceptability and become cost-competitive.

CHAPTER 3
PUBLIC HEALTH, THE ENVIRONMENT AND SUSTAINABILITY

Introduction

Although California s economy is by most metrics demonstrating robust growth and productivity, growth in demand for transportation energy and fuel supply constraints creates difficulties that affect individuals and companies. Those difficulties include near-term price spikes and long-term supply considerations that affect the costs of transportation for the direct user. However, there are additional costs that direct users do not pay for that affect all Californians, regardless of the type of transportation they use or how much transportation they need. These costs include human health problems, environmental damage and productivity losses due to traffic congestion. In the longer term, the costs of transportation may include environmental damage that affects future generations in the form of global climate change.

Human Health

Although California has made great strides in cleaning up smog and soot, air pollution still threatens the health of millions of Californians. Fragile lung tissue is easily damaged by pollutants in the air, resulting in increased risk of asthma and allergies, chronic bronchitis, lung cancer, and other respiratory diseases.

Ozone

A powerful respiratory irritant, ozone is found in most of California s urban areas during summer months. Ozone forms primarily from the action of sunlight on reactive organic gases (hydrocarbons) and nitrogen oxides, both of which come from automotive exhaust and other combustion sources. Excess exposure to ozone may lead to shortness of breath, chest pain when inhaling deeply, wheezing, and coughing. In addition, long-term, repeated exposure to high levels of ozone may lead to large reductions in lung function, inflammation of the lung lining, and increased respiratory discomfort. The EPA estimates that 5 to 20 percent of the total U.S. population is especially susceptible to the harmful effects of ozone air in the air.

While excessive exposure to ozone causes adverse health effects in most people, children are especially susceptible to these effects because their respiratory rate is higher than adults. Children also spend significantly more time outdoors, especially in the summertime when ozone levels are highest. National statistics show that children spend an average of 50 percent more time outdoors than do adults. The frequency and extent of exposure results in a greater dose of pollution to their lungs. A recent American Lung Association study[29] shows that as many as

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[29] American Lung Association

27.1 million children age 13 and under, and over 1.9 million children with asthma, are potentially exposed to unhealthful levels of ozone based on the new 0.08 ppm, eight-hour ozone-level standard. Air pollution, including ozone, can result in more frequent respiratory infections in children due to impairment of the lung's ability to defend itself. Scientists are concerned that children who experience more frequent lower respiratory infections may be at greater risk of lower-than-normal lung function later in life.

California has six major ozone non-attainment areas. These are the Sacramento Metropolitan Area, San Diego, San Joaquin Valley, South Coast, the Southeast Desert, and Ventura. Each of these regions currently violates the national ozone standard and has a serious, severe, or extreme classification. These metropolitan areas combined are home to the majority of California s population.

Particulates

In addition to California s concern regarding unhealthful ozone levels, the ARB formally identified particulate emissions from diesel-fueled engines as a toxic air contaminant in August 1998.[30] According to a study by the South Coast Air Quality Management District, cancer risk from carcinogenic air pollutants, including diesel particulates, ranges from about 1,100 per million to 1,750 per million. Higher risk levels were found in the urban core areas of Los Angeles County. Diesel soot accounts for 71 percent of the cancer risk. Other gasoline compounds, including 1,3 butadiene, benzene, carbonyls, account for the remaining cancer risk. In all, mobile sources are the cause of about 90 percent of these pollutants.

Central California has consistently exceeded both the national and State air quality standards for particulate matter that is smaller than 10 microns in diameter (PM10) and the new national standards for particulate matter smaller than 2.5 microns (PM2.5). The adverse air quality from particulate matter alone compromises the health of the more than 10 million people living in the region and adversely impacts their quality of life. Particulate matter is especially harmful to people with lung disease such as asthma and chronic obstructive pulmonary disease, which includes chronic bronchitis and emphysema, as well as people with heart disease.

Exposure

New studies have also indicated that exposure to pollution is up to 10 times higher inside vehicles than in outside air.[31] This increased exposure is due to cars surrounded by emissions from other vehicles while on freeways and streets. Additional research shows that toxic levels are 2 to 4 times higher inside cars than outdoors. A diesel truck directly in front of a passenger car can account for 50 percent of the pollutants inside that car. The air inside cars in uncongested traffic lanes were 30 to 50 percent cleaner than cars travelling in more congested

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[30] Multiple Air Toxics Exposure Study by the South Coast Air Quality Management District
[31] Study by the Research Triangle Institute of Research sponsored by the ARB and South Coast Air Quality Management District.

lanes. Particulate levels were three to five times lower inside cars that followed ethanol- or compressed natural gas transit buses as compared to diesel buses.

New research has also identified moderate air pollution as a factor that might trigger sudden deaths by changing heart rhythms in people with existing cardiac problems. Experts have estimated that particulate pollution may cause 1 percent of all heart disease fatalities in the United States.

Toxics and Volatile Organic Compounds

The extent of air pollutants and other environmental impacts from the use of motor vehicles go beyond traditional criteria pollutants from tailpipes of automobiles. Ozone, carbon monoxide, oxides of nitrogen, volatile organic compounds (VOCs), 10-micron sized particulate matter, sulfur dioxide, and particulate matter less then 10 microns in size are also accompanied by toxic compounds. Although toxic air emissions have been identified and classified to a large extent over the last fifteen years by the U.S. Environmental Protection Agency and CARB, these emissions have not had the kind of rigorous scrutiny that have been applied to criteria air pollutants. It is perhaps by chance that good progress in controlling both classes of pollutants has occurred over the last twenty-five years[32].

Traffic Congestion

Increased traffic congestion in California causes more stop-and-go driving, which in turn affects transportation energy use, air pollution, and travel times. While the number of licensed drivers increased by 31 percent from 1980 to 1997, the number of lane miles of State highways increased by only 5 percent and daily vehicle miles per lane increased by 66 percent.[33] From 1987 to 1998, the California Department of Transportation estimated daily vehicle-hours of delay more than doubled on urban freeways.[34]

Costs due to Public Health, Environmental and Traffic Congestion

Data on California s transportation costs related to public health effects for transportation activities or for the Nation s transportation activities are not available. Within a region of California, known as the South Coast Air Basin, the American Lung Association estimates the health effects costs due to unhealthy air to be between $9.4 billion and $14.3 billion.[35] According to the Environmental Protection Agency, U.S. industry paid an estimated 2.1 percent of the Gross Domestic Product in 1990 and 2.6 percent of the Gross Domestic Product in 1996 to

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[32] U.S. Environmental Protection Agency, 25 th Anniversary Review of Progress on Air Quality
[33] Caltrans, *Assembly of Statistical Reports 1997*, 80-83, August, 1999.
[34] Caltrans, *1998 HICOMP Report*, 2-9.
[35] The Health Costs of Air Pollution, American Lung Association, 1990.

comply with federal health and environmental regulations.[36] (The public paid some portion of these compliance costs through the purchase of products and services). The $210 billion in 1997 may underestimate true costs according to some economists. EPA puts health benefits resulting from the investment in compliance at between $ 4.8 and 28.7 trillion in 1997.

Just as in economic activity,[37] a multiplier effect occurs in environmental impact. Through life cycle analysis, transportation systems show broader and longer lived environmental impacts than found in just end-use considerations. This cradle-to-grave perspective incorporates impacts from all activities to design, produce, maintain, supply, rebuild, replace, and dispose of the transportation system at the end of its useful life.

Although many studies attempt to quantify external costs, the quantitative results of these studies vary by an order of magnitude for many of the cost categories. For example, Delucchi[38] estimates that the annualized cost of externalities created by motor vehicles in the U.S. is between $110 billion and $894 billion (1990$). At the lower bound of estimates, however, some analysts question whether there is in fact any net social cost of transportation at all. Among researchers closely involved with such analyses are those who question whether any form of government intervention in the transportation energy marketplace aimed at correcting social-cost disparities can be assured of doing more economic good than harm.

Although a great deal of uncertainty revolves around external cost estimates the sum of these costs in California would probably be in the billions of dollars. The cost of congestion alone is likely to reach several billion dollars. The Texas Transportation Institute[39] estimates that the Los Angeles region suffered about 740 million person-hours of delay due to congestion in 1997. Combining this estimate with a reasonable estimate for the value of time would result in State congestion costs approaching or exceeding $10 billion per year.

Global Climate Change

International and national attention is focused on rising levels of greenhouse gases[40] (GHGs) in the earth s atmosphere. GHGs are rising largely as the result of human activities in producing and using fossil fuels since the beginning of the Industrial Age. Increasing atmospheric

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[36] Environmental Investment: The Cost of a Clean Environment , EPA, 1990. This document summarized the EPA s assessment of costs to comply with the Clean and Water Acts as well as RCRA, CERCLA, TSCA and FIFRA.

[37] A multiplier effect is the effect that one dollar spent can create more than one dollar s worth of economic activity, thus multiplying the effect.

[38] Mark Delucchi, *Overview of Social Costs of Motor Vehicle Use: Purpose, Methods, Results, and Applications*, presented at the Social Cost Workshop, University of California at Davis, May 1997.

[39] Texas Institute of Transportation, *Annual Urban Mobility Study, 1999*.

[40] Natural greenhouse gases include carbon dioxide (CO_2), methane (CH_4), nitrous oxides (N_2O), and ozone (O_3) precursors, but humans have also synthesized new greenhouse gases, such as fluorocarbons (HFCs, PFCs, CFCs) and SulfurHexaFluorides

concentration of GHGs is expected to increase the average surface temperatures of the earth and affect global climate, sea levels, water resources, agriculture and ecosystems.

The international body of climate scientists comprising the United Nations (UN) Intergovernmental Panel on Climate Change, whose role is to study and forecast global climate changes and impacts, concluded that, . . . our ability to quantify the human influence on global climate is currently limited because . . . there are uncertainties in key factors . . . the balance of evidence suggests that there is a discernable human influence on global climate. [41]

In December 1997 in Kyoto, Japan representatives from 160 developed countries established emissions targets for each of the participating countries, relative to their 1990 emissions levels. The Clinton Administration signed the Kyoto Protocol on November 12, 1998; however, the U.S. Senate must ratify the protocol for it to be put into effect for the U.S. Regrettably, this has not yet occurred.

With four percent of the world s population, the U.S. produces more than 20 percent of the world s greenhouse gases and emitted nearly 10 percent more GHG emissions in 1998 than in 1990. In the Kyoto Protocol, the United States emission target is 7 percent below 1990 levels, to be achieved over the period from 2008 to 2012.

For more than a decade, the Energy Commission has conducted an ongoing assessment of greenhouse gases on the State. Its most recent report, the Energy Commission s *1997 Global Climate Change Report: Greenhouse Gas Emissions Reduction Strategies for California,* the Commission inventoried sources of California s greenhouse gas emissions and evaluated potential strategies to reduce greenhouse gases in all energy and economic sectors. Transportation contributes the greatest amount of carbon dioxide (CO_2) emissions produced in California — approximately 57 percent. This compares to the national average for the transportation sector of 32 percent.[42]

Carbon dioxide represents the lion s share of greenhouse gas emissions from transportation. While transportation s share is significant, this percentage is large in California because greenhouse gases from other sectors, such as in-state electricity generation,[43] are significantly lower than the national average. In 1994, electricity generation in California produced about 16 percent of all carbon-related emissions. Over time, transportation s contribution of CO_2, compared to other sources, is increasing. If current trends in transportation energy consumption continue, growth in the State s inventory of greenhouse gases will mirror the growth in population.

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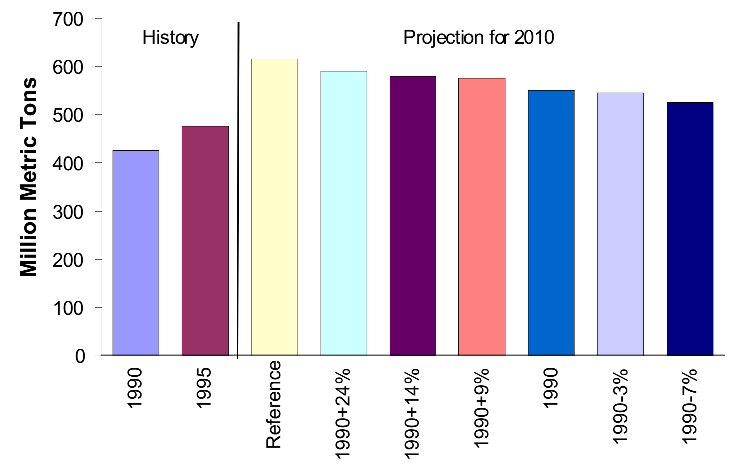
[41] Intergovernmental Panel on Climate Change, Climate Change 1995*: The Science of Climate Change*, Cambridge, UK: Cambridge University Press, 1996.

[42] 1997 Global Climate Change Report: Greenhouse Gas Emissions Reduction Strategies for California, Appendix A, Historical and Forecasted Greenhouse Gas Emissions Inventories for California, April 1998, p. 8.

[43] This does not include emissions produced out-of-state for generation serving California s electricity demand.

Figure 3.1 Carbon emission scenarios from the EIA analysis of the Kyoto Protocol



Sources: **History:** Energy Information Administration, Emission of Greehnous Gases in the United States 1996, DOE/EIA-0573(98) (Washington D.C., October 1997). **Projections:** Office of Integrated Analyses and Forecasting National Energy Modeling Systems runs KYBASE. DO30398A, FD24ABV, DO30396B, FD098B, FD1990D080396B, FD03BLW. D0803689, AND

Sustainability

The concept of sustainable development is defined in the influential *Bruntland Report*[44]: Sustainable development is development that meets the needs of current generations without compromising the ability of future generations. In the context of transportation, sustainability refers to a system that efficiently and affordably fulfills the mobility requirements of a society without jeopardizing the ability of future generations to meet those needs. Thus, actions to create transportation energy uses that are reliable, stable, and energy efficient also promote sustainability, minimizing the losses of today to provide a valued legacy for tomorrow.

According to Black[45], five factors limit transportation sustainability in the U.S.:

- *reliance on nonrenewable petroleum*
- *the effect of mobile-source emissions on air quality and health*
- *the impact of greenhouse gas emissions*
- *the high number of injury and fatal accidents in the current system*
- *the increasing gridlock on our roadways*

Transportation energy use is connected to the first three of these factors. Using such reasoning, various individuals and groups have offered proposals for an index of transportation sustainability, including Heanue[46], Kenworthy *et al.*[47], Litman[48], and Black[49]. Such an index is

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[44] World Commission on Environment and Development, 1987.
[45] Black, W.R. (1996). Sustainable Transportation: an U.S. Perspective. *Journal of Transport Geography*, 3, 159-66.
[46] Heanue, K. (1997). Transportation S&T Strategy Partnership Initiatives. Presented to the National Science and Technology Council Transportation R&D Committee, September.

meant to measure progress toward the goal of sustainability. Examples of indicators that make up these indices include market penetration of alternative fuels, degree of reliance on single-occupant vehicles, motor vehicle accident fatalities, quality of pedestrian and bicycle facilities, amount of emissions of carbon dioxide and criteria pollutants, and transit ridership.

Summary and Implications

Although this report broadly discusses the factors that can be used to address transportation energy demand and supply challenges, the Energy Commission recognizes that the effects of transportation energy use go beyond mobility, including public health, the environment, congestion, and sustainability. The Energy Commission recognizes that its expertise and authority place its current transportation focus in the following areas:

- Understanding and projecting energy supply and demand trends,
- Providing an objective source of energy information to policy-makers and consumers,
- Developing and demonstrating emerging transportation technologies and infrastructure facilities,
- Identifying institutional and government barriers and providing assistance to overcome those barriers that inhibit broader use of alternative fuels and vehicle technologies, and
- Providing tools to conduct energy analyses for transportation and land use planning organizations.

