NRDC
THE EARTH'S BEST DEFENSE

FUELING THE FUTURE

A Plan to Reduce California's Oil Dependence

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NATURAL RESOURCES DEFENSE COUNCIL
September 2002

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EXECUTIVE SUMMARY

California's drivers are heading full-speed down a rocky road toward an uncertain gasoline future. Every day, the state's refineries churn away in an attempt to produce the nearly one million barrels of gasoline California needs. But even though refineries are working at full capacity, they still come up roughly 30 thousand barrels a day (TBD) short. The state is able to make up this shortfall through imports, but it will need to find even more supplies of imports in the future. California is expected to grow by 14 million people over the next two decades. By 2010, total gasoline demand is expected to have grown around 15 percent from today's levels; by 2020, 30 percent. As demand increases with California's growing population, the shortfall will become increasingly unmanageable.

Soon, however, the gasoline problem will go from unmanageable to unsustainable. By the end of 2003, per state mandate, the oxygenate additive methyl tertiary butyl ether (MTBE) must be phased out of gasoline in order to protect water supplies. Since the early 1990s, as required by the federal Clean Air Act, MTBE has been used as an additive in reformulated gasoline to help prevent air pollution. But in 1999, after MTBE was found to contaminate groundwater, California's governor ordered its phaseout to be completed by the end of 2002 (later delayed until 2003). While necessary to protect groundwater supplies, the phaseout of MTBE will exacerbate the current in-state refinery shortfall, as it will reduce output by 5 percent, or 50 TBD—roughly doubling the amount of gasoline that must be imported. In short, just as demand is increasing, supply will be decreasing.

As the balance between supply and demand becomes increasingly unstable, the health of California's economy, public, and environment are all at risk. Prices at the gas pump—the nation's highest—will keep climbing. California drivers already pay a $.15 surcharge on every gallon of gasoline due to imports and another $.05 per gallon due to price volatility. We will likely see more frequent and more severe price spikes of as much as $.50 per gallon; as a result, average gasoline prices could climb to $2.00 per gallon. In addition to the economic fallout, unchecked gasoline consumption will result in increased pollution from more oil drilling, tanker traffic, and vehicle tailpipes. Public health will suffer, as will our coastlines and wilderness areas.

This path is not inevitable; in fact, NRDC has charted a course toward a clean and reliable fuel supply. This report presents a plan that will reduce California gasoline demand by 15 percent below 2000 levels by 2020, ensure the state's independence of imported gasoline by 2011, save drivers approximately $28 billion, and protect public health, the economy, and the environment.

RECOMMENDATIONS: CREATING A CLEAN AND RELIABLE FUEL SUPPLY

The state is facing many certainties: decreased in-state refinery supply as a result of the phaseout of MTBE, a growing fleet of cars and trucks, limits on how much the state's refineries are able to produce, and a growing reliance on unreliable gasoline import supplies. As a result, the economy, public health, and environment are at risk. California must confront these certainties immediately and devise solutions in order to provide a reliable fuel supply that minimizes the economic and environmental costs.

NRDC has crafted a four-step plan to enable California to do just that. Our plan requires action and commitment from the state government, which must in turn engage automakers, oil companies, planners, and other related business sectors, as well as the general public in a shared effort to reduce California's unsustainable gasoline consumption. The NRDC plan will:

- ▸ enable California to become independent of imported gasoline by 2011 (which would eliminate what is now a $.15 per gallon surcharge for imports);
- ▸ relieve pressure on California's refineries so that they run at only 90 percent by 2015, thereby mitigating price spikes and allowing them to respond quickly to unplanned shortfalls (which would reduce the average price per gallon by perhaps another $.05);
- ▸ save California drivers approximately $28 billion during the period between 2002 and 2020 (including the cost to implement the technologies and programs);[1]
- ▸ reduce California's need to import gasoline and crude oil from the Middle East and other troubled regions of the world by cutting gasoline demand to 15 percent below 2000 levels by 2020;
- ▸ benefit public health and the environment by decreasing air and water pollution, global warming emissions, and pressure to drill in our wilderness areas.

These goals can be accomplished in four steps:

Step 1: Raise Fuel Economy Standards for All New Cars and Light Trucks

Today's automakers already have the technology to increase the fuel economy of passenger vehicles to 42 miles per gallon (mpg) by 2015—up from today's average of 24 mpg. However, instead of taking advantage of improved technology, U.S. automakers are continuing to build less efficient cars and light trucks: the fuel economy of the typical passenger vehicle is at a 21-year low.

All automakers who sell cars in California can make voluntary commitments to raise fuel economy standards; they have already done so in Europe, where their voluntary commitments will result in the equivalent of a 41-mpg new vehicle fleet by 2008—a 36 percent increase over the base year of 1995.

In addition, California can build consumer demand for clean and efficient vehicles by expanding its existing purchase incentive programs for better electric vehicles and hybrids. A comprehensive approach would be to adopt "feebates"—a system of rebates and fees on new vehicle sales. California can also adopt a public education program and "green vehicle" labeling to help consumers make more informed choices when purchasing new vehicles.

Step 2: Invest in Hydrogen Fueling System Infrastructure

Fuel-cell powered vehicles can usher us into a gasoline-free future. A fully optimized hydrogen-powered fuel-cell car will use approximately two-thirds less energy (none of it coming from oil) than today's average car, enabling it to get the equivalent of about 80 mpg. With proper infrastructure in place, fuel-cell powered vehicles can hit the market in significant volumes by 2010.

Automakers will soon begin pilot production of several hundred fuel-cell vehicles for fleet use. The only obstacle to full-scale commercialization is creating an adequate refueling infrastructure—and this can happen quickly. Oil companies can eliminate their antiquated system based on 19th century oil technology and redirect funds to implement a clean, petroleum-free, hydrogen infrastructure. The state can offer tax incentives or grants for the construction of hydrogen refueling stations. The total capital cost for meeting California's 2020 import demand using hydrogen would be equal to the cost of meeting the anticipated demand with gasoline: building a new refinery in the Gulf Coast, installing a new pipeline to bring the fuel to California, and constructing additional service stations to supply added fuel would add up to nearly $5 billion in undiscounted capital costs.[2]

Step 3: Launch a Public Education Campaign to Promote Smart Driving and Educate Consumers About Fuel-Efficient Vehicles

In response to the electricity crisis of the summer of 2001, state government, business organizations, and advocacy groups executed a series of policies and incentives that had been coordinated in advance; around $50 million of the state's impressive $730 million conservation campaign was used for public education. The effort was highly effective: nearly one-third of households served by Pacific Gas & Electric slashed their monthly electricity use by 20 percent or more.

NRDC's plan for a clean and reliable fuel supply for California can meet the state's future fuel needs, protect the environment, and save drivers money.

California can organize a similar public education effort to reduce its dependence on gasoline. The government can also enlist the support of tire manufacturers, service stations, automakers, and oil manufacturers. Such a campaign would educate the public about the benefits and savings of:

- inflating tires properly;
- changing air and oil filters more frequently;
- driving the speed limit on highways;
- modest trip reduction and elimination;
- replacing worn tires with low-friction, fuel-efficient tires.

If followed, these measures could reduce gasoline consumption by nearly 6 percent by 2010; at today's fuel consumption levels, that would be equivalent to more than 800 million gallons, or more than 50 TBD.

Step 4: Encourage Smart-Growth Planning and Diverse Transportation Options

As metropolitan areas have spread out helter-skelter, most Americans find themselves driving longer distances in steadily worsening traffic congestion. With homes, workplaces, schools, and stores located far apart, and with local planning emphasis on building roads rather than expanding transit options, Americans have little choice but to drive.

Smart-growth planning can significantly reduce gasoline use. California is expected to add 4.2 million new homes by 2020, but planning for smart growth now would alleviate increased gasoline pressure in the years to come. A recent study for the California Energy Commission (CEC) found that California could reduce statewide gasoline consumption by 3 to 10 percent by 2020 if several smart-growth policies were adopted across the state.[3] The study identified four policies as particularly promising:

▸ city and transit station-focused land-use development;
▸ increased transit supply;
▸ market pricing of parking;
▸ improvements in regional job-to-housing ratios to encourage people to live close to where they work.

State and local policymakers can direct investments to building the infrastructure to create and promote affordable housing, create regional revenue-sharing arrangements, enhance mass-transit service, and promote location-efficient mortgages (market-based incentives to encourage homeowners to buy in greater-density neighborhoods, thereby reducing monthly expenses associated with commuting). And these policies will support efforts to reduce our dependence on gasoline.

PUTTING TO WORK NRDC'S FOUR-STEP PLAN TO REDUCE OIL DEPENDENCE

NRDC's plan for a clean and reliable fuel supply for California can meet the state's future fuel needs, protect the environment, and save drivers money. If implemented, the plan will reduce California's gasoline use by about 12 percent from projected 2010 consumption levels (a 2.0-billion-gallon reduction) and about 39 percent from projected 2020 consumption levels (a 7.5-billion-gallon reduction, or 490 TBD).

▸ **Step 1:** Fuel-efficient cars and light trucks can save 5.2 billion gallons of gasoline by 2020, or about 340 TBD;
▸ **Step 2:** Fuel-cell vehicles and battery-electric vehicles can save almost 1 billion gallons of gasoline by 2020, or about 60 TBD;
▸ **Step 3:** Public education efforts and fuel-efficient replacement tires can save 0.7 billion gallons of gasoline by 2020, or about 45 TBD;
▸ **Step 4:** Smart growth can save 0.7 billion gallons of gasoline by 2020, or about 45 TBD.

The total net discounted savings to consumers as a result of the NRDC's Four-Step Plan would be approximately $28 billion. By following these four steps, California can reverse the trend toward greater dependency on imported supplies of gasoline and oil, and put the state on a path toward a clean and reliable fuel supply, protecting the California economy, public health, and environment.

CHAPTER 1

Gas Pains in the Golden State

California's drivers are heading full-speed down a rocky road toward an uncertain gasoline future. Every day, the state's refineries churn away in an attempt to produce the nearly one million barrels of gasoline California needs. Even though refineries are working at full capacity, they still come up roughly 30,000 barrels a day (TBD) short. Even though the state is currently able to make up this shortfall through imports, it will need to find even more supplies of imports in the future. California is expected to grow by 14 million people over the next two decades. By 2010, total gasoline demand is expected to have grown around 15 percent; by 2020, 30 percent. As demand increases along with California's growing population, the shortfall will become increasingly unmanageable.

Immediately exacerbating the demand problem is the imminent phaseout of methyl tertiary butyl ether (MTBE). This additive has been used since the early 1990s as an oxygenate in gasoline to help reduce air pollution; but in 1999, after it was discovered that MTBE contaminated groundwater supplies, California's Governor Davis ordered its elimination by the end of 2002. (The governor recently delayed completion of the MTBE phaseout until December 31, 2003.) While necessary to protect groundwater supplies, the phaseout of MTBE is bad news for in-state refinery supplies, since its elimination will reduce the output of refineries by 5 percent.[4] So just as demand is increasing, supply is decreasing with the phaseout of MTBE.

California drivers already pay the highest prices in the nation at the pump through import surcharges and experience frequent price spikes due to unplanned refinery outages. The prognosis among the experts is that things will only get worse: California drivers could face average prices topping $2.00 per gallon as well as dramatic price spikes beyond that.[5] If such prices are sustained over a year's time, California drivers will see their total annual gasoline bill jump from roughly $25 billion to $30 billion.