The social-costs of transportation that are not borne by the direct user of transportation include public health, the environment, congestion, global climate change and sustainability. These costs are difficult to quantify however they could range in the billions of dollars. Some of the effects of transportation energy use could even cause atmospheric changes that require humans to adapt to new climatic conditions.

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[47] Kenworthy, J., F. Laube, P. Newman, and P. Barter (1997). *Indicators of Transport Efficiency in 37 Global Cities*. Sustainable Transportation Research Group, Institute for Science and Technology Policy, Murdoch University, Perth, Australia (report for the World Bank).
[48] Litman, T. (1999). *Sustainable Transportation Indicators*. From website www.islandnet.com/~litman/sti.htm.
[49] Black, W.R., (2000). Toward of Measure of Transport Sustainability. Presented at the Transportation Research Board Meetings, Washington, DC, January.

CHAPTER 4
TRANSPORTATION ENERGY OPPORTUNITIES: SUPPLY, DEMAND AND TRANSITIONING FROM PETROLEUM

Introduction

There are many options to addressing transportation energy supply limits, demand growth, cost, price volatility and price issues. Those options fall into four broad categories:

- ***Petroleum Fuel Supply*** *— to address ways to increase supplies of petroleum fuel supply*
- ***Fuel Use Efficiency*** *— to address ways to reduce the demand for petroleum fuels*
- ***Fuel Diversity and Choice*** *— to address ways to meet transportation energy demand through alternatives to petroleum; and*
- ***Environmental Quality, Sustainability and Internalizing Externalities*** *— to address the effect that use of petroleum fuels has on society*

A menu of potential actions and policies have been reviewed and considered to respond to California s transportation energy challenges. Although no single option provides a panacea to solve all of the issues of transportation supply, demand and cost, a menu of options can, when taken together, address them. One key to selecting opportunities for further consideration or implementation is to note their synergistic effect on improving transportation energy supply and managing demand. Another key to our choices is the sustainable qualities exhibited by their outcomes.

While policy-makers seek solutions that can provide near-term relief for the State s fuel supply and demand problems, policy-makers must also consider the inevitable transition from a supply system dominated by petroleum. Easing such a transition and reducing the potential for a chaotic market would be beneficial and prudent. The direction, timing, and pace of a transition, however, are unknown and a sensible pathway calls for a flexible readiness strategy. Taking appropriate actions for a variety of energy and technology choices would be consistent with this need.

The following discussion presents some of the options that could be taken, in combination, to change transportation energy use in California. They are not ranked in order of preference.

Petroleum Fuel Supply

This section lists a variety of potential strategies intended to maintain and increase the amount of petroleum-based fuels available to help mitigate the impact of price spikes during periods of tight supply.

Temporary Relief from Jones Act. Under the Jones Act, all petroleum products that originate in the United States and that are shipped by marine tanker to a destination in another U.S. port must be transported on a U.S. flagship vessel. These types of ships are less plentiful than foreign flagged marine vessels, charge a higher rate to transport gasoline and other petroleum products, and are expected to experience a decline in fleet size between now and 2003.[50] During periods of refinery disruptions, the Jones Act can be temporarily suspended to increase the number of available marine tankers that could be used to import additional volumes of gasoline and blending components to California. This action could potentially increase supply for the State by reducing the time required to arrange for a vessel to load a cargo, hence quickening the delivery of needed fuel to the State.

Pipeline Transport. Constructing a pipeline to transport refined products between Texas and California to allow for additional deliveries of gasoline could add to the State s supply capability. California currently exports gasoline and other refined products to Arizona and Nevada through a system of product pipelines operated primarily by the Kinder Morgan Company. It is possible that this existing system could be augmented and reversed to enable the transportation of gasoline from the Gulf Coast to California. This would require that the current total volume of gasoline and other refined products (approximately 175 thousand barrels per day) that originate in California to be displaced by sources in Texas. In addition, the Longhorn Pipeline connection to the Kinder Morgan system in El Paso, Texas would have to be completed to permit additional Texas refiners access to the system.[51] Finally, the section of the pipeline system connecting El Paso with Phoenix, Arizona would have to be expanded to include transportation of the refined products that are currently being shipped from California and to enable shipment of additional gasoline from Texas to California. There would also have to be an adequate capability at the end of the pipeline in Texas to produce CARB gasoline. The costs, benefits, and potential funding mechanism for these types of pipeline projects all need to be studied.

Redefine Minimum Octane Standard for Premium Grade Gasoline. Premium grade gasoline is usually marketed with a minimum octane rating of 92. This grade of fuel will be the most

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[50] United States Government Accounting Office, Marine Industry — As U.S. Single-Hull Oil Vessels Are Eliminated, Few Double-Hull Vessels May Replace Them, publication number GAO/RCED-00-80, April, 2000.

[51] The Longhorn Pipeline project is in the latter stages of an environmental assessment review by the U.S. EPA and the U.S. Department of Transportation s Office of Pipeline Safety. It is possible that permits to operate could be issued as early as this summer. Completion of this system will enable refiners in the Houston area to initially ship 75 thousand barrels per day of gasoline and other refined products to markets in El Paso, Texas and Phoenix, Arizona. The pipeline capacity can be expanded to 225 thousand barrels per day over a period of years if a sufficient number of shippers decide to move refined products into western Texas and Arizona.

difficult blend to produce following the phaseout of MTBE and transition to Phase 3 RFG. If the octane rating of premium grade gasoline sold in the State were redefined to a minimum octane level of 90 or 91, the demand for blending components possessing high-octane values would be reduced. Existing key components such as alkylates and iso-octane could be used in a larger volume of gasoline, reducing the price impact of a relatively scarce and expensive commodity. This strategy must be coordinated with automakers to ensure that a minimum octane level is consistent with the performance needs of vehicles.

Flexible Fuel Specifications. The sale of non-complying gasoline is a potential strategy to help combat price volatility. The concept assumes that gasoline not meeting California s standards could be obtained more readily from outside the State because more refineries are capable of producing conventional gasoline. If California s RFG regulations were temporarily waived and the federal RFG regulations were maintained, conventional gasoline could be sold in 20 to 30 percent of the State. But the majority of gasoline sold in the State would still have to meet the federal standards, which means that the gasoline would only be readily available from inventories located in the US Gulf Coast. Conventional gasoline could be drawn down from inventories located in Washington. A temporary lifting of the Federal RFG standard could provide temporary relief of supply shortages. However, the greatest disadvantage with this option is the obvious and serious set back to public health and environmental progress. Also, the sale of non-complying fuel would not necessarily reduce likelihood of price spikes or reduce price of petroleum fuels.

Petroleum Reserve. Since imports can take over four weeks to arrive after a major refinery outage, a petroleum reserve could serve as a more immediate supply substitute for gasoline or blending components. The petroleum reserve could be administered by the State of California, private companies or could be established as a financial instrument. Such a reserve would need to be constructed and operated in a manner that diminishes the magnitude and duration of price spikes that occur in California due to severe refinery outages rather than to permanently decrease the price of gasoline. There is no certainty that there would be long-term cost savings.

Purchase and Operate a California Refinery. The State could purchase an idle refinery in California to produce fuel in the event of supply shortfalls. To save time, the refinery would be kept in a hot standby mode (if feasible) and be immediately capable of ramping up to full capacity. The refinery would need access to the pipeline distribution infrastructure and possess truck-loading capability in order to distribute fuel. In addition, the facility would have to be upgraded to fully comply with Phase 3 RFG regulations. For a private investor, the capital that would be required to upgrade such a facility might be prohibitive when compared to the volume of gasoline and diesel fuel that could be produced.

Limit Pulls From Terminals — Allocation. During periods of rapid wholesale price increases, some market participants will purchase additional volumes of petroleum products to put in storage on speculation that the market price will continue to rise and the product can be sold in the near future at a higher price. The fuel is not delivered to retail outlets for immediate consumption and is therefore referred to as phantom demand . This type of practice can exacerbate an ongoing price spike. Some steps could be taken to help discourage this practice. One approach could be to limit the volume of petroleum products that can be pulled from terminals by individual marketers. Although this is a practice that already occurs in the industry, it has not been mandated on a statewide basis.

Temporary Price Spike Relief

The following strategies may provide a means for government to relieve some of the economic hardships caused by temporary price spikes. They are not listed in any order of preference.

Economic Assistance Funded By Sales Tax Windfall Relief Act. The concept of this strategy is to create a fund from the increased sales tax revenue that is generated by rapid increases in fuel prices. An approximate 8 percent sales tax is levied on each gallon of gasoline sold at service stations. A temporary program, called a Sales Tax Windfall Relief Act, could be put in place to collect additional sales tax revenues when prices increase rapidly over a short period of time. The monies generated could be placed in a fund that would be used to reimburse consumers who can least afford to pay for higher fuel prices, provide transit passes, enable the acquisition of a non-petroleum fueled vehicle or a superior fuel economy vehicle. These consumers would have to meet a variety of criteria to qualify. Unfortunately, the administrative costs of such a program could negate a significant amount of its intended benefits.

Suspend State Fuel Excise Tax. Each gallon of gasoline sold is assessed an 18 cent State excise tax. During periods of rapid price increases, this tax could be temporarily suspended. Since the tax is enforced at the initial point of wholesale, enforcement will be more manageable. But the revenues generated by the excise tax would have to be reimbursed by the government to avoid loss of funding for various transportation projects.

Reduce or Suspend Bridge Tolls. Commuters who have to cross toll bridges could be given some relief by reducing or eliminating this fee. Similar to the case with the suspension of the excise tax, significant sums of revenue for highway projects would be lost, unless the shortfall was compensated by another funding source.

Fuel Use Efficiency

This section lists a variety of strategies intended to address improved fuel use efficiency to meet California s transportation energy demand. These options are not ranked in any order of preference.

Transportation Energy Efficiency. Technological progress clearly offers enhanced opportunities to moderate transportation energy demand growth by improving the efficiency of end-use applications. Higher efficiency not only extends energy supplies, but can also reduce the cost, public health and environmental impacts of transportation activities. Higher efficiency in vehicles has been indirectly achieved through emissions standards that resulted in vehicles with greater combustion efficiency or improved aerodynamics, to lower fuel consumption, to achieve lower vehicle emissions. Research into vehicle and vehicle components could yield substantial improvements in efficiency as a long-term strategy. Also, this measure would require collaboration with automakers to realize the benefits. The federal government, in 1992, initiated the Partnership for a New Generation of Vehicles (PNGV), a cooperative research and development program with auto makers designed to create prototype automobiles with fuel economy doubling and tripling that of conventional cars. This program created proof-of-concept vehicles that demonstrated that 5-passenger cars can be manufactured in a profitable manner and have extraordinary fuel economy: averaging 40+mpg and targeting 80+mpg. Part of the PNGV program is a University Competition, known as FutureCar and FutureTruck, to build vehicles with high fuel economies. The Energy Commission has supported the UC Davis Engineering School s participation in competitions to build new automotive technologies. These include the FutureCar and FutureTruck Competitions. UC Davis has won awards in many categories for its novel designs, and it has attracted worldwide automotive industry attention for those achievements. The Energy Commission should increase sponsorships and closer working relationships between the University transportation studies programs and other educational institutions.

Enhanced use of diesel engines. Modern diesel engines for passenger cars are greatly improved over older passenger car diesel engines. New diesel passenger cars have 45 to 60 percent better fuel economy than their gasoline counterparts due to higher engine efficiency[52]. These vehicles are equal to their gasoline counterparts in other performance characteristics, as well. Due to the demand for high-powered light-trucks and sport utility vehicles in the U.S., domestic manufacturers are using a growing number of diesel engines in these vehicle categories to meet CAFE standards. However, diesel engines for passenger cars and light-trucks must further improve their emission performance to meet California s future exhaust emission standards.

GTL-Diesel opportunity to expand the use of heavy-duty diesel engines. Using cleaner diesel fuels results in reduced exhaust emissions. GTL Diesel, an alternative fuel derived from natural gas, has properties that can reduce tailpipe and toxic emissions while maintaining high performance in diesel engines. During 1993-1998, GTL —Diesel blends were commercially used in California in existing diesel engines and fuel infrastructure without requiring equipment modifications. Although fuel economy and power are slightly reduced by up to 3 percent based on laboratory testing, GTL fueled, heavy-duty diesel engines are demonstrating 5 to18 percent reduction in oxides of nitrogen (NO_x) and 20 to 40 percent reduction in the remaining criteria pollutants. An optimized GTL fueled engine could achieve a 26% reduction in (NO_x) and 67% particulate matter (PM) reduction from the baseline GTL emission level[53]. Such performance could enhance the overall use of heavy-duty diesel engines but additional emissions improvement would be required for future light-duty vehicle applications.

Regulating Fuel Economy. The most progress with transportation energy efficiency in the U.S. has occurred with passenger cars due to federal Corporate Average Fuel Economy (CAFE) standards.[54] With the adoption of standards and compliance schedules, one for passenger cars

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[52] Cummins Light Truck Diesel Engine Progress Report, Society of Automotive Engineering 2000-01-2196
[53] Emission Performance of Fischer Tropsch Fuels, Southwest Research Institute, conference presentation at Gas-to-Liquids Processing 99, May 17-19, 1999, San Antonio, TX
[54] CAFE standards in the Energy Policy and Conservation Act of 1975 (PL-173). Effective in 1978, it established a standard of 18 miles per gallon (mpg) for passenger cars, increasing annually to a maximum of 27.5 mpg by 1985. A manufacturer s compliance with the law is based on a calculation of the sales-weighted fuel economy of all models sold by that manufacturer. Separate, lower mpg standards apply to light-duty trucks.

and one for light-duty trucks, large gains in new vehicle fuel economy were achieved in the latter half of the 1970s through most of the 1980s. [55] A discussion on changing the current federal CAF requirements is in Appendix G.

Incentives. The Energy Commission received authorization in the 2000/01 Budget to develop a vehicle efficiency incentive program. Beginning in 2001, the Energy Commission will begin a pilot program to determine the amounts and types of incentives that are necessary in order to build market demand for energy efficient vehicles. If successful in the pilot stage, the Energy Commission will propose an expanded program that will include heavy-duty vehicles and possibly off-road vehicles. The basis for this program will be a study, currently underway at the Energy Commission, which will analyze the well-to-wheels efficiency of various vehicle products and technologies. This option represents a longer-term strategy for reducing demand and could take several years to realize the benefits. It would also require collaboration and cooperation with automakers who produce and market energy efficient vehicles.

Fuel Taxes. Fuel use decisions are affected directly by fuel prices. If a higher gasoline tax were levied nationwide, an additional decrease in gasoline demand would be expected. As the cost of driving increases vehicle miles traveled (VMT) decreases, gasoline demand is reduced. Drivers may reduce their driving costs by buying more fuel efficient vehicles, which would likely reduce gasoline consumption even further.[56] In this case, consumers would have greater interest in vehicles with higher fuel economy ratings and automakers would respond to that demand. If the tax is imposed in California only, little if any auto manufacturer response can be expected since only a small portion of the market is affected. In previous studies, increasing fuel taxes (both State-only and nationwide[57]) showed significant net benefits, mainly through the effect of reduced costs related to driving. However, any consideration of levying additional fuel taxes should be made in the context of ensuring affordable supplies of energy for transportation.

Pay at the Pump Insurance. Analysis by Energy Commission staff [58] shows that pay-at-the-pump insurance may yield not only social benefits through a reduction in driving but also private benefits for the average driver as well. This result comes about as insurance is priced more efficiently; that is, it is more closely tied to travel than is currently the case. Additional private benefits for insured motorists are likely from a reduction in the external costs imposed by uninsured motorists, as these drivers now would have to pay at least some insurance costs at the gasoline pump.

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[55] New light-duty vehicles for all manufacturers averaged 15.3 mpg in 1975. The new car fleet improved to 25.9 mpg by 1987. Passenger cars improved more than light-duty trucks by achieving 28.6 mpg versus 21.6 mpg, respectively. Nevertheless, these trucks improved by nearly 58 percent over 12 years while passenger cars improved 81 percent.

[56] See *1997 Global Climate Change* (California Energy Commission report #P500-98-001, January,1998) pp. 124-5.

[57] The SB 1214 study analyzed 20, 40, and 50 cent (1992$) state-only higher fuel taxes and 20 and 50 cent nationwide higher taxes.

[58] Kavalec C. and J. Woods, (1999). Toward Marginal Cost Pricing of Accident Risk: The Energy, Travel, and Welfare Impacts of Pay-at-the-Pump Auto Insurance" *Energy Policy*, Vol. 27, No. 6, 331-342.

VMT Taxes, User Fees and Parking Fees. Proposals for a tax on vehicle miles traveled (VMT) usually involve a per mile charge that would be collected once or twice a year. Such a tax raises the marginal cost of driving directly and, therefore, is theoretically the most effective method of reducing VMT. In an analysis for the California Air Resources Board[59], Deakin and Harvey found that a two-cent VMT tax could reduce VMT and fuel uses by four to five percent in 2010, depending on the region within California. Such a tax could present collection difficulties, would require a periodic inspection to determine mileage, and would face the same barriers as a higher fuel tax. More fundamentally, a VMT tax does not target gasoline use directly, so it is not the most efficient method of reducing the costs associated with gasoline use. As discussed above, a higher gasoline tax also reduces VMT while at the same time providing an incentive to switch to an automobile with higher fuel efficiency, further reducing gasoline use.

Congestion Fee. A form of VMT tax that would impose per mile charges on heavily traveled roadways during peak periods in an attempt to reduce traffic flow. The result would be less congestion in such areas during rush hours as motorists unwilling to pay the fee switch to transit, an alternate route, or revise their schedules to drive the targeted roadways during non-peak periods. Reducing congestion would improve fuel efficiency as drivers spend less time in stop-and-go traffic, such that the percentage reduction in fuel use would likely be greater than that of VMT. For example, the analysis by Deakin and Harvey showed that a region-wide congestion pricing scheme for the Los Angeles metropolitan region (19 cents per mile) could reduce gasoline use by almost ten percent in 2010 while VMT was reduced by around three percent.

Employee parking pricing measures. This measure would impose or increase charges to employee parking at or near the workplace. Such a policy represents an attempt to remove a hidden subsidy to recover the cost of providing the parking. To the extent that commuters would switch to transit or increase car pooling, VMT and gasoline use would be reduced. The analysis by Deakin and Harvey showed that a parking fee charged to drive-alone commute vehicles of $1.00 and $3.00 per day could reduce VMT and gasoline use by around one and two to three percent, respectively.

Public Transportation. Expansion of light-rail and bus transit may reduce total fuel use, but it is uncertain whether the benefits from this reduction always exceed the costs. Current gasoline prices (at least until very recently) and existing parking policies do not appear to make transit a welcome alternative to automobile travel, especially for middle- and upper-income travelers. The effectiveness of transit expansion may be increased significantly if accompanied by pricing policies aimed at reducing automobile travel.

Request Voluntary Conservation Measures. During periods of tight supplies that are the result of major refinery production problems, consumers can help to limit the price impacts by temporarily changing their behavior in ways designed to decrease demand for gasoline. Increased use of mass transit, ridesharing and telecommuting could help to ease rapid price increases if the reduction in demand is significant. Consumers, State and local employees could

[59] Transportation Pricing Strategies for California: An Assessment of Congestion Emissions, Energy and Equity Impacts, No. 92-316, June, 1995.

also reduce their level of discretionary travel, deferring trips whenever possible to a later time. All of these measures would be considered voluntary and could be requested by State officials during periods of rapid price increases.

Reduce or Eliminate Mass Transit Fees. Increased ridership of mass transit could be an effective tool to help combat rapid price increases. Reducing or even eliminating mass transit fares, especially during normal commute hours, could attract a sufficient increase in the number of riders to dampen demand and moderate significant price spikes. The potential merit of this concept should be assessed to determine what increased level of ridership would be required to reduce price spikes and what level and sources of funding would be required to offset the temporary loss in revenue for transit agencies.

Alter work and school schedules. Altering work and school schedules to accommodate a shorter week could reduce travel demand and related fuel consumption. Employees could have their schedule shifted to four, 10-hour days. The new off day could be Wednesday, as opposed to the creation of three-day weekends by the designation of Friday or Monday; an extended weekend may actually increase travel demand. Wednesday could also be designated an off day for educational institutions, kindergarten through university. Reduction in gasoline demand could be significant, but impacts on workers and students could take their toll if this strategy were employed over extended periods of time.

Fuel Diversity and Choice

California needs to turn to energy sources other than petroleum to meet its transportation energy needs and to ensure continued fuel reliability, starting now. Pursuing a tactical alternative fuel development course is in the State s best interest. This will not only provide opportunities for achieving an orderly long-term transition, but also help capture near-term opportunities such as pursuing niche markets for those options than can improve transportation energy supply and market competition.

While technical successes continue to be achieved in the development of alternative-fuel vehicle options, market inroads thus far are limited. The estimated combined market penetration of AFVs in California is still measured in the tens of thousands of vehicles, or around one half of one percent of the State s 22 million registered highway vehicles. Therefore, if alternatives to petroleum fuels are to become serious competitors in California s transportation energy markets, the forces necessary to bring about their sustained market inroads and growth must be created.

Table 4.1 Types of Alternative Fuel Vehicles

TYPE	DESCRIPTION	CONSIDERATIONS
Electric Vehicles	Over 2,300 on road today, primarily in light-duty applications. Multiple forms available (sports cars, sedans, pick-ups, vans, SUVs). Both City Cars and NEVs emerging. Future penetration will increase consistent with State mandates.	No vehicles available. Long waiting period between order and delivery of vehicle. Typically charged at night using off-peak power. Volume production needed to bring purchase/lease prices down.
Ethanol Vehicles	Over 30,000 vehicles on the road today. Typically configured as flexible fuel vehicles that run on either gasoline, ethanol or combination. Current on-road fleet uses 100 percent gasoline because no fuel available at this time.	No ethanol fuel available at this time. Fuel cost could be $1.40/gallon (gasoline equivalent). Special construction considerations for fuel storage.
Fuel Cell vehicles	Prototype buses and cars on road in California. Technology may run on pure hydrogen, or hydrogen derived from other fuels (natural gas, gasoline, methanol or ethanol).	May require alternative fuel infrastructure if non-gasoline fuel cell vehicles are ultimate choice. May also need building code changes to accommodate on-site reformers and/or compressors.[60]
Hybrid electric vehicles	Two light-duty vehicle models on market. Buses undergoing testing in transit service (New York City). Hybrid option for SUVs under development for near term launch. Can be designed to be able to use both petroleum fuel and electricity or petroleum only.	Limited product availability. Petroleum dependent hybrids are the only commercially available product at this time. Hybrids do not uniformly benefit public health or the environment.
Methanol Vehicles	Typically configured as flexible fuel vehicles that run on either gasoline, methanol or combination.	Fueling facilities available in limited regions. Special construction considerations for fuel storage. Fuel cost $1.50/gallon (gasoline equivalent)
Natural Gas Vehicle	Thousands on road today primarily in heavy-duty on-road freight uses. Some light-duty vehicles are also available.	Fueling infrastructure must maintain a level of demand to justify cost of building fueling stations. Current programs address this.

An important consideration to the development and ultimate commercial availability of alternative fuel vehicles is an understanding of the amount of time it typically takes for new products to make their way into the marketplace. Figure 4.1 shows the time it has taken for now-familiar products to make their way into the marketplace.

Transitioning Consumers into Alternative Fuel Vehicles

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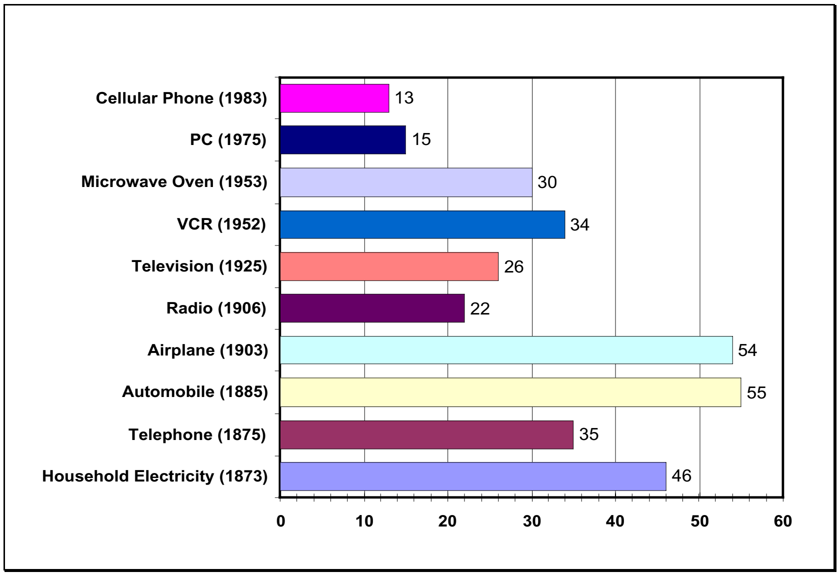
[60] The Energy Commission participates on the California Fuel Cell Partnership in cooperation with the Air Resources Board, Department of Energy, South Coast Air Quality Management District, fuel cell manufacturers, automakers and oil industry, to develop and demonstrate vehicles and fueling infrastructure.

To transition away from petroleum-based fuels, viable alternatives must become available. However, not all of these alternatives can be compared against gasoline vehicles because some of them meet customer needs in new and innovative ways. For example, auto manufacturers are designing limited range, low-cost battery electric vehicles, also known as City Cars for niche markets (most likely second and third car purchases, with young adult drivers). Consumers need to become familiar with and accepting of this technology before significant penetration will be achieved.

Viewed from that standpoint, there is a market for new vehicle technologies that would, if fostered well, reduce demand for petroleum. This strategy is a paradigm shift, however, and it will not come easily or quickly. For example, the introduction of the wireless telephone, which has taken 20 years to develop a foothold in the market, is now so common that other countries are completely eliminating the cost of constructing a wired telephone infrastructure. A similar opportunity can be captured in other countries by eliminating the cost of constructing a gasoline and/or diesel refining, distribution, and retail system. Although California will not be able to capture that benefit, it can capture the advantages of improved public health, a better environment and fuel-on-fuel competition (e.g., gasoline versus natural gas, ethanol and electricity).

Figure 4.1 The Speed of Change: How many years it took to spread these technologies to 25% of the U.S. Population.



Source: Wall Street Journal, June 16, 1997

Mandates for Alternative Fuel Vehicles. The Energy Policy Act of 1992 requires, among other activities, the purchase of alternative-fuel vehicles by federal and State government fleets. However, its policy of alternative-fuel substitution as a mechanism to limit petroleum imports and reduce overall petroleum use has not been as effective as Congress envisioned. While progress in the purchase and deployment of alternative-fuel vehicles in light-duty State and federal government fleets has occurred, a recent report by the federal General Accounting Office documents the lack of alternative-fuel use[61]. In addition, analyses of EPACT goals for 10 and 20 percent displacement of petroleum by 2000 and 2010 show that major changes to the law or in implementation and enforcement will be required to attain even the 10 percent petroleum displacement goal.

In 1990, the California Air Resources Board adopted a regulation in 1990 to require automakers to produce, and offer for sale, zero emission vehicles. This regulation has been an effective and innovative strategy to get automakers to invest in new vehicle technology. Automakers are now offering multiple products to demonstrating that they can produce cleaner vehicles to overcome California s public health problems related to transportation energy use. The new line-up includes traditional battery electric vehicles, commercially available hybrid vehicles, prototype fuel cell vehicles, more efficient and cleaner gasoline vehicles and neighborhood electric vehicles. Despite automaker resistance to the mandate, this is an area where government and industry have created proven results.

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[61] Energy Policy Act of 1992, Limited Progress in Acquiring Alternative Fuel Vehicles and Reaching Fuel Goals, GAO/RCED-00-59, February 2000, U.S. General Accounting Office.

Fleet Market. The fleet vehicle market has been the primary introductory market for AFVs. Public and private fleets in California have been instrumental participants in the State s demonstrations of new energy technologies. Over 350 different fleet operators around the State have acquired methanol FFVs. The State s own government agency fleet, numbering about 50,000 vehicles of various types, is subject to EPACT alternative-fuel requirements and a Governor s Executive Order W-100-94 directing accelerated AFV acquisition. California s State government fleet offers an opportunity for the demonstration and commercial introduction of advanced energy technologies involving alternative fuels and efficiency improvements.

To date, a full commitment to transforming the State vehicle fleet into an example of new energy technology applications has yet to be made. This has been due to limited product offerings from manufacturers that do not offer vehicles that meet the duty cycles for these departments and by the lack of specific budget augmentations for this purpose. Designing and implementing a legislatively-directed and adequately funded State fleet energy initiative, one which includes both vehicle purchases and demonstrations of pre-production technologies, to achieve and maintain the State-owned fleet as a model of energy efficiency and alternative energy technology applications, would send a positive signal to the marketplace.

Fueling Infrastructure and Distribution

An important consideration to using alternative fuel vehicles to displace petroleum is the availability of adequate and convenient fueling. For example, in California, most FFVs are operating entirely on gasoline due to the lack of alternative fueling infrastructure. Alternative-fuel distribution technology development plays a critical role in establishing practicable transportation energy options. Coordinating the introduction of alternative-fuel vehicles with adequate fuel distribution provisions for these vehicles has always been a challenging proposition.

California has gained commercial experience with the distribution of a number of alternative transportation fuels, including methanol, CNG and LNG, electricity and LPG. The Energy Commission is the lead agency for State-sponsored alternative-fuel infrastructure programs involving most of the above fuels, cost-sharing the acquisition and installation of fuel storage and dispensing equipment. The Commission s programs established a network of methanol fueling facilities at fleet and retail sites, supported by the California Fuel Methanol Reserve (CFMR), a cooperative supply arrangement between the State and fuel suppliers and distributors. The CFMR help overcome initial costs to deploying methanol (M-85) fueling facilities that allowed many stations to be built and operated. This experience in developing a methanol fueling infrastructure offers an instructive example of how to overcome the technical and institutional challenges confronting alcohol vehicle fueling. Over the course of the methanol program, a total of about 140 fueling facility installations were completed in the State, some of which remain in operation serving methanol FFV fleets.

Cost sharing of vehicle fueling facilities is another proven mechanism for overcoming the initial low revenue stream from limited fuel sales, while also providing in-use confirmation of the new storage and dispensing technologies required. Fueling facilities for methanol, CNG, and LNG, as well as EV charging stations, have resulted from State-sponsored programs. Meanwhile, the LPG industry in California has achieved success establishing a network of fleet and retail sites for refueling LPG vehicles.

Ethanol presents a particular dilemma for alternative fuel infrastructure development in California. Ethanol FFVs are being marketed in the State in numbers exceeding those of any type of AFV technology to date. Thus far, the first ethanol fueling facility in the State is yet to go into operation, although other states now have at least some ethanol stations. Meanwhile, California is exploring the potential for developing a biomass-to-ethanol industry as part of its efforts to find a substitute for the gasoline oxygenate MTBE. Based on the current rate of ethanol FFV introduction, the magnitude of potential ethanol demand by FFVs may match or exceed its market potential as a gasoline-blending component. However, an adequate supply of ethanol and E85 fueling infrastructure to serve these vehicles will be necessary if this potential is to be realized.