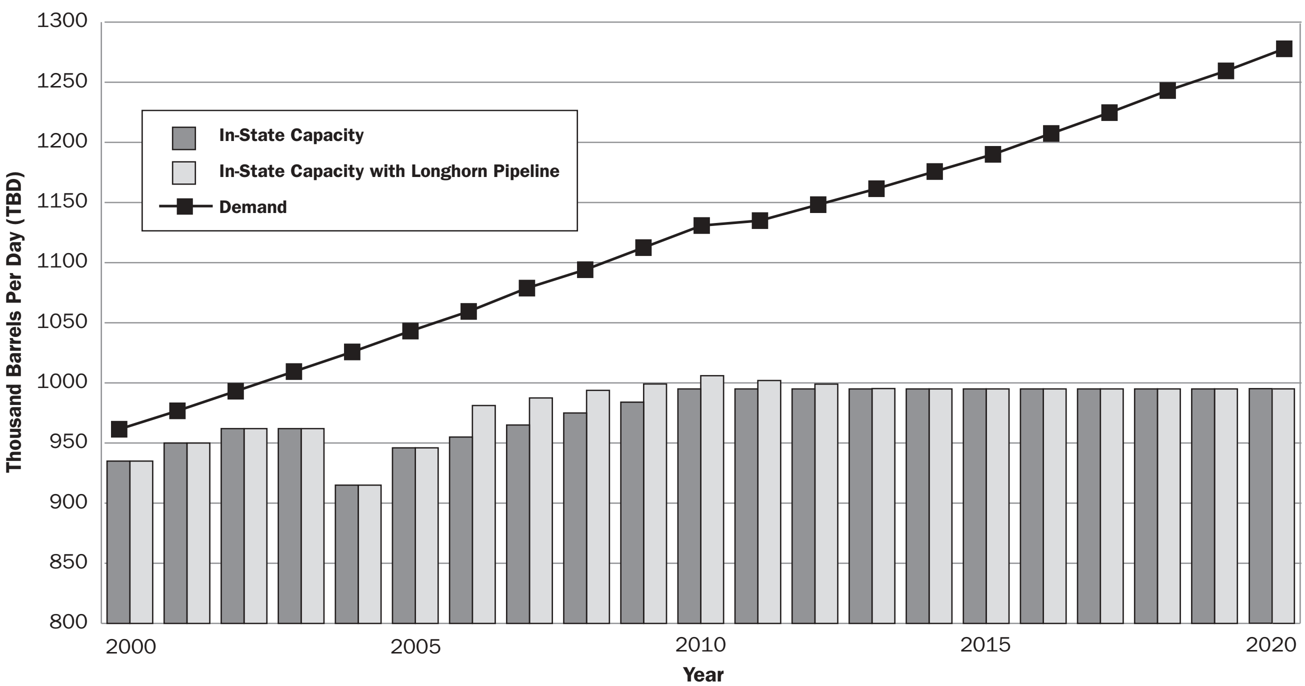
Ensuring a clean and reliable gasoline supply is critical to California's future. Rising gasoline consumption means more air and water pollution; it also creates pressure to explore and drill in wilderness areas and to expand refinery capacity. As we learned from the electricity crisis during the summer of 2001, it is unwise to place California's energy supply solely in the hands of the private market. With the imminent phase out of MTBE and with California's population expected to grow by 14 million over the next two decades, the state must find ways to meets its transportation energy needs without undermining the economy, public health, air and water quality, and the integrity of its coasts and wilderness areas.

In this chapter we will quantify the problem (the shortfall), we will consider the options before California for solving the problem, and we will examine the consequences of continued gasoline dependence—taking into account economic, air quality, environmental, and energy security impacts.

RUNNING ON EMPTY: QUANTIFYING CALIFORNIA'S GASOLINE SHORTFALL

Facing pressures of a growing fleet of cars and light trucks, the state's refineries are already running at full capacity—yet they still cannot keep up with growing demand (see Figure 1.1). As a result, there will be a greater likelihood of supply disruptions due to refinery breakdowns and increased reliance on out-of-state refiners, especially foreign, to make up the shortfall. And when MTBE is phased out in the end of 2003, the gasoline shortfall will immediately jump from 30 TBD to 80 TBD—perhaps even as high as 100 TBD.[6] Unfortunately, ethanol—the only practical available substitute allowed by federal law to replace MTBE—has undesirable blending properties which

FIGURE 1.1
California's Gasoline Demand Versus In-State Refinery Production Capacity



Notes:
1. One barrel equals 42 gallons.
2. Longhorn Pipeline is a planned pipeline from Texas to Tucson that would reduce by 75 TBD the amount of gasoline California refineries would need to export to Arizona.
3. In-state refinery relies on additives such as ethanol or alkylates that are imported.

Sources: NRDC estimate based on CEC consultant report by Stillwater Associates, for 2000 to 2010 demand and in-state refinery capacity (Stillwater Associates, *MTBE Phaseout in California*, consultant report, California Energy Commission, March 2002, Figure 3.2). For 2010 to 2020, we use the CEC gasoline demand forecast for the AB2076 Petroleum Dependency study (CEC, *Task 2: Base Case Forecast of California Transportation Energy Demand*, staff final report, California Energy Commission, March 2002) and assume no additional refinery creep after 2010.

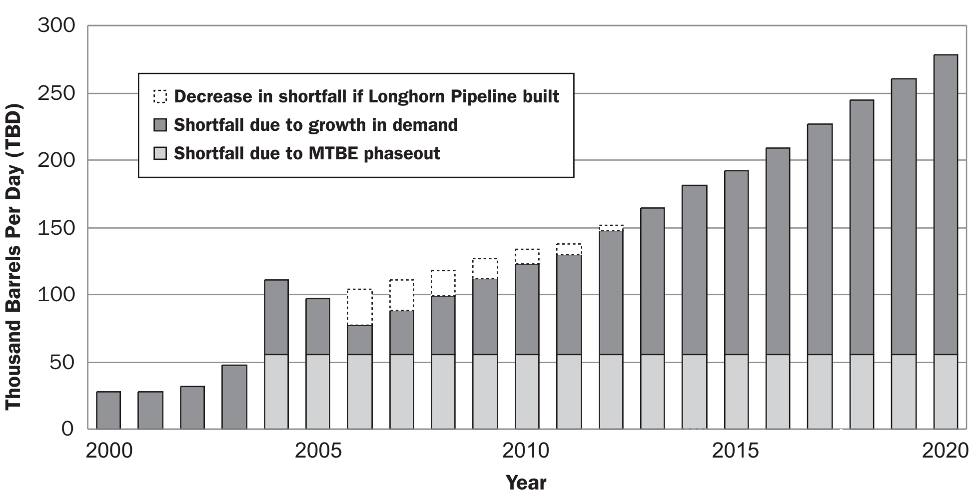
will result in a 5 percent reduction in the amount of gasoline California's refinery system can produce.[7]

Since 1998, to make up for the shortfall and refinery outages and breakdowns, California has been importing significant amounts of gasoline.[8] Today, the state imports roughly 5 percent of its total gasoline demand; over the next several years, we project the figure will grow to about 10 percent (see Figure 1.2); by 2020, the state will be importing more than 20 percent of its gasoline supply. With refineries in the U.S. Gulf Coast having little spare production, California must turn with increasing frequency to supplies imported from foreign countries, including the Middle East. The state will be sacrificing the reliability of its future gasoline supplies by turning to an undependable global market for gasoline. To make matters worse, supplies from foreign countries are tightening as global demand climbs—especially for gasoline that meets California's cleaner burning specifications.

Refiners are planning to construct a pipeline from Texas to Tucson, which would alleviate pressure for imports—but only partially and temporarily. Currently, Los Angeles refineries supply about 60 TBD to Arizona, which has a total demand of about 90 to 100 TBD.[9] The planned project, called the Longhorn Pipeline, could connect the Gulf Coast to Tucson as early as 2005. The Longhorn Pipeline would have a capacity of 75 TBD and could, for a short time, reduce the need to ship gasoline from California to Arizona. However, as Arizona continues to grow, so does its demand for gasoline from California.

As early as 2004, the shortfall will grow to more than 100 TBD. By 2010, total gasoline demand in California is expected to grow 15 percent, with a shortfall of 130 TBD; by 2020, the shortfall will jump to 280 TBD. To accommodate the shortfall, California will need to import from 7 to 11 percent of its gasoline over the next eight years, rising steeply to more than 20 percent by 2020. When Gulf Coast and foreign

FIGURE 1.2
California's Growing Demand for Imported Gasoline
(Does not include imports of additives such as ethanol or alkylates)



Source: NRDC estimate based on analysis described in Figure 1.1.

refiners see the increased demand, they may choose to offer special batches of California gasoline and additives—at a substantial price premium.

EXAMINING SUPPLY OPTIONS: IMPORTS, REFINERIES, OR EFFICIENCY?

California has a number of options to address the state's gasoline shortfall, some of which are being studied by the CEC:[10]

- to rely increasingly on imports from the Gulf Coast, which would require constructing a new refinery and pipeline to California;
- to rely increasingly on imports from foreign countries, which are transported by marine tanker;
- to expand refinery capacity in California through capacity "creep" of existing facilities (gradual improvement of efficiency over time) and/or reopening shut-down refineries;
- to replace new gasoline demand with programs promoting fuel efficiency, alternative fuels, smart driving, and smart growth.

According to the U.S. Department of Energy, growth in demand nationwide will continue to outstrip the ability of refiners to increase capacity.

The Supply of Imports Is Unreliable and Scarce

Gulf Coast refineries have little spare capacity. California cannot rely on imports from the Gulf Coast as refinery capacity is tight. According to the U.S. Department of Energy, growth in demand nationwide will continue to outstrip the ability of refiners to increase capacity. Despite forecasts that the United States can expand its gasoline production by 1,820 TBD, imports of refined petroleum products (including diesel, jet fuel, and gasoline additives) are projected to increase by 57 percent between 2000 and 2010.[11] Demand is sufficiently high in easier-to-reach markets, especially the Midwest, to consume the Gulf Coast refineries' supply. The only way to divert more gasoline supplies from the Gulf Coast to California would be to increase foreign imports to the northeastern states—an option that would, of course, be at the expense of other regions.

However it does not appear that Gulf Coast refiners are planning to meet future California import demand. Based on a recent survey by a consultant to the CEC, Gulf Coast refiners have no immediate plans to upgrade their facilities to manufacture gasoline in compliance with California's clean-burning, 2004 Phase 3 gasoline specifications.[12]

Another option would be to turn to "alkylates," chemicals derived from oil that can extend refinery output. But the total U.S. capacity to produce alkylates is limited, and the production of alkylates must compete for a key additive against the higher value chemical industry. As a result, California gasoline prices would have to rise by $.30 to $.55 per gallon over the national average to attract sufficient volumes of alkylates consistently. According to a report by a CEC consultant, the quantity of alkylates that could be imported would be expensive and limited to about one cargo per month, equal to about 9 TBD.[13,14]

There is not adequate marine tanker shipping from the Gulf Coast. Even if gasoline were available in sufficient quantities to meet California's import needs, the CEC

TABLE 1.1
Cost of Building a Pipeline and Related Infrastructure in Order to Meet Projected 2020 Gasoline Demand

Infrastructure	Estimated cost
New Refinery	$3.0 billion
New Pipeline	$1.6 billion
New Service Stations	$0.3 billion
Total Cost	**$4.9 billion**

Source: NRDC estimate (see Appendix B). Does not include cost of expansion of existing refineries assumed by Stillwater Associates in their recent study for the California Energy Commissions (Stillwater, 2002).

warns that there are not enough tankers to move the gas to California from the Gulf Coast.[15] Gasoline prices would have to rise $.10 to $.25 per gallon before shipping companies would deem it economically viable to build vessels.[16]

Global capacity is limited. Only three foreign refiners are prepared to supply more than 50 TBD to meet California's Phase 3 specifications—which accounts for about half of the near-term shortfall. These refiners are located in New Brunswick, Canada (18 TBD); Alberta, Canada (11 TBD of additives); and Dubai (25 TBD). Therefore, with demand growing and fuel specifications becoming tighter worldwide, gasoline and other refined petroleum products will become less and less available.[17]

Gas prices would have to rise substantially above national and global prices before additional imports could be found to make up the entire shortfall; furthermore, these higher prices would have to be sustained for some time to convince Gulf Coast and foreign refiners that it would be economically advantageous for them to invest in modifying their refiners to supply gasoline to California on a regular basis.