Developing a State Master Plan to Guide Non-Petroleum Infrastructure. The Governor s 2000/01 Budget included a Clean Transportation Fuels Initiative which provides up to $6 million to fund clean fueling infrastructure for public fleets, including school and transit districts. The Commission will leverage its $6 million for cost-sharing arrangements with other government and private entities to build up to 60 fueling facilities throughout California. As part of this effort, the Commission, through a partnership with other federal, State, municipal and private entities, will develop an integrated Clean Fuels Infrastructure Plan to guide further State investment in non-petroleum fuels infrastructure. The plan will allow the Commission to stimulate competitive energy choices through a Statewide effort and oversee infrastructure development through project co-funding and incentives. The plan seeks cost-effective development of non-petroleum fuels by focusing on strategic locations throughout California and on high-mileage fleets. Little or no funding has previously been available, particularly for government fleets, to establish the supporting fueling infrastructure.

Emerging Technologies

Electronic based technologies are emerging to transform the traditional concept of transportation and its ability to provide access to goods and services. Electronic technologies have the potential to provide ways to avoid transportation. Electronic-communication (e-communication) is already a rapidly expanding use of information technologies to engage in business, communications and social interactions. Genetic engineering, nanotechnologies and robotics (GNR) is a second wave of three new technologies. Together these newer technologies have the potential to create fundamental changes in information flow, manufacturing, and the economy.

The purpose of this discussion is to introduce these advances so that they can be included in the formation of future deliberations on transportation energy policy. The impacts of e-communications and GNR are new and not yet well understood. However, their potential to impact California and its patterns of energy use and demand may be profound. Analyses to predict trends in transportation energy use need to develop and include an understanding of the impacts of e-communications and GNR.

Environmental Quality, Sustainability and Internalizing Externalities

Local and regional governments routinely make land use decisions that significantly influence California s long-term transportation energy demand and infrastructure. However, increasing traffic congestion and longer driving distances caused by distribution of housing relative to work, shopping and recreation suggests that local land use decision-makers should actively review energy effects as part of their deliberations of land use requests. Until recently, the transportation energy demand consequences to the economy, the environment, and social effects have not been part of the criteria considered in the decision-making process for local land use. Following such a path can help decision-makers direct investments in urban development and new infrastructure in a more prudent manner, potentially reducing the long-term impacts from inefficient energy consumption.

Opportunities to influence and change current development patterns as they affect transportation energy use lie throughout the land use decision-making process, ranging from public education and citizen outreach stages to the final vote on a land use plan. The energy consumption difference between typical and more resource efficient suburban development patterns can be dramatic. The San Diego Association of Governments (SANDAG) conducted a 1994 analysis of the San Diego region with support funding from the Energy Commission. SANDAG found that a shift in new development patterns from existing policies to pedestrian-oriented development (POD) and transit focus area (TFA) style development would result, when fully mature, in a 10.5% reduction in annual transportation energy consumption for the entire SANDAG region. Estimated annual savings as a result of these new development patterns are $207 million per year,[62] using year 2000 dollars.

The outcomes of a more efficiently coordinated land use and transportation system are numerous and beneficial. One prominent outcome of integrating transit options into the fabric of development patterns is greater overall efficiency and effectiveness, including reduced transportation energy consumption. Transportation energy considerations, particularly sustainable transportation energy considerations, have been neglected and are lacking in current land use decisions. If land use patterns consider energy impacts, the benefits accrue over the long term.

If land use patterns that include consideration of energy impacts are implemented, these savings are long-term. Most communities are built to last many years. While individual structures may change over time, the land use pattern is generally permanently established with regard to transportation infrastructure, housing, workplace and retail components are initially developed. As a result, the savings achieved at the outset can be very long lasting. These points all reinforce the need to actively consider decisions that embed transportation energy demand into communities, when reviewing and approving land use developments.

[62] San Diego Regional Energy Plan, Volume 2 , December 1994, SANDAG, pg. 134.

PLACE3S™ — A community planning tool

The PLACE^{3}S™ program is a tool for examining and quantifying transportation energy use when local land use decision-makers review and approve projects[1]. It is effective for both new development and redevelopment of an existing area.

At the neighborhood level, the PLACE^{3}S™ program examines each parcel, the character of the community s entire infrastructure, housing types, transportation options, worker skills and job requirements, economic activity in the community, and the energy (electrical, natural gas, and gasoline) needed by this community[1]. The PLACE^{3}S program can generate scenarios for alternative development patterns to a level of detail that includes specific building types for each parcel and identify likely new industry/businesses that match the available labor pool. This approach is very useful for redevelopment of or infill within existing neighborhoods.

At a larger scale, the PLACE^{3}S™ program is useful for examining the implications of existing community expansion by helping local land use decision-makers better understand how new subdivisions fit with long-term local and State government policies. It allows decision-makers to identify alternative land use development patterns that also meet consumers needs, improve the quality of life (as defined by the local residents), and reduce the energy/environmental impacts of the proposed development.

At a regional scale, the PLACE^{3}S™ program can help cities, regional and State governments understand the implications of development trends, i.e., growth equals more energy demand and there are ways to minimize the amount of energy necessary to accommodate that growth. By focusing on transportation energy, decision-makers can examine the public infrastructure needs, and alternatives, that specifically relate to the region s transportation system - roads, highways, and public transit. Infrastructure decisions directly influence the type of future development in the housing, retail, and commercial sectors.

At each of these levels, the PLACE^{3}S™ program can be effective in identifying the opportunities for prudent public investments by local governments. Decision-makers in cities, counties, and regional governments can all benefit from using the PLACE^{3}S™ program or a similar approach.

Summary and Implications

There are a variety of strategies and initiatives that can affect California s transportation energy use. Some are long term in nature and others can provide short term, temporary relief from disruptions in transportation energy supply. All of these strategies and initiatives carry with them costs and benefits that need to be weighed and considered.

APPENDIX A
Joint Project: Vehicle Population Data For Transportation Analysis

Vehicle Data Categories

GEOGRAPHY DATA

1.	Regions:	
	State Summary	Sacramento Region
	San Francisco Region	San Diego Region
	Los Angeles Region	Rest of the State
2.	Counties:	
	58, plus out-of-state	
3.	Zip Code: All	
4.	Census Tract:	50 % of all DMV data base (all of Southern California)
FLEET IDENTIFICATION DATA		
1.	Fleet Types:	
Personal		Government - District — Schools
Other Commercial		Government - District — Colleges
Daily Rental		Government - District — Transit
Government — All		Government - District — Fire
Government — City		Government - District — Police
Government — County		Government - District — Utility
Government — State		Government - District — Water/Irrigation
Government — Federal		Government - District — Other
Government - District — All		
2.	Fleet-Size Range: Individual Fleets, or Fleet Groups	
	1 - 9	100 - 299
	10 - 19	300 - 999
	20 - 49	1000 - 4999
	50 - 99	5000 +

LIGHT-DUTY VEHICLE DATA	
1. Model Years: All model years contained in DMV's Vehicle Registration filepass.	
2. Size-Classes:	
CAR-MINI	PICKUP-STANDARD
CAR-SUBCOMPACT	VAN-COMPACT
CAR-COMPACT	VAN-STANDARD
CAR-MIDSIZE	SPORT/UTILITY-COMPACT
CAR-LARGE	SPORT/UTILITY-STANDARD
CAR-SPORT	SPORT/UTILITY-MINI
PICKUP-COMPACT	GVWR 3 TRUCK

MEDIUM AND HEAVY-DUTY VEHICLE DATA		
1. Model Years: All model years contained in DMV s Vehicle Registration filepass		
2. GVWR Classes: GVWR-3, GVWR-4 GVWR-5, GVWR-6, GVWR-7, GVWR-8		
3. Body Styles:		
AMBULANCE	FIRE TRUCK	REFRIGERATED
ARMORED TRUCK	FLAT BED /PLATFRM	SPORT PICKUP
AUTO CARRIER	FORWARD CONTROL	SPORTS VAN
BEVERAGE	GARBAGE	STAKE OR RACK
BOOM	GLIDERS	STATION WAGON
BUS	INCOMPLETE CHASSIS	STEP VAN
CARGO CUTAWAY	INCOMPLETE CHASSIS	SUBURBAN/CARRYALL
CARGO VAN	LOGGER	TANDEM
CARRIER	MOTORIZED CUTAWAY	TANK
CHASSIS & CAB	MOTORIZED HOME	TILT CAB
CLUB CAB PICKUP	MULTIPLE BODIES	TILT TANDEM
CLUB CHASSIS	PANEL	TOW TRUCK WRECKER
CONCRETE MIXER	PARCEL DELIVERY	TRACTOR TRUCK DSL
CONVENTIONAL CAB	PICKUP	TRACTOR TRUCK GAS
CRANE	PICKUP W CAMPER	TRAVELALL

CREW CHASSIS	RACK	UNKNOWN
CREW PICKUP	REFRIGERATED	UTILITY
CUTAWAY	SPORT PICKUP	VAN
DROMEDAY	SPORTS VAN	VAN CAMPER
DUMP	STAKE OR RACK	

FUEL TYPE DATA
All
Diesel
Gasoline
Alternate Fuels: Electric, Natural Gas, LPG, Butane, Propane, Methanol, etc.

APPENDIX B
Examples of Vehicle Population Statistics From The Joint Project

Figure B.1 California On-Road Vehicle Population (1997-1998)

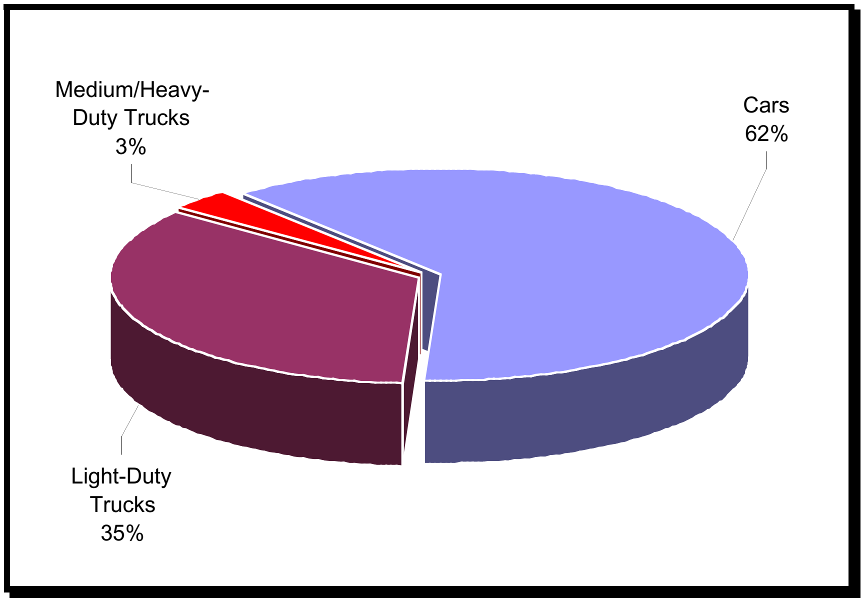


Figure B.2 California Cars (1997-1998)

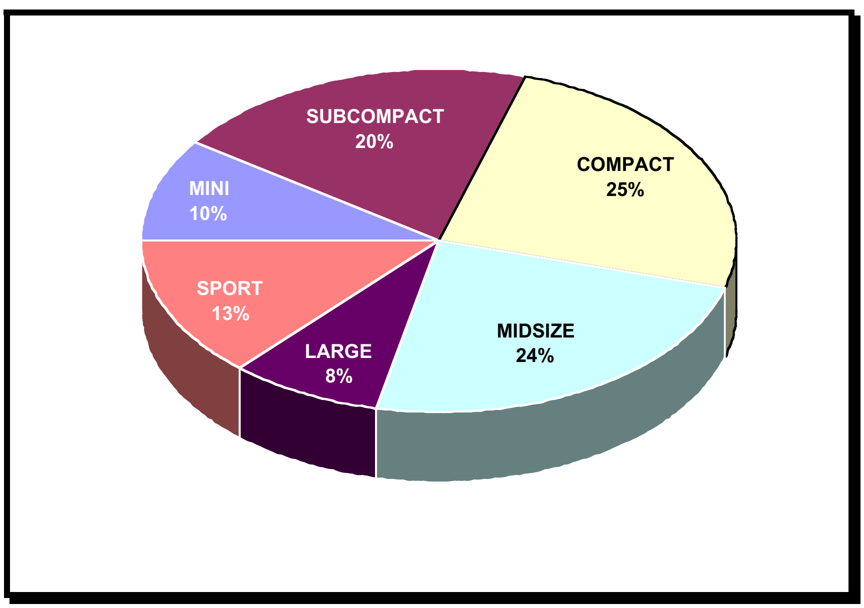


Figure B.3 California Light-Duty Vehicle Age Distribution (1997-1998)

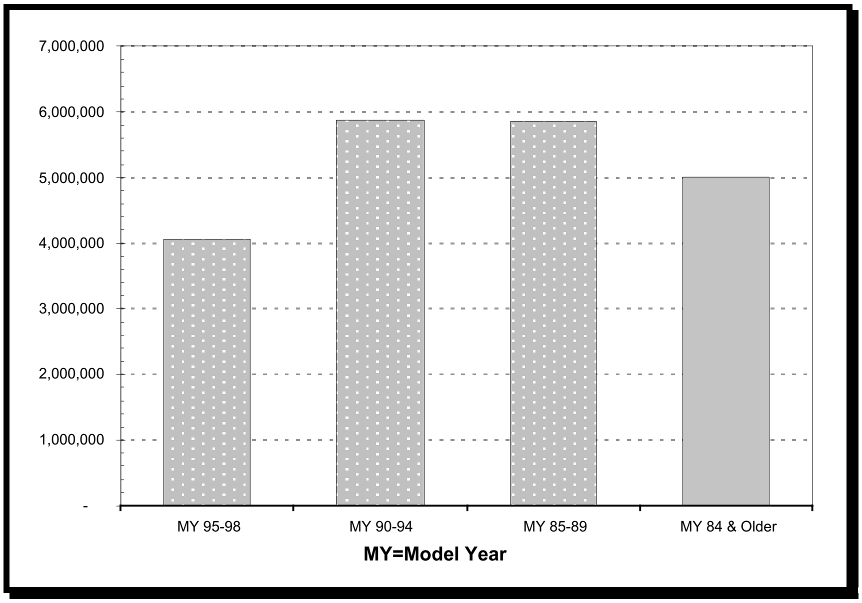


Figure B.4 California Light-Duty Vehicle Age Distribution (1997-1998)

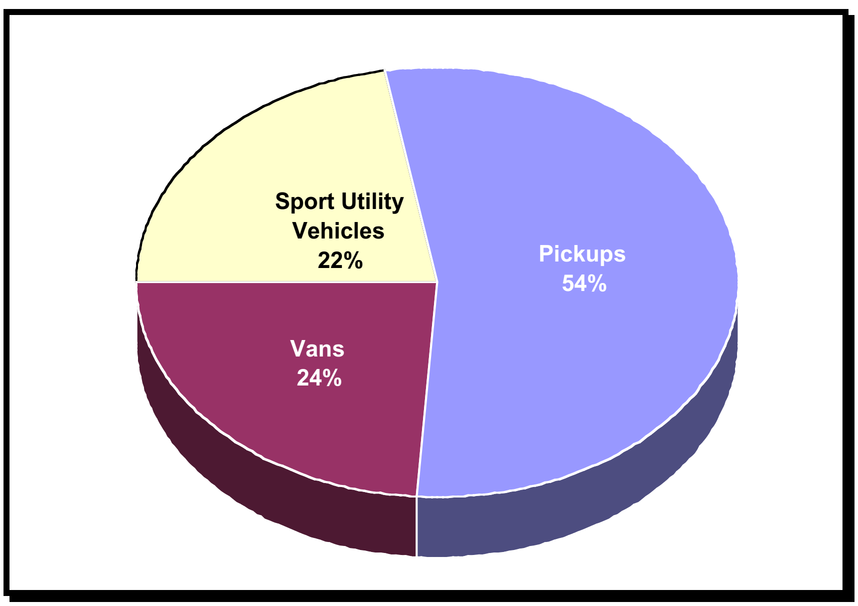


Figure B.5 California Medium/heavy-duty Vehicles (1998)