Constructing a Gulf Coast Refinery Would Be Polluting and Cost- and Time-Prohibitive

Unless demand is reduced, California's growing gasoline thirst can only be quenched by the output of one very large refinery capable of producing more than 250 TBD by 2020. (For comparison, the average California refinery produces around 80 TBD.) However, this scenario would be highly unlikely because of the enormous financial—as well as environmental—risk involved.

A CEC consultant, Stillwater Associates, estimates the cost of a new refinery (to be built in the Gulf Coast and capable of producing 200 to 300 TBD) to be in excess of $3 billion.[18] Oil company officials have cited costs between $2 and $4 billion.[19] More tankers and/or a new pipeline would have to be built to bring the gasoline to California; another CEC consultant estimated this cost to be around $1.6 billion.[20] Finally, service stations would need to be expanded to pump additional gasoline, at a cost NRDC estimates roughly as $300 million. The total cost of meeting California's 2020 demand would be $4.9 billion for a new refinery, a pipeline from the Gulf Coast, and service stations (see Table 1.1; for additional details of cost estimate, see

Appendix B). According to the American Petroleum Institute, the low rate of return from current refinery operations (about 4 percent) inhibits the ability of the oil industry to attract investment capital.[21] Therefore, even if financing could be found, such a project would likely take at least a decade to complete—too long to address California's imminent gasoline shortfall.

Expanding the Existing California Refinery System Is Not an Effective Solution

Increasing production at existing facilities would undermine clean air goals. Opportunities to expand California's refinery system are limited to small increases in existing facilities. Increasing capacity at existing refineries would necessitate pollution reductions from other sources, including motor vehicles, power plants, and small businesses. Because the state is already struggling to identify air pollution reduction measures to help it meet federal clean air requirements, major expansions at existing facilities would severely undermine California's clean air goals.

With the impending phaseout of MTBE and an increasing dependence on an unreliable, unstable gasoline supply, Californians are destined for higher, more volatile prices and frequent price spikes at the pump.

Re-opening idle facilities or building a new facility would not alleviate the shortfall. There are no current proposals to build a new refinery in California. Given the state's very serious air quality situation, it does not appear that such a major facility could be opened in California and still enable the state to meet federal requirements to reduce smog- and soot-forming emissions. Even if it were possible, opening a new refinery would take at least a decade, given the time required for construction, permitting, and environmental review. Thus, such a proposal would not remedy the upcoming shortfall in gasoline supply.

There have been at least three recent proposals to re-open idle refineries or to expand significantly an existing refinery. Re-opening idle facilities would take less time than would building an entirely new refinery. However, the only such project under consideration would, at the earliest, start production in 2005 and only supply about 22 TBD, still leaving a substantial (roughly 80 TBD) shortfall in in-state refining capacity.[22]

Refinery "creep" is limited. California refiners have been able to expand gasoline production capacity by optimizing and modifying their refineries—a "capacity creep" of about 1 percent per year. It is unclear if such a rate can actually be sustained into the future. However, even if it does continue, capacity will continue to fall short. In fact, the shortfall analysis presented above assumes this optimistic rate of creep up until 2010 (identical to the CEC consultant's forecast); nonetheless, a large gap remains.[23]

Investing in a Clean and Reliable Fuel Supply Benefits Public Health, the Environment, and the Economy

As we will demonstrate in Chapter 2, California's future transportation needs can be met more cheaply, more cleanly, and just as quickly through fuel efficiency, alternative fuels, conservation, and smart growth. By eliminating the need for imports and by avoiding increased reliance on refineries, the state will create a more reliable transportation fuel system, save drivers and the state billions of dollars, and protect public health and the environment.

ECONOMIC CONSEQUENCES OF CONTINUED OIL DEPENDENCE

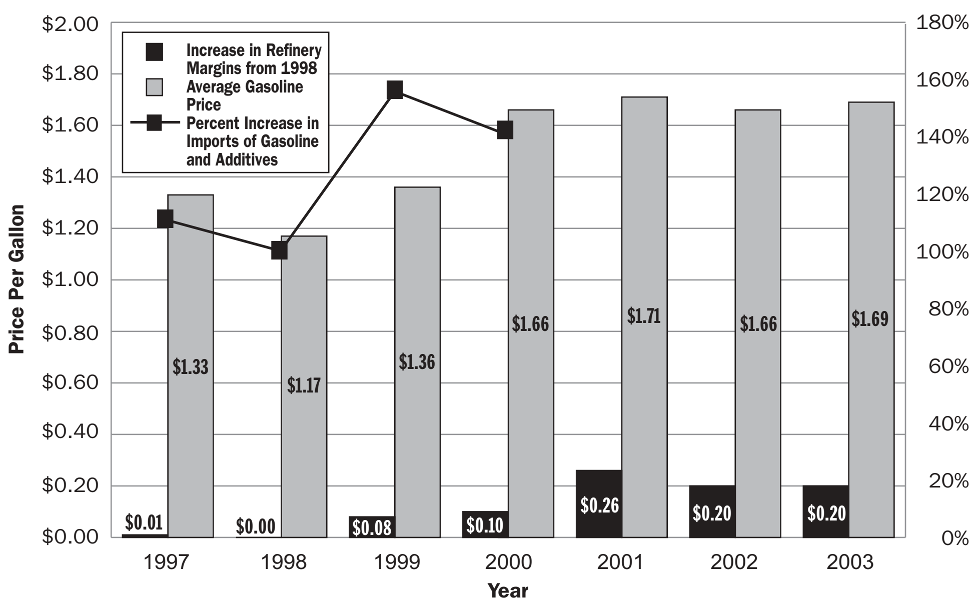
With the impending phaseout of MTBE and an increasing dependence on an unreliable, unstable gasoline supply, Californians are destined for higher, more volatile prices and frequent price spikes at the pump.

The Import Surcharge Means Higher Prices

Imports are more expensive because refiners must offset transportation costs. The CEC estimates the current import surcharge to be about $.15 per gallon, roughly the average cost of transportation from the Gulf Coast (see Figure 1.3).[24,25] Marine tanker shipping costs, according to CEC, have ranged from $.10 to $.18 per gallon over the last couple of years, but because the supply of marine tankers available to ship gasoline from the Gulf is expected to decline, transportation costs will increase.[26,27]

Future gas prices will likely be more than $2.00 per gallon. Assuming that the shortfall for the next eight years is in the area of 100 TBD and that only about 50 TBD will be available through foreign supplies, there will be an expected shortfall of roughly 5 percent of total demand. Imports will be much more expensive than will the base

FIGURE 1.3
Increased Reliance on Imports Correlates with Higher Gas Prices
Each $.10 per gallon increase in refinery margins is equivalent to an additional $1.5 billion in refinery revenue.



Source: 1997 to 2001 price data from the CEC website. 2002 and 2003 price forecasts from CEC's price forecasts for AB2076 study. Refinery margin calculations and forecasts are NRDC's estimates based on CEC's price data and forecasts. Increase in imports is NRDC's estimate based on Figure 1.5 of the CEC consultant's report (Stillwater, 2002).

supply, leading to the likelihood that the average price per gallon of gasoline will climb to more than $2.00.

Shortages in Gasoline Supply Will Lead to Volatility and Price Spikes

Small gasoline shortages, as described below, result in large price spikes. Since there is no surplus production capacity, or "reserve margin," in the event of a supply disruption, additional supplies must be imported from out of the state (the nearest source being the Gulf Coast)—a process that typically takes from two to four weeks.[28] The shortfall in supply and delay in new shipments cause prices to jump. The price increase depends on the supply shortfall and the amount of gasoline stocks.

Furthermore, since refineries must run full-time to meet demand, the likelihood of breakdowns due to equipment failure and other operational failures is greatly increased. According to the state's Energy Commission, California can expect the following:[29]

> *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.*

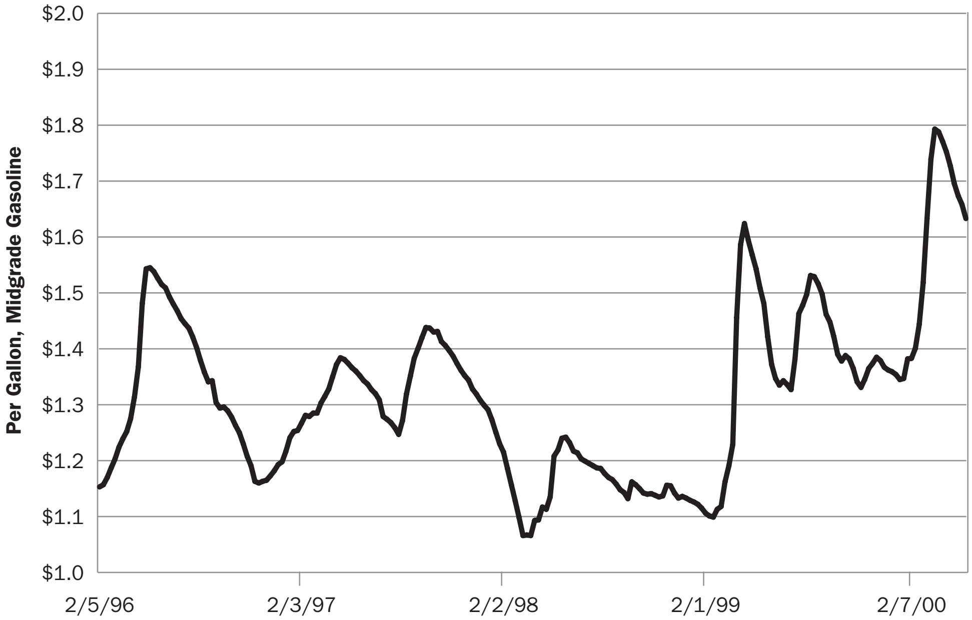
Gasoline prices jumped by more than $.52 per gallon between February and April of 1999 and resulted in a $1.3 billion windfall profit for oil refiners.

A 5 percent shortfall would result in gasoline price spikes of $2.30 per gallon; a 10 percent shortfall would result in a price of $3.00 per gallon.[30] If such spikes do occur, international refiners will likely find it profitable to manufacture a specialty batch of gasoline for the California market, to be sold at a premium price.

The last several years demonstrate the extent to which California's gasoline supply system makes the state economically vulnerable. Between 1996 and early 2001, 20 separate instances of price spikes occurred in the San Francisco and Los Angeles areas that can be linked to reported refinery problems[31] (see Figure 1.4). For example, in 1999 two major refinery outages occurred, resulting in the loss of 15 percent of the state's gasoline production capacity and about a 6 percent loss in supply, taking into account existing inventories.[32] Gasoline prices jumped by more than $.52 per gallon between February and April of 1999 and resulted in a $1.3 billion windfall profit for oil refiners (see Figure 1.4).[33] Some experts have predicted that gasoline prices in California could reach $3.00 per gallon if refineries or pipelines fail during the peak-driving season, a so-called "perfect storm" scenario.[34] A $.50 per gallon increment in gasoline prices that lasts for one month would cost California drivers about $700 million extra in gasoline costs.