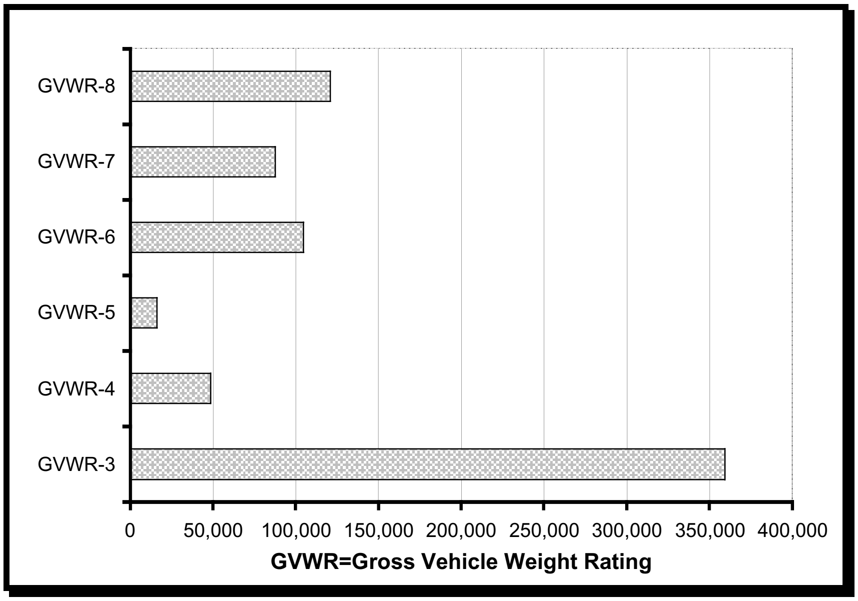


Figure B.6 California Vehicle Use (1997-1998)

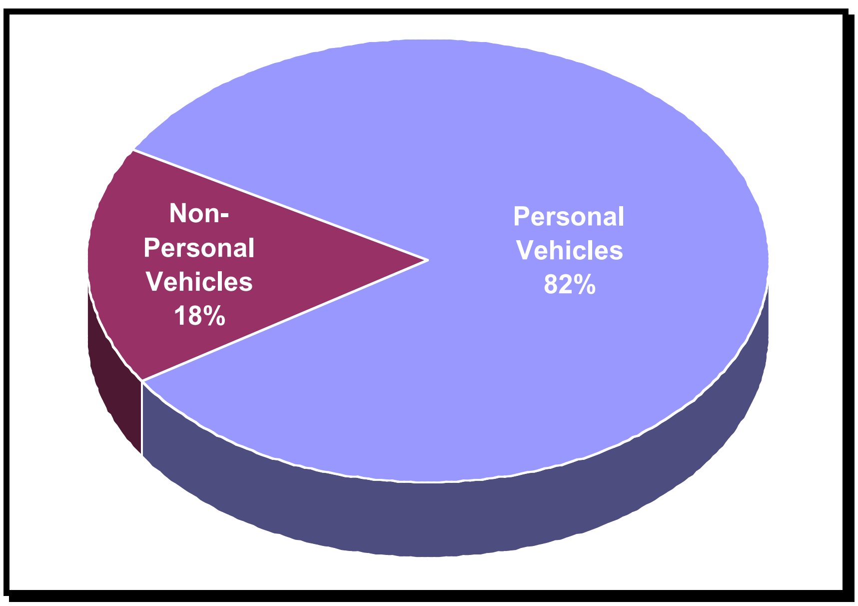


Figure B.7 California Non-Personal Fleets (1997-1998)

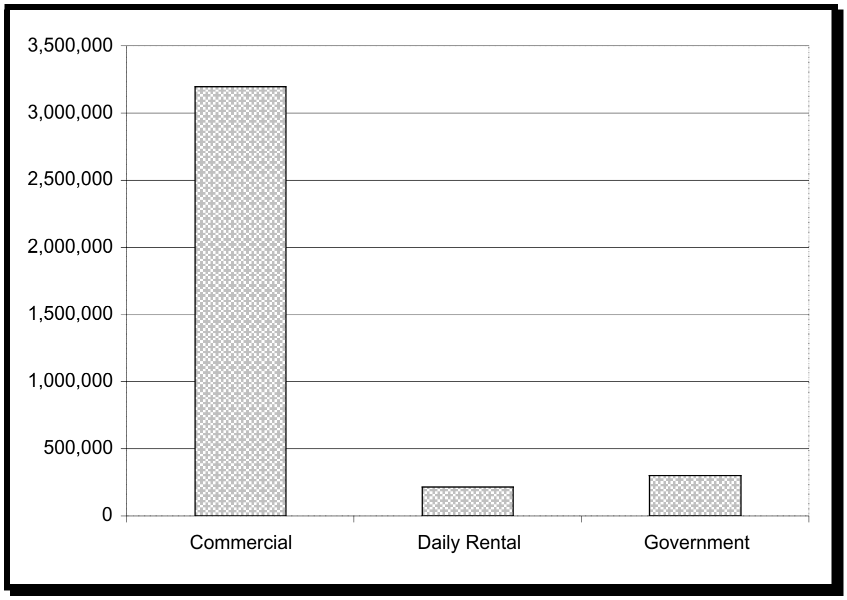
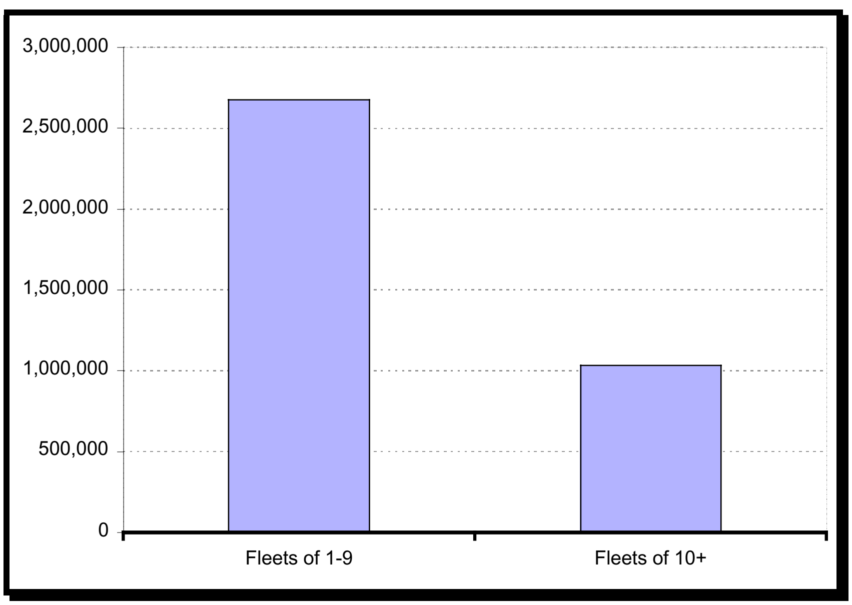


Figure B.8 California Non-Personal Fleet Size (1997-1998)



APPENDIX C
Forecasting Models, Methodology and Input Data

Forecasting Models

This section provides a brief description of the models used by staff to generate the forecasts described in Chapter 1. For readers interested in more detail, full documentation is available for each model from the Energy Commission s Demand Analysis Office.

CALCARS

The California Light Duty Vehicle Conventional and Alternative Fuel Response Simulator (CALCARS) is a personal light-duty vehicle forecasting methodology that the Energy Commission currently uses to projects number and type of light-duty vehicles (LDVs) owned, along with annual vehicle miles traveled (VMT) and fuel consumption by personal cars and light-duty trucks. Patterned after the Personal Vehicle Model (PVM), developed in 1983 for the Energy Commission, CALCARS uses a nested multinomial logit structure for vehicle ownership and choice. Unlike the PVM and other vehicle choice models however, CALCARS combines stated (hypothetical) and revealed (actual) preference data to forecast the penetration and use of both conventional and alternative fuel vehicles (AFVs). Coefficients for vehicle characteristics such as range, fuel availability, and emissions are estimated simultaneously with "conventional" characteristics such as operating cost and vehicle price in the vehicle choice portions of CALCARS. In the VMT estimate, the stated effects of range and fuel availability on travel are combined with data on the use of currently held vehicles.

Currently, the model can accommodate up to 35 classes of vehicles, 17 vintages, and the following fuel types: gasoline, methanol (M85), compressed natural gas (CNG), and electricity. Because CALCARS analyzes vehicle ownership and operation decisions at the household level, it can generate forecasts for any geographic region for which the necessary input data can be assembled. The Commission currently produces forecasts for five California regions (San Francisco, Los Angeles, San Diego, Sacramento, and rest of State, defined in Table C.1) as well as a statewide forecast. In the base year (1997), projections for each gasoline class-vintage combination (e.g., 5 year-old subcompact car) are calibrated to actual totals using data from the California Department of Motor Vehicles (the most recent fully processed DMV numbers available at the time these forecasts were made were from 1997). Fuel use is scaled so that 1999 LDV gasoline demand estimated by CALCARS matches historical levels in the five regions and statewide.

Table C.1 Energy Commission Forecast Regions (counties contained in each region)

REGION	COUNTIES
1. San Francisco	Alameda, Contra Costa, Marin, Napa, San Mateo, Santa Clara, Solano, Sonoma, San Francisco
2. Los Angeles	Imperial, Los Angeles, Orange, Riverside, San Bernardino, Ventura
3. San Diego	San Diego
4. Sacramento	El Dorado, Placer, Sacramento, Yolo
5. Rest of State	All Other Counties

Source: California Energy Commission, Demand Analysis Office

Gasoline commercial fleet LDVs are projected by CALCARS through forecasts from the Freight Model (described below) so that total (commercial plus personal) light-duty vehicle projections can be generated. The forecasts from the Freight Model are assigned to individual vintages using 1997 DMV data. Exogenous fleet AFV sales projections are input into CALCARS based on staff analysis.

Freight Model

The Freight Model serves two purposes in the current analysis. First, it projects the volume of freight transported by truck and rail, truck stock and VMT, along with truck and rail consumption of gasoline, diesel, methanol, and liquefied petroleum gas (LPG). These outputs are driven by projections of industrial activity by economic sector in the region or statewide. Second, it provides projections for commercial light-duty vehicles, which are used as inputs into CALCARS.

Transit Model

The Transit Model forecasts transit activity and energy demand for urban bus and rail systems, intercity bus and rail systems, school buses, and other (charter, church, etc.) buses. Based on individual systems (e.g., BART), the Transit Model can provide forecasts both regionally and statewide. The model is driven primarily by projections of population, employment, and income. It is also sensitive to changes in transit fares, auto operating costs, and service policies.

Input Data

Economic and Demographic Inputs

The energy demand forecasts use California Department of Finance (DOF) projections for population, number of households, number of employed persons (full- and part-time), and industrial growth, and the UCLA Anderson Forecast of 1999 for personal income growth. Table C.2 presents a summary of these projections. Annual growth rates for population, number of households, employment, and personal income average roughly 1.4, 1.3, 1.3, and 2.9 percent, respectively, over the forecast period.

Table C.2 Summary of Economic/Demographic Projections

YEAR	POPULATION (MILLIONS)	HOUSEHOLDS (MILLIONS)	EMPLOYED* (MILLIONS)	PERS. INCOME (MILLION 2000$)
1999	34.07	11.36	13.96	970.61
2005	37.37	12.33	15.35	1,139.24
2010	39.96	13.12	16.54	1,329.36
2015	42.37	13.89	17.33	1,523.60
2020	45.45	14.88	18.05	1,754.83

* *Does not include agricultural workers nor the self-employed.*

Fuel Price Inputs

The real prices of diesel and gasoline are assumed to remain constant over the forecast period per the most recent projections from the Commission s Fuels Office. Compressed natural gas and electricity price projections come from three sources: the *Transportation Fuels Price Analysis*, Commission staff report, October 1995; *Natural Gas Market Outlook* (appendices), Commission staff report, June 1998; and the *Retail Electricity Price Forecast*, Commission Website, December, 1997. Table C.3 shows the projected prices for 2000 and for 2005 and beyond (the prices for all fuel types are assumed to remain constant after 2005).

Table C.3: Projected Retail Fuel Prices (2000 dollars, including taxes)

FUEL	2000	2005-2020
Gasoline (per gal.)	$1.50	$1.50
Diesel (per gallon)	$1.41	$1.41
CNG (per therm)	$1.21	$1.06
Electricity (per kWh)	$0.08	$0.06

Source: California Energy Commission Fuels Office

Vehicle Attributes and Technology

For the base case forecast, CALCARS includes 20 classes of gasoline vehicles. For the alternative fuel vehicle scenario, a maximum of 10 additional classes are included, four of which are dedicated CNG, two are bi-fuel (CNG/gasoline), and four are electric. Table C.4 gives a description of the 30 classes. Table C.5 presents the vehicle attributes that are used in the vehicle choice submodels of CALCARS, along with a brief description. Projected and historical values for vehicle price, fuel efficiency, acceleration, range, emissions, top speed, and electric vehicle battery replacement cost come from K.G. Duleep (Environmental Analysis Inc.) a recognized expert in vehicle technology. All of the other attributes come from Energy Commission analysis. As an example, Table C.6 provides projected attributes for standard gasoline, CNG, and electric subcompact cars, for 2005, 2010, and 2015.

Table C.4 CALCARS Size Classes

CLASS	FUEL TYPE	DESCRIPTION	EXAMPLE
1	Gasoline	Mini Car	Chevrolet Chevette
2	Gasoline	Subcompact Car (luxury)	Audi 90
3	Gasoline	Subcompact Car (standard)	Geo Prizm
4	Gasoline	Compact Car (luxury)	Mercedes 300
5	Gasoline	Compact Car (standard)	Chrysler Lebaron
6	Gasoline	Midsize Car (luxury)	Volvo 850
7	Gasoline	Midsize Car (standard)	Oldsmobile Cutlass
8	Gasoline	Large Car (luxury)	Cadillac Fleetwood
9	Gasoline	Large Car (standard)	Chevrolet Caprice
10	Gasoline	Sports Car (luxury)	Dodge Stealth
11	Gasoline	Sports Car (standard)	Chevrolet Camaro
12	Gasoline	Compact Pickup	Ford Ranger
13	Gasoline	Standard Pickup (luxury)	Dodge W300
14	Gasoline	Standard Pickup (standard)	Ford F-150
15	Gasoline	Compact Van	Plymouth Grand Voyager
16	Gasoline	Standard Van (luxury)	Dodge Ram Van
17	Gasoline	Standard Van (standard)	Ford Econoline
18	Gasoline	Compact Sport Utility	Nissan Pathfinder
19	Gasoline	Standard Sport Utility	GMC Jimmy
20	Gasoline	Mini Sport Utility	Suzuki Samurai
21	CNG	Subcompact Car	Honda Civic
22	CNG	Large Car	Ford Crown Victoria
23	CNG	Standard Truck	Ford F-150
24	CNG	Standard Van	Ford Econoline
25	Bi-Fuel	Compact Car	Ford Contour
26	Bi-Fuel	Standard Truck	Ford F-150
27	Electric	Mini Car	Honda EV Plus
28	Electric	Subcompact Car	GM EV1
29	Electric	Compact Pickup	Ford Ranger
30	Electric	Compact Van	Chrysler EPIC EV

Source: California Energy Commission, Demand Analysis Office

Table C.5 Vehicle Class-Specific Attributes Used in Forecasts

ATTRIBUTE	DESCRIPTION
Acceleration	0-30 mph, in seconds
Top speed	Mph
Tailpipe emissions	Percentage of a 1993 gasoline vehicle
Dual fuel capability	Yes or no, gasoline and alternative fuel
Service station fuel availability	Percentage of gasoline stations
Home refueling or recharging capability	Yes or no
Luggage space	Percentage of comparable gasoline vehicle
Fuel operating cost	Cents per mile
Purchase price	In dollars
Range	In miles, on a full tank or charge
Home refueling time	In minutes, for vehicles with this capability
Service station refuel or recharge time	In minutes
Fuel type	Electric, compressed natural gas, methanol, or gasoline
Size	Mini, subcompact, compact, midsize, large
Body style	Standard car, station wagon, sports
	car, pickup truck, van, sport utility

Source: California Energy Commission, Demand Analysis Office

Table C.6 Vehicle Characteristics for Subcompact Car for Various Years

YEAR	FUEL TYPE	PRICE (98$)	FUEL ECONOMY**	ACCELERATION	TOP SPEED	RANGE	EMISSIONS	BATTERY RPLCMNT COST (98$)
2000	Gasoline*	14,725	29.75	3.59	108	454	0.57	--
	CNG	18,820	31.24	3.87	103	152	0.40	--
	Electric	43,635	3.70	2.98	80	120	0	15,567
2005	Gasoline*	15,419	31.46	3.53	109	480	0.50	--
	CNG	19,364	31.79	3.78	104	155	0.40	--
	Electric	42,809	3.69	2.92	80	120	0	13,512
2010	Gasoline*	15,658	33.73	3.43	111	515	0.50	--
	CNG	19,607	34.09	3.67	106	166	0.40	--
	Electric	41,623	3.73	2.83	80	120	0	11,588
2015	Gasoline*	15,827	34.95	3.33	113	534	0.50	--
	CNG	19,780	35.32	3.56	108	171	0.40	--
	Electric	40,587	3.78	2.75	80	120	0	9,920

*Standard (non-luxury) class.