Increased use of ethanol to replace MTBE will contribute to price hikes. California must phase out MTBE in order to protect its water supply. Since oxygenates are required by federal law to be added to 70 percent of California's gasoline and since ethanol is the only practical alternative, California's demand for ethanol will dramatically increase.[35,36] In 2003, assuming the MTBE phaseout does occur, California's demand for ethanol will be somewhere between 660 and 950 million gallons, compared to the current demand of about 150 million.[37] This increased demand is about half of the 1.77 billion gallons produced last year nationally.[38]

FIGURE 1.4
Gasoline Price Volatility



Source: CEC website, "California Weekly Average Gasoline Prices," http://www.energy.ca.gov/fuels/weekly/retail_gasoline_prices.html, 3/28/02.

The CEC estimates that the cost to California drivers to rely exclusively on ethanol as an additive will be at least $.03 per gallon—or roughly $475 million per year.[39]

The CEC has warned that supply disruptions of ethanol are likely if MTBE is phased out by the end of 2002; these disruptions would cost an additional $660 million per month, or roughly $.50 per gallon.[40] A consultant for the CEC has in fact projected price spikes of up to $3.00 per gallon if adequate supplies of imported gasoline cannot be found; these findings prompted Governor Davis to delay the phaseout of MTBE by one year, until the end of 2003.[41,42]

It is important to note that the oxygen content requirement mandated by the federal Clean Air Act of 1990 is obsolete. The California Air Resources Board (CARB) has demonstrated that a non-oxygenated gasoline blend—called California Phase 3 Reformulated Gasoline or "CaRFG3"—that meets revised reformulated gasoline specifications would actually do a better job of cleaning the air than would an ethanol blend. In fact, California has requested a waiver from the federal Clean Air Act's requirement to add oxygenated compounds into gasoline; if granted, California would no longer be dependent on Midwest ethanol producers, and such a waiver would substantially alleviate the anticipated short-term supply crisis. So far, the Bush Administration has refused to grant regulatory relief, shifting the burden to Congress to resolve this problem. We must keep in mind that even if the waiver were granted, it is likely that a substantial number of refiners would still choose to blend ethanol; nonetheless, the market power of ethanol producers would be greatly reduced.

The Oil Refiners Are Profiting Disproportionately from an Unstable Market

In the gasoline market, as in the electricity market, the most expensive supply sets the price; as a result, with tightened supply, oil refiners everywhere are able to increase their profit margins. For example, in 1998, when California imported around 100 TBD of gasoline and additives, average gasoline prices were $1.17 per gallon (see Figure 1.3). Then in 1999, due to refinery problems, imports of gasoline and additives shot up by approximately 50 percent to 165 TBD, and average prices rose to $1.36 per gallon. In 2001, average prices rose to $1.71 per gallon. While some of the increase was due to rising world oil prices, data published by the CEC indicate that refinery profits jumped 25 cents per gallon (80 percent) between 1998 and 2001.[43]

According to the Attorney General's office, oil companies reaped $1.3 billion in "windfall profits" in gasoline sales during the first eight months of 1999 due to gas price spikes alone.[44,45] Refiners saw margins rise steeply after 1998: in 2000, margins were $1.4 billion higher; and by 2001, they were $3.8 billion higher.

Increased reliance on imported gasoline and ethanol places the fate of California's gasoline supply in the hands of Gulf Coast refiners, foreign gas suppliers, and Midwest ethanol producers.

California cannot rely on the private market for a reliable gasoline supply. Having an unsound gasoline policy in an unstable gasoline supply market leaves California vulnerable to volatile price fluctuations. Increased reliance on imported gasoline and ethanol places the fate of California's gasoline supply in the hands of Gulf Coast refiners, foreign gas suppliers, and Midwest ethanol producers. It is unwise to depend on the private market to ensure a stable, reliable source of gasoline; refiners profit enormously from an unstable, volatile gasoline market and, further, do not fully pay for the pollution costs of using gasoline. Rather, the burden falls disproportionately on the drivers to pay the price.

AIR QUALITY CONSEQUENCES OF CONTINUED OIL DEPENDENCE

While Its Population Is Growing, California Is Struggling to Cut Pollution

Even though more than four decades of air pollution controls protect public health, Californians are still breathing unhealthy air. In fact, 90 percent of Californians live in areas that do not meet federal standards for healthy air quality. Today, air pollution contributes annually to as many as 17,000 cases of premature death, 55,000 hospital admissions, 1.3 million asthma attacks, 3.3 million lost work days, and an average cancer risk in urban areas ranging from 500 to 1,000 in a million.[46]

Exhaust from passenger vehicles contributes about one-third of the total statewide emissions of nitrogen oxides (NOx) and hydrocarbons; these pollutants combine in the atmosphere to form smog and particulate matter (i.e., soot).[47] But there are other sources of pollution as well, both upstream and downstream. Refining gasoline, trucking gasoline to gas stations, and refueling are all processes that pump dangerous particulates into the air and harm public health.

Even with pollution at present levels, the state is struggling to find sufficient reductions to meet federal ambient air standards for ozone (i.e., smog) and particulate matter (PM); California standards are even stricter and present greater challenges. New federal standards for ozone ("8-hour ozone standard") and fine PM

(PM2.5) will require further reductions. CARB projects that, over the next two decades, statewide levels of hydrocarbons will drop by 20 percent and NOx by 40 percent. Even with these reductions, the state must find more reductions to ensure all areas meet the current federal 1-hour ozone standard. For example, CARB estimates that the San Joaquin Valley must reduce emissions of hydrocarbons and NOx by about 30 percent, or about 300 tons per day (tpd); the greater Los Angeles area must find an additional 100 tpd in hydrocarbon reductions.[48]

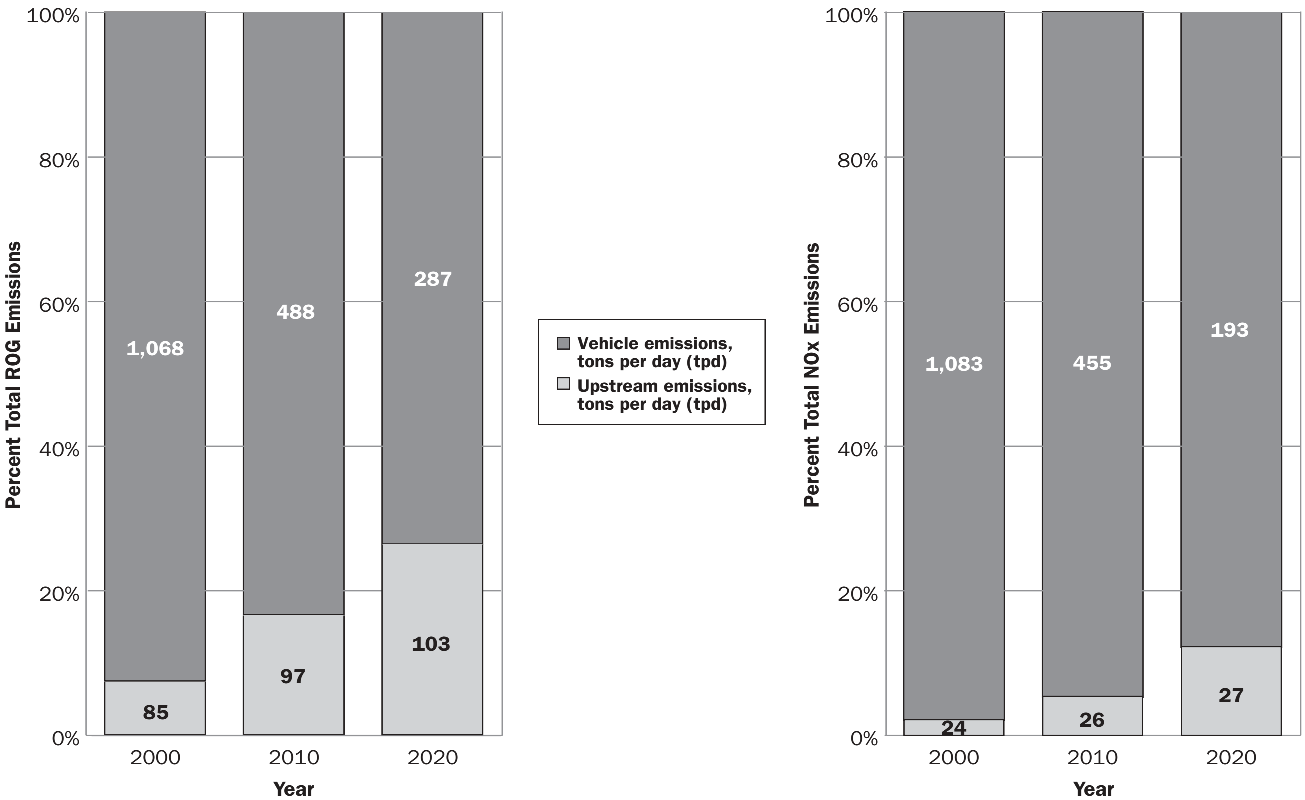
Reducing oil dependence is an integral component of California's Clean Air Plan. Rising gasoline consumption contributes substantially to the pollution problem. CARB has recently released a "Clean Air Plan" (CAP)—a list of proposed measures that, if adopted on schedule, would reduce hydrocarbons and NOx by 500 tpd by 2010 and an additional 150 tpd by 2020.[49] Included in this plan are measures that reduce oil dependence, including the promotion of Zero-Emission Vehicles, fuel efficiency, and smart growth. However it is unclear whether this will be adequate for all areas to meet the current 1-hour ozone standard, even if all the measures in the CAP were adopted. CARB admits that to meet future, more health-protective state and federal standards for ozone and soot, the state will likely require even greater pollution reductions. It is imperative for California to adopt every measure possible to achieve sufficient pollution reductions.

Refinery and other upstream emissions must be reduced. "Upstream" pollution from passenger vehicles—including refinery, delivery, and refueling emissions—is a small but growing portion of the total smog-forming pollution burden. As vehicle tailpipe standards become tighter, upstream pollution will constitute a greater portion of the overall passenger vehicle pollution burden. We estimate that by 2020, upstream emissions of hydrocarbons as a fraction of total emissions will increase almost fourfold—up from today's 7 percent to about 26 percent (see Figure 1.5). Similarly for NOx, the fraction will increase almost sixfold, up from today's 2 percent to 12 percent in 2020.[50] Reducing upstream emissions must be an integral part of California's strategy to improve air quality.

In-state oil production, refineries, and gasoline refueling emissions are the biggest sources of upstream hydrocarbons. In-state oil production is declining, but refueling emissions will grow with demand. Refineries are the biggest source of upstream NOx: refinery emissions not only add to the state pollution burden, but they also disproportionately expose local communities to increased health risks.

Cancer-causing air toxics produced by gasoline use harm public health. Air toxics are chemicals that are known or suspected to cause cancer and other health problems in humans. There are ten major air toxics, of which diesel particulates have been identified as the group that poses the greatest cancer risk to individuals, accounting for an average of 70 percent of the statewide cancer risk.[51] Air toxics associated with gasoline-powered vehicles pose tremendous harm as well. Emissions from gasoline-powered vehicles produce four of the major ten air toxics (benzene,

FIGURE 1.5
Fuel Cycle Smog Emissions from "Upstream" Sources: Refining, Distribution, and Refueling



Total statewide Reactive Organic Gas (ROG) emissions (summer) = 3,000 tpd in 2000, 2,500 tpd estimated for 2010, 2,400 tpd estimated for 2020.

Total statewide NOx emissions (summer) = 3,500 tpd in 2000, 2,500 tpd estimated for 2010, 2,000 tpd estimated for 2020.

1,3-butadiene, formaldehyde, and acetaldehyde) and contribute most of the non-diesel cancer risk from air toxics—or 155 potential excess cancer risks on statewide average basis.[52] In urban areas of California, where cars are perhaps more abundant than anywhere else in the nation, the average cancer risk ranges from 500 to 1,000 in a million—a rate that is much higher than the 1 in a million acceptable level set by Congress.[53,54] Reducing gasoline consumption will mitigate the dangers posed to humans by air toxics.

OTHER ENVIRONMENTAL CONSEQUENCES OF CONTINUED OIL DEPENDENCE

Continued expansion of oil infrastructure undermines California's efforts to protect its water, coasts, and wilderness areas. Spills from tankers threaten our coastlines. Gasoline leaking from storage tanks contaminates our drinking water. Rising demand for oil creates pressure to exploit our precious wilderness lands. On top of this, California is especially vulnerable to the effects of global warming, including increased smog and soot levels due to hotter temperatures and reductions in water supply due to loss of snow pack. A program to cut our oil dependence through better vehicles and better fuels would dramatically reduce these environmental threats.

Growing Gasoline Dependence Increases the Likelihood of Oil Spills and Leakage from Storage Tanks

Oil spills are an inevitable consequence of offshore drilling and shipping. Spills pose a constant threat to the land, water, wildlife, and livelihoods of coastal communities. One of the most damaging spills in California's history occurred in 1969 when an oil well blew out off the coast of Santa Barbara, releasing 80,000 barrels of oil over the course of ten days. One study found that, over the last decade, there have been five oil spills off the shore of California, releasing a total of 800 barrels of oil.[55]

The 1989 *Exxon Valdez* disaster spilled 10.8 million gallons of oil into Alaska's Prince William Sound. One study estimated that if that spill had happened in California, it would have covered two-thirds of its coast.[56,57] In California, the oil tanker *American Trader* spilled about 400,000 gallons of Alaskan crude oil off the Huntington Beach coastline on February 7, 1990. Two spills in 1996 released 714,000 gallons into Galveston Bay and 820,000 gallons off the coast of Rhode Island. In 2000 alone, almost 1.5 million gallons of oil were spilled into U.S. waters.[58]

While oil spills threaten waters and coastline, leaking gasoline storage tanks have contaminated large amounts of California's water supply. MTBE contamination has forced water suppliers to shut down drinking water wells in Santa Monica, South Lake Tahoe, Santa Clara Valley, and the Sacramento area. A recent study by the Lawrence Livermore National Laboratory estimated that MTBE has contaminated groundwater at more than 10,000 shallow monitoring sites in California. About 70 percent of the sites that were tested for MTBE showed detectable levels.[59]

Continued expansion of oil infrastructure undermines California's efforts to protect its water, coasts, and wilderness areas.

Greater Demand for Gasoline Increases the Likelihood of Exploiting Pristine Public Land

One quarter of the oil that it takes to run California's refineries comes from Alaska, which accounts for about half of Alaska's total production.[60,61] With greater need for oil comes more pressure to drill in precious wilderness areas, such as Alaska's Arctic National Wildlife Refuge, Utah's Redrock Canyon Country (off the California coast), and California's Los Padres National Forest. Most federal lands with potential oil resources are already available for exploration and development. In fact, federal lands already account for 29 percent of U.S. crude oil production. More than 90 percent of federal public lands in the Rocky Mountain region managed by the Bureau of Land Management are open to exploration and production leasing. Similarly, more than 80 percent of estimated undiscovered, economically recoverable offshore oil resources are open to exploration—and this includes California. The U.S. Interior Department has proposed allowing new oil drilling in federal waters between Ventura and San Luis Obispo Counties; developing the 36 leases could add four to five offshore drilling platforms.[62]

Once rural areas and wildlands have been industrialized by oil development, their wilderness values are destroyed, and they become dense webs of power lines, pipelines, waste pits, roads, and processing facilities. For example, the 20 platforms operating off of the California coast emit nearly 1,000 tons of smog pollution per year (equal to that produced by 35,000 cars) and pose a constant threat to our coastlines from accidental spills.[63]

Exploiting wilderness areas for oil is unwise, unnecessary, and will not make the United States energy independent. Domestic oil production peaked in 1970 at 9.64 million barrels per day and has since declined by 40 percent.[64] A glaring example of ill-advised exploration can be found in California itself: the U.S. Forest Service has proposed opening up to oil and gas companies some 140,000 roadless acres in the Los Padres Forest, which parallels the coast from Ventura County to Big Sur. The amount of oil in this area would fuel California's passenger vehicles for about three months.[65] Even opening the Arctic National Wildlife Refuge to drilling and production would yield only another 410,000 barrels per day at its peak production (estimated to be reached in 2027)—and this amount would be less than 2 percent of projected annual demand for the United States for that year.[66] There simply is not enough new oil recoverable from domestic sources at a cost reasonable enough to influence the world price for oil or to substantially displace imports.

As the largest consumer of crude oil in the United States and the thirteenth largest consumer in the world, California's growing appetite for crude oil contributes substantially to national energy insecurity.

Unchecked Gasoline Use Contributes to Global Warming

It is well recognized that emissions from the burning of petroleum and other fossil fuels are blanketing the earth with a thickening layer of CO_2, which blocks heat from escaping into space. The heat trapped by this CO_2 blanket is raising temperatures and harming the environment. In a study commissioned last year by President Bush to review the state of the science, the National Academy of Sciences confirmed that global warming is occurring.[67]

The production and burning of gasoline produces about 40 percent of California's global warming pollution emissions, primarily in the form of CO_2. Although projections of impacts at the regional level are less certain, recent studies demonstrate that California's environment and economy are likely to be severely impacted by global climate change. An Intergovernmental Panel on Climate Change (IPCC) estimate projects that the western United States will experience an average mean warming of 4°F (2°C) by 2030–2050 (a winter warming of about 5°F, and a summer warming of 2°F.)

With global warming, California can expect more heat waves, a decrease in snow pack—vital to our water supply system—rising sea levels, and an increase in El Niño-like storms. Increased temperatures will exacerbate the nation's worst air quality problems, since higher temperatures will lead to an increase in the formation of smog (ground-level ozone) and soot (particulate matter). California's cities and agriculture industry, heavily dependent on an already overburdened water supply system, will be increasingly parched. The long, heavily populated coastline will be battered by increased storms and inundated by higher sea levels. From the great coastal redwoods to the offshore kelp forests, every aspect of California's varied and delicate ecosystem will be affected. Finding solutions to the gasoline crisis is necessary to help reduce the negative impacts of global warming.

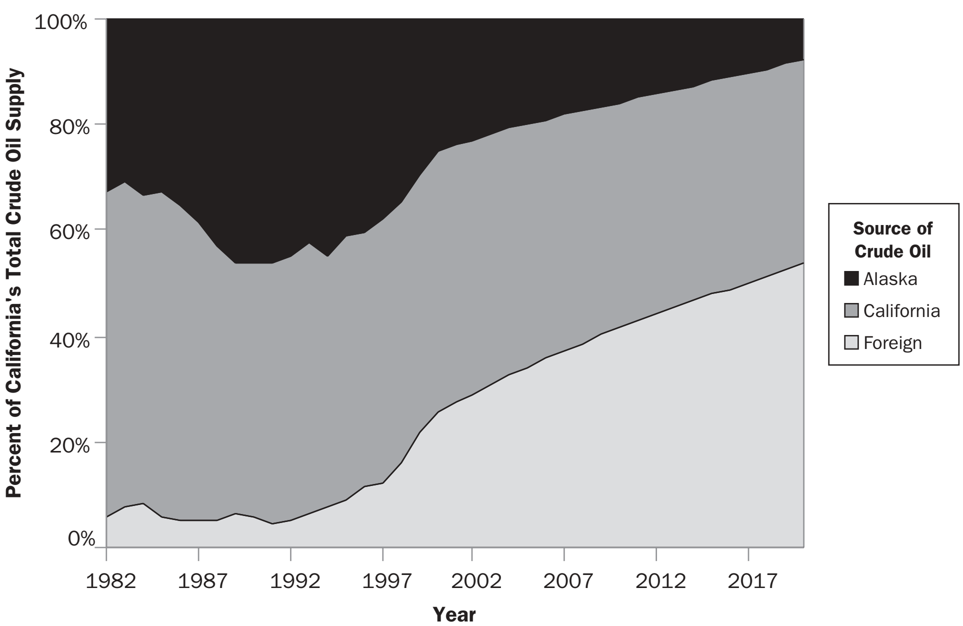
ENERGY SECURITY CONSEQUENCES OF CONTINUED GASOLINE DEPENDENCE

California Is Importing Increasing Amounts of Foreign Crude Oil to Keep Its Refineries Running

As the largest consumer of crude oil in the United States and the thirteenth largest consumer in the world, California's growing appetite for crude oil contributes substantially to national energy insecurity. Imports of crude oil have tripled since 1995. California now must import 29 percent of its crude oil from foreign countries to keep its refineries running.[68,69]

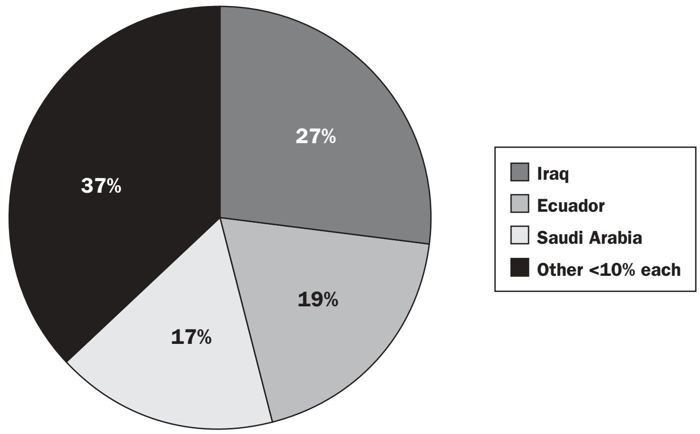
With in-state and Alaskan crude oil production declining, California's refineries will need to import almost 40 percent of their oil from foreign countries by 2010; this number will climb to more than half by 2020 (see Figure 1.6).[70] In 2000, California imported about 45 percent of its crude oil from just two countries, Iraq and Saudi Arabia. The largest supplier of crude oil to California is Iraq, followed by Ecuador and Saudi Arabia, with most of the remainder coming from Central and South America (see Figure 1.7).[71]

FIGURE 1.6
California Is Becoming Increasingly Dependent on Foreign Sources of Crude Oil to Keep Its Refineries Running



Source: 1982 to 2000, California Energy Commission website, http://www.energy.ca.gov/fuels/oil/crude_oil_receipts.html. 2001 to 2010, California production and Alaska imports from CEC 1999 Fuels Report, assuming most conservative decline in Alaska production. Foreign demand is NRDC's estimate assuming that crude oil demand for refineries increases at about 0.5% per year between 2001 to 2010 due to refinery capacity expansions. 2011 to 2020 estimates are simple linear extrapolation of California and Alaska production trends.

FIGURE 1.7
Foreign Sources of California Crude Oil Imports in 2000



Source: Unpublished data provided by CEC.