**For gasoline and CNG, miles per gasoline-equivalent gallon (where one gallon = 1.11 therms); for electric, miles per kWh.

Source: Energy and Environmental Analysis

APPENDIX D
Forecasting Results

Table D.1 Projected Base Case Statewide Transportation Fuel Demand

YEAR	GASOLINE (MIL GL.)	COMP. NATURAL GAS (MIL THERMS)	ELECTRICITY (MIL kWh)	DIESEL (MIL GL.)
1999	13,856	33	483	2,460
2000	14,037	33	494	2,523
2001	14,378	34	505	2,582
2002	14,722	34	517	2,639
2003	15,046	35	528	2,685
2004	15,349	35	540	2,730
2005	15,673	41	551	2,776
2006	15,957	47	563	2,823
2007	16,386	52	575	2,866
2008	16,705	59	587	2,905
2009	17,122	65	599	2,945
2010	17,418	72	611	2,984
2011	17,686	73	624	3,027
2012	17,959	75	636	3,069
2013	18,194	76	649	3,110
2014	18,405	77	662	3,153
2015	18,658	78	675	3,195
2016	18,949	80	689	3,234
2017	19,201	82	703	3,270
2018	19,457	83	717	3,305
2019	19,704	85	731	3,341
2020	19,946	87	746	3,374

Source: California Energy Commission, June 2000 Staff Forecast

Table D.2 Projected Fuel Efficiency by Vehicle Type (Miles per gasoline-equivalent gallon)

Year	Light Duty Vehicles	Medium- and Heavy-duty Trucks*	Buses*
1999	20.54	4.73	4.71
2000	20.43	4.74	4.68
2001	20.31	4.76	4.66
2002	20.20	4.77	4.63
2003	20.10	4.78	4.61
2004	19.99	4.79	4.60
2005	19.90	4.81	4.58
2006	19.81	4.82	4.57
2007	19.73	4.84	4.55
2008	19.65	4.85	4.54
2009	19.57	4.86	4.53
2010	19.50	4.88	4.52
2011	19.43	4.89	4.51
2012	19.39	4.90	4.50
2013	19.36	4.91	4.48
2014	19.34	4.92	4.48
2015	19.32	4.93	4.47
2016	19.30	4.94	4.47
2017	19.29	4.96	4.47
2018	19.28	4.97	4.46
2019	19.27	4.99	4.46
2020	19.27	5.01	4.46

*Includes gasoline, diesel and CNG.

Source: California Energy Commission, June 2000 Staff Forecast

Table D.3 Projected On-Road VMT (million miles) in California by Source

YEAR	LIGHT-DUTY VEHICLES	MEDIUM- AND HEAVY-DUTY TRUCKS	BUSES	TOTAL
1999	279,328	12,953	1,067	293,200
2000	282,059	13,301	1,095	296,222
2001	287,522	13,612	1,119	301,946
2002	293,011	13,911	1,142	307,728
2003	298,283	14,163	1,165	313,269
2004	302,935	14,416	1,186	318,182
2005	308,081	14,702	1,206	323,627
2006	312,590	15,002	1,226	328,441
2007	319,828	15,283	1,245	335,983
2008	324,954	15,547	1,261	341,393
2009	331,988	15,811	1,273	348,699
2010	336,632	16,092	1,286	353,615
2011	340,817	16,349	1,301	358,038
2012	345,467	16,606	1,317	362,927
2013	349,494	16,863	1,335	367,195
2014	353,228	17,121	1,355	371,172
2015	357,801	17,378	1,375	375,987
2016	363,191	17,623	1,396	381,612
2017	367,880	17,868	1,417	386,536
2018	372,660	18,113	1,439	391,552
2019	377,336	18,358	1,461	396,465
2020	381,961	18,603	1,483	401,326

Source: California Energy Commission, June 2000 Staff Forecast

Table D.4 Total On-road Vehicle Stock Projections for California (thousands): Cars and Trucks

YEAR	LIGHT-DUTY VEHICLES	MEDIUM- AND HEAVY-DUTY TRUCKS	TOTAL
1999	21,458	352	21,810
2000	21,778	340	22,118
2001	22,154	332	22,486
2002	22,532	327	22,859
2003	22,884	325	23,209
2004	23,226	326	23,552
2005	23,613	328	23,941
2006	23,945	332	24,277
2007	24,438	337	24,775
2008	24,824	343	25,167
2009	25,316	348	25,664
2010	25,690	354	26,044
2011	26,040	360	26,400
2012	26,397	365	26,762
2013	26,715	371	27,086
2014	27,022	377	27,399
2015	27,393	382	27,775
2016	27,826	388	28,214
2017	28,200	394	28,594
2018	28,603	400	29,003
2019	28,987	405	29,392
2020	29,364	411	29,775

Source: California Energy Commission, June 2000 Staff Forecast

Table D.5 Projected On-Road Statewide Transportation Fuel Demand Higher Alternative Fuel Vehicle Penetration

YEAR	GASOLINE (MILLION GALLONS)	COMP. NATURAL GAS (MILLION THERMS)	ELECTRICITY (MILLION kWh)
1999	13,856	33	483
2000	14,037	33	494
2001	14,378	34	505
2002	14,722	34	517
2003	15,004	55	685
2004	15,265	64	953
2005	15,551	70	1,221
2006	15,800	75	1,484
2007	16,199	81	1,749
2008	16,498	85	1,938
2009	16,902	89	2,097
2010	17,189	127	2,249
2011	17,445	132	2,410
2012	17,705	136	2,576
2013	17,939	141	2,707
2014	18,149	144	2,805
2015	18,403	148	2,898
2016	18,693	153	2,997
2017	18,947	157	3,097
2018	19,202	161	3,186
2019	19,447	168	3,307
2020	19,688	173	3,387

Source: California Energy Commission, June 2000 Staff Forecast

Table D.6 Projected Fuel Efficiency by Vehicle Type (miles per gasoline-equivalent gallon)

YEAR	LIGHT-DUTY VEHICLES		MEDIUM- AND HEAVY-DUTY TRUCKS*	BUSES*
	CASE A	*CASE B*		
1999	20.58	20.58	4.73	4.71
2000	20.52	20.60	4.74	4.68
2001	20.42	20.63	4.76	4.66
2002	20.33	20.72	4.77	4.63
2003	20.26	20.88	4.78	4.61
2004	20.18	21.03	4.79	4.60
2005	20.12	21.20	4.81	4.58
2006	20.08	21.39	4.82	4.57
2007	20.03	21.58	4.84	4.55
2008	19.99	21.77	4.85	4.54
2009	19.96	21.96	4.86	4.53
2010	19.93	22.16	4.88	4.52
2011	19.91	22.36	4.89	4.51
2012	19.90	22.56	4.90	4.50
2013	19.89	22.77	4.91	4.48
2014	19.88	22.96	4.92	4.48
2015	19.88	23.16	4.93	4.47
2016	19.88	23.34	4.94	4.47
2017	19.88	23.52	4.96	4.47
2018	19.88	23.69	4.97	4.46
2019	19.87	23.87	4.99	4.46
2020	19.87	24.04	5.01	4.46

*Includes gasoline and diesel only.

Source: California Energy Commission Staff Forecast

Table D.7 Case B Light-duty Vehicle Stock (thousands) and Fuel Efficiency by Fuel Type

YEAR	GASOLINE (MPG)	ELECTRICITY (MILES/KWH)	CNG (MILES/THERM)
1999	21,455 (20.58)	1 (3.28)	14 (18.62)
2000	21,734 (20.60)	1 (3.28)	14 (18.62)
2001	22,031 (20.61)	35 (3.28)	48 (18.62)
2002	22,304 (20.63)	108 (3.28)	89 (19.23)
2003	22,490 (20.68)	249 (3.26)	124 (19.59)
2004	22,669 (20.72)	394 (3.25)	154 (19.87)
2005	22,888 (20.78)	543 (3.24)	181 (20.13)
2006	23,069 (20.87)	686 (3.24)	203 (20.39)
2007	23,414 (20.98)	819 (3.23)	226 (20.65)
2008	23,702 (21.11)	917 (3.23)	245 (20.91)
2009	24,082 (21.25)	1,016 (3.23)	266 (21.15)
2010	24,367 (21.40)	1,102 (3.23)	283 (21.39)
2011	24,639 (21.56)	1,177 (3.23)	298 (21.61)
2012	24,928 (21.74)	1,243 (3.23)	311 (21.81)
2013	25,201 (21.92)	1,295 (3.23)	321 (22.00)
2014	25,466 (22.10)	1,337 (3.24)	330 (22.19)
2015	25,795 (22.28)	1,377 (3.24)	341 (22.37)
2016	26,187 (22.45)	1,417 (3.24)	355 (22.55)
2017	26,525 (22.62)	1,455 (3.24)	378 (22.52)
2018	26,886 (22.78)	1,492 (3.25)	393 (22.64)
2019	27,233 (22.95)	1,534 (3.26)	403 (22.81)
2020	27,584 (23.11)	1,568 (3.27)	411 (22.97)

Source: California Energy Commission 2000 Staff Forecast

Table D.8 Total On-road Vehicle Stock Projections for California (thousands): Cars and Trucks

YEAR	LIGHT-DUTY VEHICLES		MEDIUM- AND	TOTAL	
	CASE *A*	CASE *B*	HEAVY-DUTY TRUCKS	CASE *A*	CASE *B*
1999	21,455	21,455	291	21,746	21,746
2000	21,734	21,735	286	22,020	22,021
2001	22,187	22,114	284	22,471	22,398
2002	22,565	22,502	282	22,847	22,784
2003	22,916	22,862	282	23,198	23,144
2004	23,256	23,217	281	23,537	23,498
2005	23,642	23,613	282	23,924	23,895
2006	23,975	23,958	283	24,258	24,241
2007	24,463	24,459	284	24,747	24,743
2008	24,851	24,864	286	25,137	25,150
2009	25,340	25,364	289	25,629	25,653
2010	25,713	25,751	292	26,005	26,043
2011	26,063	26,114	294	26,357	26,408
2012	26,415	26,482	297	26,712	26,779
2013	26,737	26,817	300	27,037	27,117
2014	27,045	27,134	304	27,349	27,438
2015	27,414	27,514	308	27,722	27,822
2016	27,843	27,958	311	28,154	28,269
2017	28,218	28,359	314	28,532	28,673
2018	28,616	28,770	318	28,934	29,088
2019	29,005	29,170	322	29,327	29,492
2020	29,383	29,563	325	29,708	29,888

Source: California Energy Commission Staff Forecast

APPENDIX E
Land Use Planning

Land use decisions undertaken over the past fifty years have profoundly affected today s society and the evolution of our transportation energy systems. Today s development patterns are rooted in the post-World War II baby boom and land use decisions made in that era. The nation s rapid population growth, particularly California s, found ex-GIs with new families realizing the American Dream, complete with new single family homes and perceived elbow room on larger-than-before lots in suburban locales. Lower cost land on the urban fringe encouraged dispersed, lower density development patterns. This gave way to freeway system development for the movement of goods and people, and a newfound dependence upon the automobile. Resulting low-density residential development patterns created longer travel distances and greater travel demands that could not be well served by mass transit. However, the American Dream had been realized in California, and freeways, cars, and personal mobility were essential parts of that dream.

A Model Approach

San Francisco offers an exemplary approach addressing the related problems of transportation energy consumption, traffic congestion, and affordable housing shortages in its new Better Neighborhoods 2002 program, consisting of three separate transit villages located near present or future transportation facilities. The villages will incorporate mixed-use designs, featuring housing above shops and eateries whose customers and residents would take advantage of nearby transit rather than use private vehicles.

In 1955 the California Legislature enacted a State planning law affecting land use. The law requires cities and counties to prepare land use and circulation elements in their general plans. The Legislature broadened the planning requirement to include housing elements in 1967, then conservation and open space elements in 1970 and safety and noise elements in 1971. (*California General Plan Guidelines,* Governor s Office of Planning and Research, November 1998, p. 9).

Exacerbating the current trend of growth is a related flurry of other statewide problems related to population growth and low-density urban development patterns. Current and projected severe shortages in water and water storage facilities, highway capacity, and school infrastructure are well documented. In the 1970s and 1980s urban encroachment on agricultural land, environmental resources and open space accelerated. This resulted in a 6 to 12 percent increase in land consumption for each one percent of population growth in metropolitan areas (*Planning at the Edge of the Millennium: Improving Land Use Decisions in California,* California Planning Roundtable, January, 2000, p. 4). Land consumption rates have now collided with resource protection realities. As development changed the landscape, more than 1000 plant and animal species are now listed as rare, endangered, or threatened by State and Federal wildlife agencies. (*Planning at the Edge of the Millennium: Improving Land Use Decisions in California,* California Planning Roundtable, January, 2000, p. 4)

Although the State s transportation system has served individual travel needs well, the pattern of land development it supports now results in consequences that the public, and the State, find disturbing. These undesirable consequences are most evident in the State s air quality. Our transportation system, including light-duty vehicles, heavy-duty vehicles, rail, marine and aviation, is responsible for as much as 70% of the total pollutants emitted in the State[63]. Because a majority of our metropolitan regions fail to meet air quality attainment standards, over 90% of Californians breathe unhealthy air during some part of the year. The transportation system is the most significant contributor to this problem. Due to the current pattern of low-density suburban development that encourages automotive use and the growth in vehicle-miles-traveled, reducing mobile source emissions will continue to be a challenge.

California s land use decision-making process is conducted by local jurisdictions and varies in length and complexity depending on the magnitude and type of project under consideration. A community plan or specific plan will normally entail the early selection of a citizens group from the planning area. The citizens group works with local authorities to arrive at a draft plan or set of plan alternatives to present to the planning commission. To fulfill statutory and constitutional due process requirements, the planning commission (comprised of lay persons in the community) and elected body (city council or board of supervisors) hold at least one public hearing, but more often than not, a series of hearings, to elicit public participation. After deliberating on testimony, staff reports, and feedback by community stakeholders, organizations, developers, individual citizens, and other interests, the elected body adopts a version of the plan as official public policy. The decision-making process for individual projects follows a shorter course, most often lacking the selection of a citizens group. However, the due process component of the decision making process remains intact, as public hearings flow through the planning commission on to the elected body. Predictably, the larger and more controversial the project, the more protracted the process may be, and lobbying is applied on decision-makers in proportionate measure throughout the process.

Opportunities to influence and change current development patterns as they affect transportation energy use occur throughout the land-use decision-making process, from the earliest public education and citizen outreach stages to the final vote. Further, ample opportunity exists to influence development patterns within the crucial links between land use and transportation. Some examples of these opportunities are shown in Table E.1.

The outcomes of a more efficiently coordinated land use and transportation system are numerous and beneficial. One prominent outcome of integrating transit options into the fabric of metropolitan and regional development patterns is greater overall efficiency and effectiveness, including reduced transportation energy consumption. Transportation energy considerations, particularly sustainable transportation energy, have been neglected and are lacking in current land use decisions.

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[63] California Air Resources Board Emission Model EMFAC2000

Table E.1 Opportunities to Influence Land Use Decision-making

Educate citizens advisory committees on the transportation energy impacts of maintaining present development patterns
Present planning commissioners with case studies where advanced alternative land use schemes have successfully met housing needs while preserving natural resources, yet still reduced overall transportation energy consumption
Introduce elected officials to the beneficial outcomes of community-level and neighborhood-level strategies to: • *Provide access to and support multi-modal transportation systems;* • *Concentrate development to reduce transportation energy consumption;* • *Reduce travel distances;* • *Cluster activity centers for transit, shopping and employment;* • *Integrate the network of transit services;* • *And interconnect street networks.*

Reducing Land Use Impacts on Energy Demand

Chapter 4 describes how the economic, health, environmental effects related to energy use become embedded in land use decisions in a way that cannot later be easily corrected. Local and regional governments routinely make land use decisions that significantly influence California s long-term transportation energy demand and infrastructure. Until recently, the economic, health and environmental effects of this embedded-energy demand have not been part of the criteria considered in the decision-making process for local land use. Following such a path can help decision-makers direct investments in urban development and new infrastructure in a more prudent manner, potentially reducing the long-term impacts from inefficient energy consumption.

The energy consumption difference between typical and more resource efficient suburban development patterns (see sidebar description) can be significant. The San Diego Association of Governments (SANDAG) conducted a 1994 analysis of the San Diego region with support funding from the Energy Commission. SANDAG found that a shift in new development patterns from existing policies to pedestrian-oriented development (POD) and transit focus area (TFA) style development could result, when fully mature, in a 10.5% reduction in annual transportation energy consumption for the entire SANDAG region. This would create annual estimated savings of $207 million,[64] in year 2000 dollars.

The SANDAG example illustrates key decisions made in the land use planning process can result in embedding energy demand. By considering energy effects of land use planning decisions,

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[64] San Diego Regional Energy Plan, Volume 2 , December 1994, SANDAG, pg. 134.

communities can realize significant energy savings by implementing land use planning criteria. Even though the community did not ultimately implement the criteria in their immediate land use decisions, the SANDAG example serves as an illustration of the transportation energy impacts of planning decisions and help consider those impacts in future land use decisions and new development projects. The absolute savings that accrue from implementing these actions are obtained primarily from reduced gasoline expenditures related to passenger car use. Other regional economic benefits also accrue due to increased disposable income for the region s

Alternative Development Patterns

As an example, a new housing subdivision, patterned after recent suburban developments, normally provides single family housing on quiet streets. With this development pattern of segregated land uses, household members typically drive a car to go grocery shopping, run errands at retail stores, or commute to work. Mass transit cannot economically provide adequate levels of service to be a viable option for many residents and, if available, typically requires a long walk to the bus stop where only infrequent service is offered. Parks, schools, and community infrastructure are generally beyond easy walking distance. Alternatively, the same housing needs can be met with a mixed-use development pattern. Arterial streets would be lined with 2-3 story buildings, with retail shops on the ground floor and single or multi-family housing on the upper floors. The streets behind the arterial would contain a mixture of single and multi-family housing clustered near key community infrastructure features (parks, community pools, community centers, schools, etc.). This multi-level, higher density allows for more open space for community use and makes mass transit more cost effective, with bus or trolley stops usually within _ mile of a sufficient number of riders to allow for 10 minute to 20 minute bus service throughout key commute hours. Job needs can be integrated into the development plans and new employers can be targeted and encouraged to provide new employment centers within the development scheme. Consequently, household members can walk a short distance to meet their shopping needs, walk to work, or walk a short distance to a public transit stop. Various versions of this development style are called pedestrian-oriented development (POD), transit focus areas (TFA), and urban village.

residents.

These energy use reductions are long term if land use patterns that address energy impacts are implemented. Most communities are built to last many years. While individual structures may change over time, the land use pattern is generally established in a permanent manner when the transportation infrastructure and housing and retail components are initially developed. Thus, savings achieved at the outset are very long lasting. These points all reinforce the need to actively consider the embedded-energy demand of a community when initially reviewing and approving land use developments.

The Energy Commission is currently working with the City of San Diego and the El Cajon Boulevard Business Improvement Association to develop redevelopment plans for the Mid-City area, east of downtown San Diego. Redevelopment plans for smart growth and for transit- and pedestrian-intense areas will be developed for a segment of Interstate 15. These plans will be the backbone of the City of San Diego s solicitations for developing six freeway interchange properties. The program adds new capability to the City s and the community s ability to contrast near-term and long-term costs and benefits of their Mid-City development plans. Policy-makers, businesses, developers and private citizens will be able to make informed choices about the type, location and level of development they want with data that measures the transportation energy use, emissions, and other parameters. As result of this process, the Mid-City portion of San Diego can become an enjoyable place to live and work with less impacts to the economy, the environment and public health.

APPENDIX F
Expanded Use Of Ethanol — Reduced Fungibility And Flexibility

The expanded use of ethanol in California will create a number of difficulties that will directly affect three types of gasoline blending and distribution practices currently used by California refiners to supply fuel to the State s consumers.

Currently, refiners typically add MTBE to gasoline before it is shipped to fuel terminals located throughout the State where the fuel is temporarily stored. The fuel distribution infrastructure does not have an adequate number of storage tanks to allow the gasoline produced by each refiner to be segregated in individual tanks. This is why most of the gasoline that is shipped through these terminals is stored in community tanks where multiple refiners share the same set of tanks. The cost to segregate and store gasoline production for each individual refinery that will be shipped through the pipeline distribution infrastructure would be prohibitively expensive. In many locations, there is inadequate space to build new tanks even if the costs were reasonable.

As we approach the time when MTBE is to be replaced with ethanol, operators of the common carrier pipeline system in California are expected to limit the concentration of ethanol that can be mixed with the gasoline stored in their community storage tanks to a single level. The actual concentration of ethanol will likely be set at a level desired by the majority of the shippers that use the common carrier system. Segregation limitations and the intent to provide the maximum degree of fungibility possible are the primary factors that are expected to result in this limitation.

Under ARB regulations, refiners can produce complying gasoline with or without the use of an oxygenate. This means that gasoline currently containing MTBE can be mixed with non-oxygenated gasoline without an increase in its volatility. This is not the case for ethanol blends of gasoline. The mixing of RFG containing ethanol with other non-ethanol RFG blends will significantly increase the volatility of the resultant mixture. Due to the likelihood of a violation of the RFG volatility specification, federal law prohibits such commingling.

Another concern regarding the expanded use of ethanol is that mixing two complying gasolines containing different concentrations of ethanol could also result in an increase in volatility in the resulting mixture. When two separate batches of finished gasoline that contain different levels of ethanol and identical vapor pressures are mixed together, the volatility of the combined blend can increase, resulting in a possible violation of the vapor pressure specification.[65] However, the measured increase must be at least 0.2 pounds per

[65] The maximum vapor pressure of reformulated gasoline currently sold during the non-winter months is 7.0 pounds per square inch. The exact months vary by location in the State. The new Phase 3 RFG specifications

square inch (psi) over the specification before a citation is likely to be issued. This is allowed because the test method used to measure volatility can not accurately determine changes that are smaller than this value.

The expanded use of ethanol will create a number of difficulties that will directly affect three types of gasoline blending and distribution practices currently used by California refiners to supply fuel to the State s consumers. These individual scenarios are described in greater detail in the following sections.

Creation of Mid-grade Gasoline

California consumers are able to purchase three different grades of gasoline regular, mid-grade, and premium. These different gasolines are distinguished by varying levels of octane.[66] Regular grade has an octane rating of 87, mid-grade is 89, and premium is the highest at 92. Few refiners in California produce mid-grade gasoline at the refinery. Instead, most mid-grade is created by mixing regular and premium together. The blending process can occur either at the gasoline storage terminal or the service station. At the terminal, a gasoline tanker truck is loaded with a combination of regular and premium in the correct proportions to achieve a level of 89 octane for mid-grade gasoline. The tanker truck then delivers this mixture to a service station that has an underground storage tank that is connected to a mid-grade pump nozzle. But the majority of service stations in the State have mid-grade pumps that are connected to a regular and premium underground storage tank. Mid-grade is then blended together as the motorist fuels their vehicle.

Today, refiners are able to continue this practice regardless of the amount of oxygen contained in the gasoline because the use of different concentrations of MTBE has little effect on volatility of gasoline compared to the use of ethanol. The Energy Commission anticipates that there will be limitations imposed by the common carrier pipeline operator that will restrict the concentration of ethanol to one level. Thus, a refiner would not be permitted to ship a premium grade of gasoline to a terminal with the intent of blending a higher concentration of ethanol compared to the regular grade of gasoline. Refiners will also not be permitted to combine a premium blend of gasoline containing ethanol with a blend of gasoline produced without any oxygenate because a violation of the volatility limit would

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have a maximum vapor pressure specification of 6.9 psi if refiners take credit for carbon monoxide benefits of using greater amounts of ethanol.

[66] Octane is a measure of a blend of gasoline components ability to resist engine knocking. Knocking or pinging is a sound that results from premature ignition of the compressed fuel-air mixture in one or more of the cylinders. The higher the octane value, the greater resistance to engine knocking. This is why a consumer who is experiencing knocking in their engine can sometimes fix the problem by switching to a grade of gasoline with a higher octane level.

likely result.[67] Therefore, regular and premium grades of gasoline will have to contain the same concentrations of ethanol, decreasing the flexibility a refiner has to produce a variety of different gasoline blends.

Blending Higher Concentrations of Oxygenates in Premium to Achieve 92 Octane

Several different types of blending components that are produced at the refinery are combined together to create finished gasoline. Most gasoline blending components have an octane level of less than 92. But oxygenates have octane values that are greater than 100. This means that California refiners normally use higher concentrations of MTBE in their premium grade of gasoline compared to their regular grade. Refiners are able to reduce their operating costs by producing regular grades of gasoline with lower concentrations of MTBE compared to the premium grade blends. This may not be an option when California refiners switch from MTBE to ethanol because both grades of gasoline will need to contain the identical concentrations of ethanol for reasons discussed earlier.

Blending Greater Quantities of Oxygenates to Create Sufficient Volumes of Gasoline during Periods of Production Problems

California has experienced periods of rapid price increases that were precipitated by a number of severe refinery outages over the last two years. In addition, numerous refinery equipment problems of lesser severity also had an impact on the gasoline production capability of refineries. During these types of episodes, refiners usually have the ability to increase the concentrations of oxygenates in their gasoline blends to the legal limits in an effort to continue supplying the same volume of gasoline.[68] The blends of gasoline with greater volumes of MTBE can be combined with gasoline produced by other refiners throughout the distribution system without violating the volatility standard. This practice will likely not be an option if ethanol remains the only oxygenate to satisfy the State s conditions of use after December 31, 2002. Thus, refiners that experience an equipment outage severe enough to affect production of gasoline components at the refinery will not have the option of increasing the ethanol content in the gasoline to help maintain their normal production volume of gasoline. As a result, the fuel supply impact of unplanned refinery outages could be more severe than today. The possible exception to this scenario would be for those refiners that have their own proprietary distribution system. However, the majority of gasoline is distributed through the common carrier distribution network.

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[67] Federal law prohibits this practice in all severe and extreme ozone nonattainment regions of the State during the volatile organic compound (VOC) control periods, essentially the non-winter months when the maximum volatility limit for gasoline in California is set at 7.0 pounds per square inch.

[68] Maximum concentration of oxygen allowed in California gasoline is 3.7 weight percent for ethanol and 2.7 weight percent for MTBE and other oxygenates. These oxygen levels translate to a 10 percent by volume maximum concentration for ethanol and a 15 percent by volume maximum concentration for MTBE.

Conclusion

The widespread use of ethanol will either diminish or eliminate some of the current gasoline blending and distribution practices. The net result will likely be decreased flexibility for refiners and higher cost of gasoline for consumers. Refiners, pipeline operators, terminal owners, State regulators, and other interested stakeholders recognize that steps should be taken to retain the maximum amount of flexibility for refiners, thus minimizing operating expenses and helping to maintain a satisfactory fuel supply.

APPENDIX G
Achieving Higher Fuel Economy Through Corporate Average Fuel Economy Regulations

The most progress with transportation energy efficiency in the U.S. has occurred with passenger cars due to federal Corporate Average Fuel Economy (CAFE) standards.[69] With the adoption of standards and compliance schedules, one for passenger cars and one for light-duty trucks, large gains in new vehicle fuel economy were achieved in the latter half of the 1970s through most of the 1980s as illustrated in Figure G.1 [70].

Today s new automobiles sold in the U.S. achieve about twice the fuel economy (in miles per gallon) as new cars in 1975. The CAFE standard -- the average level that must be achieved by a manufacturer s vehicles sales for any model year -- reached the legislated maximum of 27.5 mpg in 1990, and the industry average since that time has remained between 27.6 and 28.6 mpg. Light-duty trucks, also subject to CAFE standards, must achieve an average of 20.2 mpg. The aggregate fuel economy performance of new vehicles clearly parallels the timeline of the standard, reaching a plateau, as the standard remained unchanged.