Heavy reliance on foreign oil means that the American economy generally and the Californian economy specifically will be dependent on unstable regions of the world for energy security.

Imports will come increasingly from the Middle East since this region holds 65 percent of the world's 1 trillion barrels of proven oil reserves. Worldwide excess oil production capacity is approximately 5 million barrels per day, about 90 percent of which belongs to members of the Organization of Petroleum Exporting Countries (OPEC). About 40 percent of the world's total excess production capacity lies in Saudi Arabia alone.[72] Middle East OPEC members supply about 26 percent of world oil now, but unless we alter our demand, the International Energy Agency projects that their share will grow to 41 percent by 2020.[73] Of the nearly 19 million barrels per day increase in world oil demand forecast between 2010 and 2020, more than 85 percent will come from Middle East OPEC countries.[74]

Heavy reliance on foreign oil means that the American economy generally and the Californian economy specifically will be dependent on unstable regions of the world for energy security. This dependence will continue to dictate U.S. foreign policy in the Middle East and other volatile regions of the world; in addition, it will leave California and the United States vulnerable to supply disruptions due to regional instability and OPEC price hikes. In recent years, OPEC has regained its ability to influence the price of oil substantially throughout the world. While increased oil production from other regions, including the North Sea and Alaska's North Slope, has driven the Persian Gulf share down over the past 20 years, many non-OPEC oilfields are past their peak production levels. Despite the temporary softening of oil demand due to the current global economic slowdown, OPEC's market power will only grow as its production approaches half of world oil output in the next two decades.

Given the imminent phaseout of MTBE and the increasing pressures of a growing population, California's gasoline supply is in turmoil. Supply is decreasing in the short-term while demand is increasing; in the face of this imbalance, the state is confronting a dangerous shortfall that could lead to unprecedented price spikes. But where once California relied on imports and increased refinery output to meet shortfalls, these options are no longer viable; rather, these short-sighted solutions are putting the economy and the environment increasingly in harm's way. Last year's electricity crisis aptly demonstrates the risks of placing California's energy future solely in the hands of the private market—and at the mercy of foreign suppliers. With in-state refiners profiting handsomely from an unreliable gasoline supply, California's drivers must brace themselves for a rocky time at the pump. Instead, as it confronts the shortfall, the state has the opportunity to stave off crisis and invest in fuel efficiency, hydrogen-fuel-cell infrastructure, public education, and smart growth to develop a clean and reliable fuel supply.

CHAPTER 2

Investing in a Clean and Reliable Fuel Supply

To meet the transportation energy needs of the future, California must begin to invest in the technologies and the communities of the 21st century. The state has the ability and the opportunity to direct future investments into a sustainable energy system that will be less polluting and more reliable—and eventually pollution- and petroleum-free. But in order to do so, California must develop a responsible energy policy that can minimize impacts on public health, the economy, and the environment. The good news is that effective solutions exist today that could enable the state to realize this goal. NRDC has outlined a plan to ensure that California is independent of imported gasoline by 2011 and to reduce the state's gasoline demand by about 15 percent below 2000 levels by 2020. NRDC's four-step plan is as follows:

- **Step 1:** to raise fuel economy of all new cars and light trucks;
- **Step 2:** to build a hydrogen-fueling-system infrastructure that can support large-scale commercialization of fuel-cell vehicles by 2010;
- **Step 3:** to educate the public to drive smarter and purchase fuel-efficient vehicles and tires;
- **Step 4:** to build new communities that are less auto-dependent through smart growth.

These measures will:

- reduce average gasoline prices by as much as $.20 per gallon by eliminating imports and mitigating price spikes resulting from unexpected refinery or supply disruptions;
- provide consumers with opportunities to purchase fuel-efficient vehicles in every class (including cars, SUVs, minivans, and pickups), ultimately saving an average of $2,640 over a vehicle's lifetime;
- jump-start the market for truly clean, petroleum-free cars and fuels by creating a hydrogen-fuel infrastructure for fuel-cell vehicles;
- ensure that automakers begin mass producing fuel-cell vehicles by the end of this decade—ultimately putting 385,000 fuel-cell vehicles on the market by 2020;

▸ save California drivers approximately $25 billion over the next two decades;[75]
▸ help drivers make better choices when they purchase vehicles by educating them about the merits of and opportunities for reducing gasoline consumption;
▸ create more livable communities and help preserve open space by encouraging growth toward more compact, transit-friendly communities that reduce the need to drive; reduce air and water pollution, global warming emissions, and pressure to drill in our wilderness areas.

California should be encouraged to invest in fuel-efficient cars, not gas-guzzlers. Fuel suppliers should be rewarded for pioneering clean-fuel infrastructure using electricity and hydrogen, not for expanding an antiquated system based on polluting and unreliable supplies of oil. Developers and cities should be encouraged to limit sprawl and build transit- and pedestrian-friendly communities, not continue to gobble up open space. The economy, the environment, and public health will benefit.

NRDC has outlined a plan to ensure that California is independent of imported gasoline by 2011 and to reduce the state's gasoline demand by about 15 percent below 2000 levels by 2020.

STEP 1: RAISE FUEL ECONOMY STANDARDS FOR ALL NEW CARS AND LIGHT TRUCKS

Automakers have the technology to increase the fuel economy of passenger vehicles to more than 40 mpg, up significantly from today's average of 24 mpg. The single most effective way to ensure that these levels are reached would be for automakers immediately to support current efforts in the U.S. Congress to raise fuel-economy standards. But California drivers should not have to wait for the federal government to take action. Automakers can make voluntary commitments to raise fuel economy, just as they have done in Europe. Under intense public pressure, automakers in Europe have made voluntary commitments to cut CO_2 levels by 25 percent by 2008—about equivalent to raising fuel-economy levels by 36 percent, to 41 mpg. An analysis from the American Council for an Energy Efficient Economy (ACEEE) underscores that this is indeed possible for the U.S. fleet: technologies exist that can raise the fuel economy of America's gasoline vehicles to 42 mpg within ten years, without changing the size, weight, or safety of today's fleet.

In the United States, automakers have recognized that they must do something to appear to be responsive to intensifying public concern over falling fuel efficiency levels, rising global warming emissions, and increasing dependence on foreign oil. Ford, General Motors (GM), and DaimlerChrysler all have essentially committed to voluntarily raising the fuel economy of their SUV fleet by 25 percent over the period from 2000 to 2005. Toyota has announced plans to substantially increase production of hybrid electrics to 300,000 units globally by 2005. These are good first steps—however, they must be extended in order to provide meaningful reductions in oil dependence and pollution, which a 42 mpg level would accomplish.[76] Automakers should not be shortchanging California's drivers by withholding fuel-efficient technologies and adding to our gasoline-dependence problems.

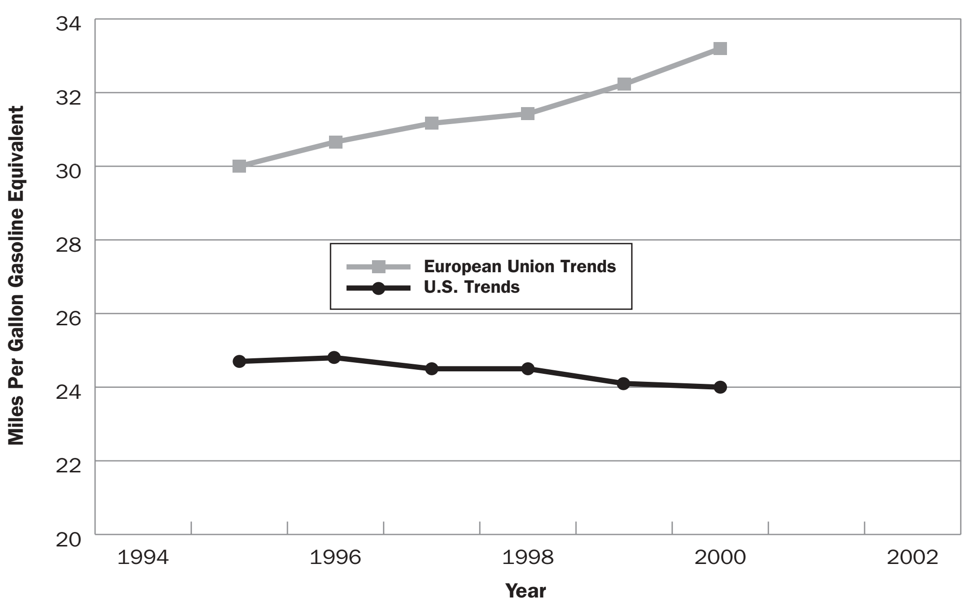
Automakers Can Make Voluntary Commitments to Raise Fuel-Economy Standards

In July 1998, the European Commission and the European car industry represented by the European Automobile Manufacturers Association (ACEA)—of which Ford, GM, and DaimlerChrysler are all members—agreed to reduce CO_2 emissions from passenger vehicles. The key commitment pledged by ACEA was to cut CO_2 emissions by 25 percent over a ten year period. The Japanese and Korean automaker trade organizations also agreed to the same target but delayed their end-date by one year, to 2009.[77] Adjusting for the European drive cycle and the higher use of diesel fuel in Europe, this agreement secured the equivalent of a 41-mpg new-vehicle fleet by 2008—a 36 percent increase over the base year of 1995.[78]

Unlike the Europeans, American automakers are moving backward on fuel economy. In the United States, the same automakers refuse to increase the fuel economy of their fleets. Average new fuel economy is at a 21-year low and has been declining since 1988 (see Figure 2.1). Instead of working to improve fuel efficiency, American automakers have systematically employed new engine technologies to enhance the power and weight of the fleet. Compared to cars built in 1981, the average new passenger vehicle sold in 2001 accelerated 27 percent faster, weighed 22 percent more, and had 84 percent more horsepower. The Environmental Protection Agency estimates that if the new 2001 passenger vehicle fleet had the same average weight and performance as in 1981, it would have been more than 25 percent more fuel-efficient or averaged 30 mpg—equivalent to the average European fuel efficiency standards in 1995.[79]

Automakers have also successfully exploited loopholes in federal fuel-economy laws to sell greater numbers of less fuel-efficient SUVs and minivans. The federal

Figure 2.1
Automakers Are Improving Their Fleets in Europe But Selling More Gas Guzzlers in the United States



Sources: ACEEE (DeCicco et. al., 2001) and National Academy of Sciences (National Research Council 2001).

government classifies SUVs and minivans as "light trucks" and allows them to have 25 percent lower fuel economy than the cars they have been replacing. Automakers have gone to great lengths to take advantage of these relaxed standards and have become extremely bold in classifying vehicles built on car platforms as light trucks. Cars such as the DaimlerChrysler PT Cruiser and Audi All-Road are all considered, for fuel-economy purposes, as a light trucks.

Cost-effective technologies exist that will help raise fuel-economy standards. Manufacturers are already beginning to invest in new engine technologies and production facilities that can easily be optimized for either increased power or higher fuel economy.[80] However, unless American automakers are prodded to address fuel efficiency, trends indicate that manufacturers will continue to exploit the light-truck fuel-economy loophole and direct these and other promising new technologies toward further increases in vehicle horsepower and weight—at the expense of fuel economy. The result will be greater oil dependence, more pollution, and higher fuel bills.

Experts agree that existing and emerging technologies can significantly improve the fuel economy of cars and light trucks without restricting vehicle choice or compromising safety (see Table 2.1). Studies by the National Academy of Sciences (NAS), the Massachusetts Institute of Technology (MIT), the ACEEE, and the U.S. Department of Energy (DOE) all demonstrate that through the use of such technologies as variable valve engine timing, continuously variable transmissions, slicker aerodynamics, and high-strength, lightweight materials, fuel economy of conventional gasoline vehicles can be substantially increased in every category of vehicle, from SUVs to subcompact cars (see Figure 2.2).[81]

TABLE 2.1
Sample List of Existing and Emerging Fuel Economy Technologies

ENGINE TECHNOLOGIES
Low-friction lubricants and other engine friction reduction
Multivalve, overhead camshaft
Variable valve lift and timing
Cylinder deactivation (shuts off cylinder when power not needed)
Intake valve throttling
Integrated starter/generator
Engine accessory improvements

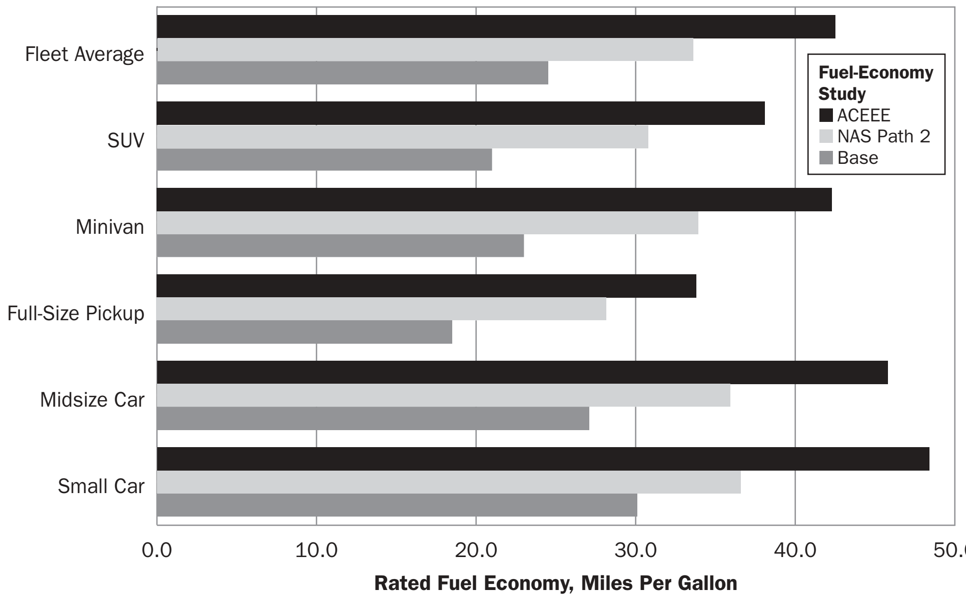
TRANSMISSION TECHNOLOGIES
Five-speed automatic transmission
Continuously variable transmission
Automatic shift/manual transmission

VEHICLE PLATFORM LOAD-REDUCTION TECHNOLOGIES
Reduced aerodynamic drag
Tires with lower rolling resistance
Lightweight, high-strength materials, such as steel, aluminum, and composites

ACCESSORY IMPROVEMENT TECHNOLOGIES
42-V electrical system
Electric power steering

Sources: ACEEE (DeCicco et. al., 2001) and National Academy of Sciences (National Research Council 2001).

FIGURE 2.2
Technologies Exist That Can Improve Fuel Economy of All Types of Vehicles



Sources: Based on fuel-economy technologies analyzed in ACEEE's advanced package (DeCicco, et al., 2001) and the National Academy of Sciences' "Path 2" assessment (National Research Council, 2002). Assumes 13-year, 166,000 mile average life for a California vehicle.

According to the ACEEE and the Union of Concerned Scientists (UCS), if existing and emerging technologies are applied to the entire passenger vehicle fleet, average fuel economy of the passenger vehicle fleet can be raised to 42 mpg—a 75 percent increase from today's levels.[82] This package includes weight reduction on the heaviest vehicles in the fleet, which also enhances overall safety during collisions by reducing the differences in vehicle weight. These technologies could reach full market penetration between 2010 and 2015. Based on the California fleet mix, we estimate increasing the fleet to 42 mpg could be achieved at a cost of about $1,640 per vehicle. But over the life of the vehicle, the average driver would save about $4,280, resulting in a net savings of about $2,640 (see Figure 2.3).[83]

The recent NAS study *Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards* supports similar conclusions regarding the technological potential for higher fuel economy.[84] The NAS study did not consider the use of lightweight, high-strength material technologies. By ignoring these highly effective and affordable measures, the NAS findings resulted in a lower fuel-economy potential and somewhat higher costs for similar fuel-economy improvement levels as compared to what the ACEEE and UCS studies had found. However, the basic conclusion is the same: there are a number of extremely cost-effective technologies that can increase fuel economy without affecting vehicle performance or safety—while saving drivers money. For the average California driver, the NAS study found that its conservative package (which it calls "Path 2") yields an average fuel economy of 33 mpg and a net savings to drivers of about $2,500 over the life of the vehicle (see Figures 2.2 and 2.3).[85]

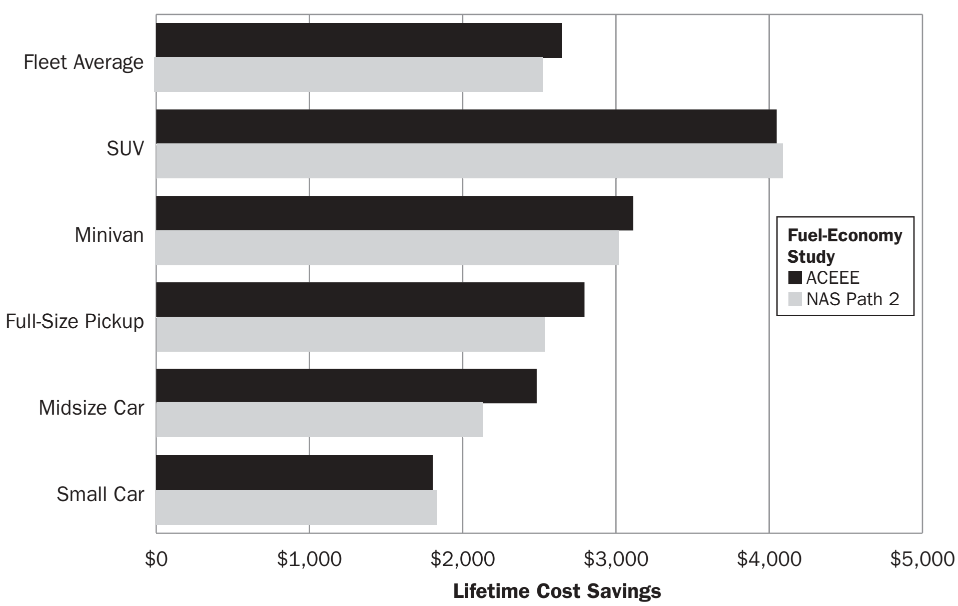
The market for advanced technology hybrid-electric vehicles is already growing and becoming more competitive. Automakers are introducing more and more hybrid vehicles into the market. Virtually every major automaker that sells vehicles in California—DaimlerChrysler, Ford, General Motors, Honda, and Toyota—is either selling hybrids now or planning to have a hybrid model in their lineup by model year 2004. Furthermore, Toyota has upped the ante, recently announcing it will increase global production of hybrid vehicles to 300,000 units by 2005. Finally, California's Zero Emission Vehicle (ZEV) program will result in the sale of up to 100,000 hybrids in 2012. Therefore, it is clear that almost all the major automakers will have the ability to begin mass producing hybrids over the next several years in numbers sufficient to decrease oil demand.

(It is important to note that the United States does not have to rely upon diesels to achieve higher fuel economy as the Europeans have. None of the recent studies relied on diesel engines to achieve high fuel economy; in fact the studies recognized that diesels are unlikely to meet future pollution standards and that concerns regarding the extreme toxicity threat posed by diesel emissions are likely to contribute to continued resistance by U.S. drivers.)

The State Can Help Build Consumer Demand for Fuel Efficiency

Higher gasoline and diesel taxes helped build consumer demand for fuel efficiency in Europe. While raising American gasoline prices to European levels would be highly unlikely politically, California can achieve similar results through three

FIGURE 2.3
Net Lifetime Savings of Vehicles If Existing and Emerging Technologies Are Employed



Source: This NRDC estimate assumes a cost of $1.64 per gallon of gasoline based on the California Energy Commission's latest price forecast. The lifetime cost savings equals the fuel savings minus the incremental cost of the fuel-economy technology. Cumulative fuel-cost savings were calculated using a 5 percent discount rate.

measures. It can provide consumers with incentives to purchase clean and efficient vehicles, adopt "green vehicle" labeling to educate consumers about a vehicle's smog and global warming pollution performance, and conduct a permanent public education campaign.

Purchase incentives can promote sales of alternative fuel cars. California currently has two consumer purchase-incentive programs that promote electric vehicles and hybrids. One program offers consumer purchase incentives for battery-electric vehicles of up to $9,000 per vehicle. And the California Energy Commission (CEC) is offering consumer purchase incentives for hybrids and natural-gas vehicles through its Efficient Vehicle Incentive Program. Another, more comprehensive approach would be to adopt "feebates," an incentive system based on a balance of sales tax rebates and fees that would encourage drivers to make wise choices when purchasing new vehicles. Such a system, called "DRIVE+," would not require new revenues since the money for the rebates comes directly from the fees. A bill to implement such a program was passed by the California legislature in 1990 but later vetoed by Governor Deukmajian. The CEC estimates that a feebate program in California could reduce gasoline consumption in 2010 by 5 to 15 percent.[86]

A consumer-education and labeling program would help drivers make informed choices. To build consumer demand further, California can adopt "green vehicle" labeling that would allow consumers to make informed choices when purchasing a new vehicle. According to J.D. Power and Associates, consumer interest in hybrids is very high. One-third of those surveyed would be willing to buy one even if lifetime fuel costs did not offset the higher purchase cost. However, many consumers are deferring their purchase decision because they do not have enough information on how these vehicles operate.[87]

Currently, in addition to the federal fuel-economy sticker, California posts a "smog index label" on new vehicles for sale that is intended to inform consumers of the smog pollution impacts of their potential purchase. Unfortunately these rating systems are overly complicated. California should develop a more consumer-friendly rating and labeling system that provides a single rating combining both the smog-forming and global warming gas emission performance. Of current systems, the ACEEE's "Green Book" and green rating system best exemplify an integrated rating method.[88]

STEP 2: INVEST IN HYDROGEN FUELING SYSTEM INFRASTRUCTURE

Fuel-cell vehicles—along with battery-electric vehicles—can lead us to a transportation future free of oil and gasoline. Because of California's Zero-Emission Vehicle program, electric vehicles powered by batteries are practical realities today; what's more, vehicles powered by fuel cells are not far behind. Fuel cells are electrochemical engines that combine hydrogen and oxygen to produce electricity and water vapor. In a fuel-cell vehicle, the electricity produced runs an electric motor; consequently, it uses no oil and has zero tailpipe emissions. A fully optimized hydrogen-powered fuel-cell vehicle would likely use two-thirds of the energy of today's average car—none of it coming from oil; this would be equivalent to a conventional gasoline-powered car's getting about 80 mpg.[89] While fuel-cell vehicles can also run off hydrocarbon fuels (such as methanol or a special gasoline formulation) by using an on-board reformer that produces hydrogen, these reformers are costly, complex, and emit smog-forming pollution. A practical fuel-cell vehicle with a reformer probably would not be ready for large-scale production by 2010. Consequently, it is clear that the cleanest, cheapest, and fastest path to a fuel-cell future is through hydrogen.