Although there are benefits that come with greater vehicle fuel efficiency, a decline in new car and light truck fleet fuel economy (combined) began to decline after 1988 and continues today. This decline of 8 percent over 11 years has been driven by three factors. First, consumers have purchased an increasingly larger fraction of light-duty trucks, including sport utility vehicles, in comparison to passenger cars over the past 20 years.[71] Second, manufacturers perceive no benefit in producing new vehicles that on average could achieve more than the existing CAFE standard. Last, the U.S. Congress has not expressed interest in raising fuel economy. Absent a sharp and prolonged gasoline price increase or higher fuel economy standards, increases in fuel demand are likely to track growth in population,

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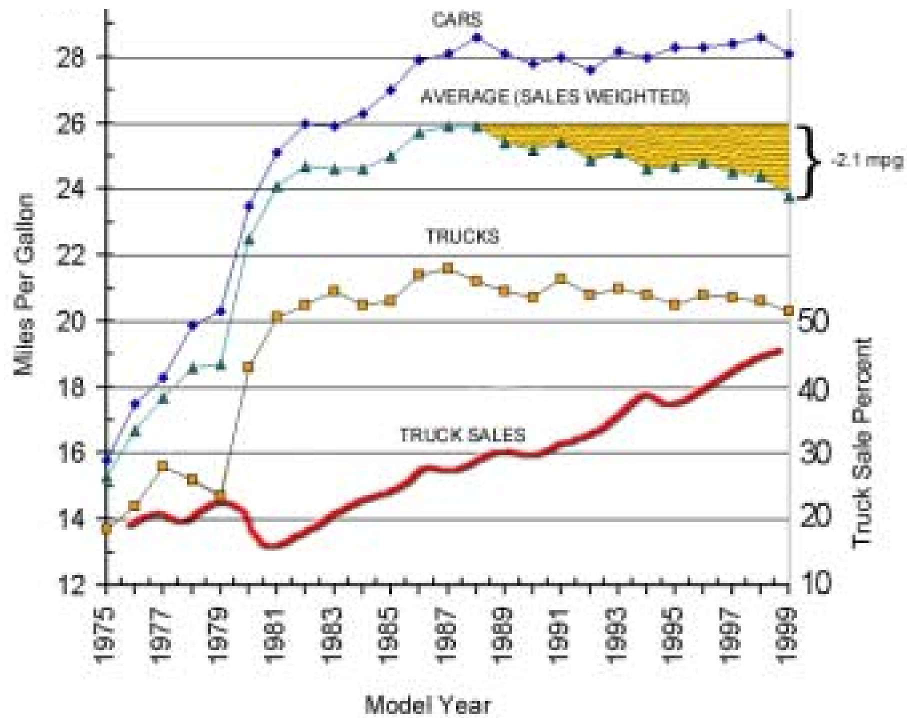
[69] CAFE standards applicable to each automotive manufacturer s annual new car production fleet were established through the Energy Policy and Conservation Act of 1975 (PL-173). Effective in 1978, a standard of 18 miles per gallon (mpg) was established for passenger cars, increasing annually to a maximum of 27.5 mpg by 1985. A manufacturer s compliance with the law is based on a calculation of the sales-weighted fuel economy of all models sold by that manufacturer. Separate but lower mpg standards apply to light-duty trucks.

[70] New light-duty vehicles for all manufacturers averaged 15.3 mpg in 1975. The new car fleet improved to 25.9 mpg by 1987. Passenger cars improved more than light-duty trucks by achieving 28.6 mpg versus 21.6 mpg, respectively. Nevertheless, these trucks improved by nearly 58 percent over 12 years while passenger cars improved 81 percent.

[71] In 1975, 80.6 percent of new vehicle sales were passenger cars with 19.4 percent sales of light-duty trucks (10,224,000 vehicles in all). In 1999, passenger car sales had fallen to 53.6 percent while truck sales rose to an all time high of 46.4 percent of new vehicle sales (14,699,000 vehicles). The number of trucks sold in 1999 was3.5 times the number sold in 1975 while passenger car sales actually dropped during this period (639,000 fewer passenger cars were sold in 1999 compared to 1975).

increased vehicle-miles-traveled, and consumer preference for light-duty trucks and sport utility vehicles. Managing the rate of transportation fuel demand growth in California may require greater emphasis on demand measures other than fuel economy standards.

Figure G.1 U.S. New Light Duty Vehicle Fuel Economy Trends



An Energy Commission analysis of the effect of increasing CAFE standards (Table G.1) beginning in 2006 to achieve average fuel economy for new light-duty vehicles of 40 mpg for cars and 30 mpg for trucks by 2012 is shown in Table 5.1.

Table G.1 Effect on On-Road Gasoline Demand, Travel, and LDV Fuel Efficiency of Higher CAFE Standards (40 mpg for cars, 30 mpg for trucks, by 2012)

VARIABLE	YEAR			
	2006	2010	2015	2020
Gasoline Demand	-0.7	-7.3	-18.0	-24.5
VMT	+0.1	+1.1	+3.0	+4.0
LDV Fuel Efficiency	+0.8	+9.2	+26.0	+38.4

The effect of higher standards is gradual as only new vehicles are affected in 2006, new and one-year-old vehicles in 2007, and so on. The increase in fuel efficiency induces higher VMT (as vehicle owners on average face a lower operating cost per mile); so that gasoline demand does not fall in percentage terms as much as does fleet-average gallons per mile. Still, the projected effect of the higher standards is sufficient to begin reducing total on-road gasoline demand by 2010, as shown in Figure 4.2. By 2020, projected gasoline demand drops to slightly over 15 million gallons per year.

The Alternative Motor Fuels Act of 1988. The Alternative Motor Fuels Act (AMFA) of 1988 created an incentive within CAFE to encourage automakers to produce vehicles with a reduced petroleum fuels demand. This initiative established a different method for the calculation of fuel economy for alternative-fuel vehicles (AFV) under CAFE regulations[72]. Under the regulation, alternative-fuel vehicle fuel economy is based on the fraction of gasoline in the fuel. The inflated gasoline fuel economy value is then used in the calculation of automakers sales-weighted new vehicle fuel economy. If enough AFVs are produced, this option could sufficiently boost a manufacturer s corporate average fuel economy and avoid financial penalties for failing to meet the CAFE standard. The key to continued use of this provision of the CAFE regulation by manufacturers is the value of the increased fuel economy impact (or avoided penalty cost) versus the development and incremental production costs of the alternative-fuel vehicles. Flexible fuel vehicles (FFV) currently have the greatest CAFE value to auto makers because incremental cost of production relative to gasoline vehicles and other alternative-fuel vehicles is low. Since 1993, manufacturers have placed about 400,000 FFV into the nationwide market, which operate on either methanol (M-85) or ethanol (E-85) fuels.

In California, however, most FFVs are operating entirely on gasoline due to the lack of alternative fueling infrastructure. The appropriateness of using the CAFE standards to stimulate FFV production is being reviewed in a federal rulemaking to ensure that fueling infrastructure becomes available to support these vehicles as part of the inclusion of FFVs in CAFE calculations. The provisions of AMFA that pertain to flexible-fuel and dual-fuel vehicles will sunset in model year 2003. An important opportunity will arise in 2001 when Congress will review these provisions for potential extension to the 2008 model year.

Other CAFE issues that need consideration and debate include:

- CAFE requires calculation, for compliance with the standard, of both autos and light duty trucks to obtain a fleet average fuel economy.
- Uniform compliance requirements for individual manufacturers annual market sales, despite considerable variation in different companies product lines
- Provisions for separate foreign and domestic sales averages, no longer relevant given the increasing globalization of the industry
- Diminishing cost-effectiveness following achievement of the first doubling of fuel economy
- Limitation of applicability to light-duty highway vehicles only
- Primary emphasis on vehicle size and weight as compliance variables

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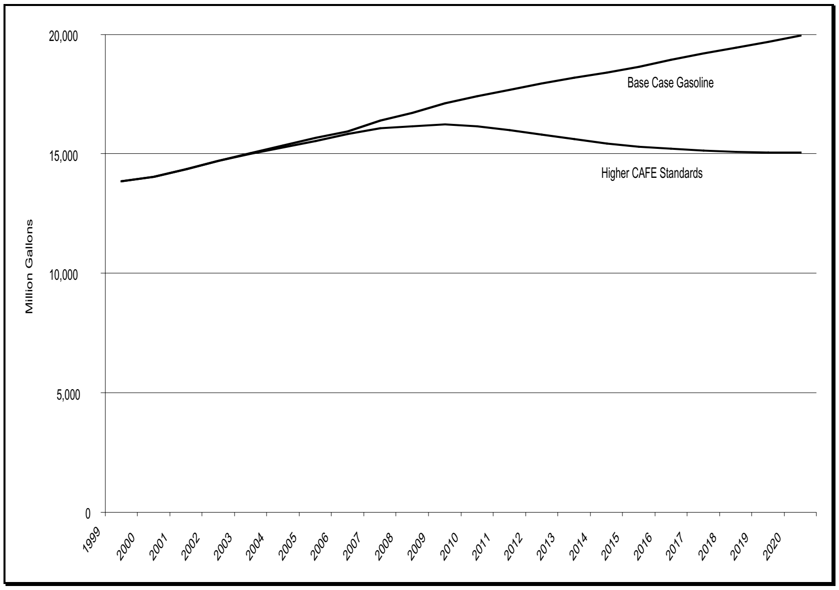
[72] The Congress found and declared that the achievement of long-term energy security for the United States is essential to the health of the national economy and that displacement of energy derived from imported oil with alternative fuels will help to achieve energy security and improve air quality.

- Competing regulatory and societal priorities for safety and emission control technology
- Inconsistency with other technology-based energy efficiency initiatives (for example, in the appliance and building construction sectors)

Figure G.2 Projected On-Road Gasoline Demand, Base Case Forecast and Higher CAFE Standard Scenario



Proposals and initiatives for further government regulation of transportation energy efficiency also tend to encompass only automobiles and light-duty trucks. Thus, as with alternative-fuel progress, the potential for efficiency gains in non-highway transportation energy sectors may offer larger opportunities.

APPENDIX H
Electric Vehicles

In 1997 automakers began to offer production-built electric vehicles (EVs), powered by batteries. Few cars were made available to the public and even fewer were made available for purchase. Only GM and Honda offered their vehicles to the public and those were only available as lease vehicles. EV availability was and continues to be restricted geographically and in quantity. Nonetheless, every EV made available to the public, government and utilities was leased and, at least one automaker issued a letter to customers stating that they would not fill future orders (Honda). Those automakers still offering EVs have standing orders and waiting lists for vehicles. Today s EV market is best described as: no product available and long, uncertain delivery dates for vehicles.

According to recent surveys, drivers of EVs are extremely satisfied with their experience. The surveys show that most EV drivers are able to displace gasoline vehicle use. Highest satisfaction is reported on performance, ease of refueling, fuel cost and maintenance. Predictable inconveniences, such as lack of convenient public access to recharge and lack of a standard connection, are minor problems relative to the overall satisfaction with EVs. Range capability (the distance the vehicle can travel between refueling stops) does not impede the drivers use of EVs. Drivers and potential drivers report their highest level of dissatisfaction as not being able to acquire an EV.

Automakers, however, have great difficulty with the cost of manufacturing EVs. Battery costs are the component cost more frequently cited. Battery technology has improved but high-volume manufacturing, necessary to bring the costs down, have not. Part of this is due to the way EVs have been introduced into the market: because the market is uncertain, automakers do not order large quantities of batteries. Because the battery makers don t have large orders, they cannot raise the capital to develop a production manufacturing facility. There are other issues as well, including lack of standard battery specifications among vehicles.

Public policymakers have the opportunity to address many of the energy problems described in this report through the successful commercialization of electric drive train technologies, such as battery-powered EVs. Chief among them is that electricity provides direct competition to gasoline — and marketplace competition helps keep prices of all products at affordable levels. Controlling emissions from gasoline vehicles (the tailpipe, refueling emissions, distribution losses, stand-by emissions) is more manageable from a power plant than from 25 million vehicles. Because California has the cleanest electricity generation in the world, emissions from EVs are an order of magnitude cleaner than gasoline vehicles — and that is amplified over time as the emission control devices and other systems on board a gasoline vehicle deteriorate and emissions become higher. Electric vehicle emissions don t degrade over time. Most importantly, the effect of moving tailpipe emissions alone away from population centers to a power plant reduces public exposure six times more than an incremental reduction in tailpipe emissions.

Electric drive train technologies used in electric vehicles are also used in fuel cell vehicles and hybrid electric vehicles. Fuel cell vehicles, depending upon their fuel source, may result in public benefits similar to battery electric vehicles — although that will depend on the fuel that is used to power the cell. Automakers do not expect to make fuel cells vehicles available until 2007. Most hybrid electric vehicles, which show that automakers can build vehicles with higher-fuel economy, still produce tailpipe, refueling, distribution, and stand-by emissions. The only hybrid vehicles that are currently available from automakers are still 100% dependent on petroleum, thus offering no opportunity for competition among fuels. Electric vehicles in the marketplace provide a technology against which automakers will compete to provide cleaner, more fuel efficient vehicles.

The over-riding public health, transportation energy diversity and fuel-on-fuel competition benefits of electric vehicles are frequently masked by a petroleum-based view of transportation. The challenge for public policymakers is to compare electric vehicles against what drivers need rather than to compare them against a gasoline vehicle. These types of analyses are just beginning to emerge and more effort should be made in this regard.

The factors that affect the market penetration of this new technology are the same as other new technologies: price, cultural acceptance and ease of use. The Energy Commission has helped in the area of price (through incentive programs) and ease of use (building standards for chargers). The Energy Commission could do more by focusing on ways to reduce the manufacturing cost of batteries, conducting effective public information campaigns, strategically developing public charging infrastructure and mandating a single, standard connection. These activities apply to all alternative fuel vehicles.

APPENDIX I
Emerging Electronic-Based Technologies

Electronic-based technologies are emerging to transform the traditional concept of transportation and its ability to provide access to goods and services. Electronic technologies have the potential to provide ways to avoid transportation. Electronic-communication (e-communication) is already a rapidly expanding use of information technologies to engage in business, communications and social interactions. GNR is a second wave of three new technologies: genetic engineering, nanotechnology and robotics. Together these newer technologies have the potential to create fundamental changes in information flow, manufacturing and the economy. At the same time that e-communication is expanding and GNR is becoming reality, we are also experiencing advances in bandwidth (the amount and speed of data that can be transmitted between computers) and increased computing speed. These technologies are already transforming California's and the world's economies.

Two individuals, Gordon Moore and George Gilder have coined terms to describe the rate at which these technologies are advancing:

- Moore s Law states that computer chips are halving in price or doubling in power every 18 months.
- Gilder s Law forecasts that for the foreseeable future (the next 10 years), the total bandwidth of communication systems will triple every 12 months.

E-communications and Transportation Energy Demand

The electronic forms of communication, rapid transmittal of vast amounts of information that may have required some form of mechanized or human transport in the past, are quickly becoming the dominant business modes of exchange. Manufacturers, retail businesses and consumers are all adapting to use e-commerce for basic work, purchasing, and social interactions. Government and academia have also embraced e-communications for procurement and information dissemination.

Whereas many companies in the past had to be constantly engaged in the physical movement of product and components, companies now have formed Internet supply/ordering systems that can reduce their inventories and be successful with just in time delivery of merchandise. These innovations not only enhance profitability use a more efficient transport system. Business is just beginning to adopt new tele-working arrangements where employees no longer work in a centralized building. Such arrangements are likely to become more common as bandwidth, voice and video conferencing becomes ubiquitous and deliver a better outcome. The advent of more powerful, inexpensive desktop computers will make this even more convenient and inexpensive in the future. (Inexpensive desktop computers are projected to be on the order of one million times more powerful by 2030).

As these changes become commonplace, it can be expected that some types of transportation patterns will decrease while others may increase — the effect on transportation energy use is not yet known. Some products, e.g., newspapers, tickets to events, and paper invoices, will begin to de-materialize. As more materials are delivered electronically, fewer will require transport via trucks, trains and airplanes. Commute traffic patterns could change dramatically if tele-working becomes commonplace. However, some transportation energy use for delivery systems could be intensified as more people shop and make major purchases electronically. Recreational travel, rather than commute travel, could become the dominant growth area for transportation energy demand.

GNR and Transportation Energy

GNR (genetic engineering, nanotechnology and robotics) is a lesser-known but growing field. One example of an application of GNR, specifically nanotechnology, that we can foresee is in manufacturing. A product using nanotechnology is constructed at or near an atomic level. For example, a carbon nanotube (one atom thick and about seven to nine atoms around) is one hundred times stronger than steel at one-sixth the weight. With carbon nanotubes, the weight of materials used in cars could be substantially reduced while gaining strength. Reduced vehicle weight can translate to improvements in fuel efficiency. Nanomaterials can also potentially improve the storage of hazardous or difficult to contain substances like hydrogen. Such a development could accelerate the development of hydrogen fuel cell technology.

The purpose of this discussion is to introduce these advances so that they can be included in the formation of future deliberations on transportation energy policy. The impacts of e-communications and GNR are new and not yet well understood. However, their potential to impact California and its patterns of energy use and demand may be profound. Analyses to predict trends in transportation energy use need to develop and include an understanding of the impacts of e-communications and GNR.