California Must Pave the Road to a Fuel-Cell Vehicle Future by Building the Hydrogen Infrastructure

Over the last decade, billions of dollars have gone into developing a fuel-cell-vehicle power plant that offers the performance of today's piston engines without smog-forming and global-warming pollutants. Today, the so-called "Holy Grail" is rapidly becoming a practical reality. Every major automaker has already built practical fuel-cell vehicle prototypes. Automakers will soon begin pilot production of several hundred fuel-cell vehicles for fleet use. Numerous automakers have announced plans to introduce fuel-cell vehicles within the next five years, including DaimlerChrysler, Ford, GM, and Renault.[90] GM recently unveiled a fuel-cell concept car dubbed the "Autonomy," announcing it can begin manufacturing by 2010.[91]

A fully optimized hydrogen-powered fuel-cell vehicle would likely use two-thirds of the energy of today's average car—none of it coming from oil.

According to the California Fuel Cell Partnership (a group that included automakers and oil companies), sales of fuel cells are projected to hit 40,000 to 100,000 vehicles seven years after a pilot program begins.[92] If growth continues, by 2020 fuel cells will begin delivering substantial, and growing, oil and smog benefits. The major barrier to full-scale commercialization is ensuring that adequate refueling infrastructure exists. California can do a lot to jump-start this process through incentives: it can provide tax credits to buyers to make these vehicles more affordable and to fuel providers to help offset the costs for building hydrogen refueling stations.

Fuel-cell vehicles can go from the test phase to large-scale production within a decade. California has formed the California Fuel Cell Partnership to begin laying the foundation for commercialization of fuel cells this decade. The members include all the major automakers, key state agencies, and several oil companies. A recent study completed for the partnership shows that it would take roughly seven to nine years from pilot testing of fuel-cell vehicles to reach sales of 40,000 to 100,000 per year. The initial phase (pilot testing) would involve producing a total of about 1,000 vehicles over a three-year period. These vehicles would be placed in fleet service that could be centrally refueled. Phase 2 (market introduction) would involve automakers' investing in production lines capable of producing 20,000 vehicles or fewer. Automakers increasingly have experience in manufacturing at this limited volume. Capital costs would be lower than at a full-scale plant, but total production cost per vehicle would likely be higher. Phase 3 (volume production) would involve automakers' investing in new production plants and higher volume supplier contracts to bring the cost down.

Hydrogen refueling systems can be built economically. With fuel-cell-vehicle technology rapidly progressing, the key to large-scale production within a decade will be building a hydrogen infrastructure. Fortunately, the technology for producing hydrogen from natural gas (a process called "steam methane reforming") is commonly used in industrial processes and can be scaled down to accommodate the needs of smaller refueling stations. These reformers can be economically built in a variety of sizes, including one small enough to fit into your neighborhood gas station. As a result, building a hydrogen refueling system can be done easily, in stages, at the local level.

The capital costs associated with building a hydrogen infrastructure are not substantially different from, and are likely cheaper than, the costs associated with expanding gasoline supplies. We estimate the cost to build a new, world-scale refinery in the Gulf Coast, a pipeline to deliver the fuel to California, and new service stations to total $4.9 billion (see Appendix B)—and this would support a fleet of about 6.2 million vehicles. Hydrogen filling stations have been estimated to cost from $530 to $760 per vehicle.[93] Using estimates of hydrogen station costs prepared by a consultant to the California Fuel Cell Partnership, we estimate the total capital costs to support 6.2 million fuel-cell vehicles at around $4.8 billion (see Appendix B for details).[94] However, since hydrogen refueling stations can be added gradually, matched to the needs of the evolving fuel-cell vehicle market, there would be no need for large, up-front capital investments. We estimate the net present value of capital costs to be $2.4 billion, assuming a 5 percent discount rate (see Appendix B). Using the lower cost estimate for hydrogen refueling stations of $530 per vehicle, the total undiscounted cost would be $3.4 billion with a net present value of $1.7 billion.

As the on-road fuel-cell fleet grows, the primary fuel source would shift from natural gas toward other resources. Renewable sources of hydrogen are likely to become cost-effective by 2020, starting with biomass-derived hydrogen and eventually moving to electrolysis from renewably generated electricity. Biomass-derived hydrogen could be coproduced in biomass ethanol plants. Once hydrogen sales reach enough volume to support larger-scale distribution, centralized production facilities would become more economical; in this case, an extensive delivery infrastructure similar to the existing network of natural gas pipelines would be needed. To take advantage of economies of scale, much of this new infrastructure could be located in or near existing oil refineries in order to use the existing infrastructure (e.g., existing pipeline rights-of-way).

Fuel-cell vehicles will be cost-effective when mass produced. Experts have projected that mature fuel cells will entail life-cycle costs equivalent to or lower than today's gasoline-powered vehicles. According to the CEC, the incremental cost of a hydrogen fuel cell will initially be between $6,300 and $12,300. As volumes increase and the technology matures, the incremental cost will drop somewhere between $1,000 and $3,600. Consequently, fuel-cell vehicles in 2020 can be cheaper to own than gasoline vehicles due to fuel-cost savings. Drivers will save up to $2,800 over the life of the vehicle. As fuel cells are a strategic investment for the automakers and a technology that provides national and global public benefits, we believe it is appropriate for the cost to be shared not just by California drivers, but also by the federal government and the automakers themselves. Automakers are already investing in advanced technologies and acknowledge that the early-year consumer price of hybrids does not cover automakers' full costs.

To acknowledge its role and the national importance of fuel-cell technology, the federal government has recently launched the Freedom CAR project, a joint government-industry partnership designed to accelerate the commercialization of fuel-cell vehicles. A bill in the U.S. Senate called the CLEAR Act (S. 760) would provide a $4,000 to $8,000 tax credit to purchasers of fuel-cell vehicles. When boosted by California's Zero Emission Vehicle (ZEV) program and additional incentives for hydrogen infrastructure, fuel cells could hit the mass market in California by 2010.

Though there is broad agreement that fuel cells will one day replace the gasoline internal-combustion engine, targeted government policies are needed to ensure that automakers move ahead with this technology. Analysis by experts and recent announcements by automakers make it clear that mass production of fuel cells could begin by the end of this decade. California, with its ZEV production requirements and the nation's smoggiest skies, is poised to be one of first regions in the world to reap the benefits of this zero-polluting, petroleum-free technology. Creating a hydrogen infrastructure is the largest single hurdle in front of us. The obstacles in our path are not lack of technology or prohibitive cost; rather, the challenge is to redirect investments away from expanding an antiquated, polluting, petroleum-based fuel system toward a cleaner, more reliable fuel infrastructure for the 21st century.

For every 1 percent reduction in gasoline demand, drivers could save about $250 million at the gasoline pump.

STEP 3: LAUNCH A PUBLIC EDUCATION CAMPAIGN TO PROMOTE SMART DRIVING AND EDUCATE CONSUMERS ABOUT FUEL-EFFICIENT VEHICLES

Californians have demonstrated that they are willing to curb energy use when the consequences are clear. The electricity demand reductions achieved by California in 2001 were no accident: state government, business organizations, and advocacy groups had a host of coordinated policies and incentives already in place when the electricity crisis hit. The impressive $730 million conservation campaign—of which roughly $50 million was earmarked for public education—was very effective.[95] Over the first seven months of 2001, Californians, in response to the state's worst energy crisis since World War II, cut electricity demand 6 percent compared to the same period a year earlier. From June through September, nearly one-third of households served by Pacific Gas & Electric slashed their monthly electricity use 20 percent or more. Even more impressive, this group's total electricity use over the summer months plunged 40 percent, compared to a year earlier.[96]

In the face of an imminent gasoline crisis, California must organize a similar public education effort urging drivers to conserve fuel. For every 1 percent reduction in gasoline demand, drivers could save about $250 million at the gasoline pump. We estimate that the technical potential exists to reduce gasoline demand by roughly 8 percent, depending on consumer participation rates; so the savings could be considerable (see Table 2.2). While such a program alone may not be sufficient by itself to make up the near-term gasoline shortfall, it will measurably reduce the risk of price spikes by reducing the quantity of gasoline and ethanol that need to be imported.

Drivers Can Keep Tires Properly Inflated

According to the EPA, one tire under-inflated by 2 pounds per square inch (psi) results in a 1 percent increase in fuel consumption. A recent survey by the National Highway Traffic Safety Administration (NHTSA) found that 27 percent of passenger cars and 32 percent of light trucks have one or more substantially under-inflated tires. Based on the NHTSA data, we estimate that if all tires were properly inflated, fuel consumption would decrease by a little more than 2 percent. This would save California drivers more than 300 million gallons of gasoline and more than $490 million per year in fuel costs.

Drivers Can Be Encouraged to Obey Highway Speed Limits

According to data from the Federal Highway Administration (FHWA), fuel consumption increases sharply at speeds above 55 mph. For a 1997 passenger vehicle, fuel economy decreases by about 10 percent when driving 65 mph and decreases by about 17 percent when driving 70 mph. Data for average speeds in the Los Angeles region suggest that 8.9 percent of miles traveled are at speeds between 57.5 mph and 62.5 mph and that 13 percent of travel is at speeds between 62.5 and 67.5 mph.[97] Based on these data, we estimate that reducing speed to 62.5 mph would save drivers around 140 million gallons of gasoline ($230 million) per year.

NRDC determined that better tires alone nationally would cut national gasoline consumption by 3 percent, saving 5 billion barrels of oil over the next 50 years.

Drivers Can Consider Modest Trip Reduction

According to the CARB's emission inventory model, EMFAC2000, there are 20 million light-duty vehicles on California's roads, traveling an average of 33 miles per day. If every driver eliminated two trips every month by (for instance) carpooling, taking mass transit, or telecommuting, gasoline consumption would be reduced by about 2 percent. Drivers would save more than 300 million gallons of gasoline and more than $490 million per year in fuel costs.

Drivers Can Properly Maintain Vehicles

The CEC estimates that frequent air filter, oil, and oil filter changes could reduce gasoline consumption by about 0.3 percent—around 50 million gallons per year.[98]

Drivers Can Be Educated About How and Where to Find Low-Friction Replacement Tires

Automakers equip new cars with low-friction tires to help these cars meet current fuel-economy standards. Most replacement tires now on the market create more drag as they roll than do original equipment tires. This "rolling resistance" increases a car's gas consumption. There are no standards or efficiency labels for replacement tires, so most consumers unwittingly buy higher-friction, less efficient tires when their originals wear out.

The NHTSA estimates that fuel-efficient tires would cost consumers no more than an extra $5 per tire.[99] Michelin has put that figure at less than $2.50 per tire.[100] Even

TABLE 2.2
Estimates of Gasoline Savings from Short-Term Voluntary Measures

Short-Term Measure	Potential Savings as a Percentage of Total Gasoline Usage	Gasoline Saved (million gallons per year)	Fuel Cost Savings (millions per year)
1. Proper tire inflation	2.0%	300	$490
2. Driving the speed limit	0.9%	140	$230
3. Modest trip reduction	2.0%	300	$490
4. Regularly scheduled vehicle maintenance	0.3%	50	$80
5. Fuel-efficient replacement tires	3.0%	450	$740
Cumulative (corrected for double-counting)	**8.0%**	**1,190**	**$2,030**

Note: Assumes a gasoline price of $1.64 per gallon; also assumes 15 billion gallons of gasoline will be consumed, which is roughly the amount projected to be consumed by passenger vehicles each year in the 2004-5 timeframe.

using the higher figure, the average driver could recoup the additional expense in fuel savings in just one year and would save an additional $90 over the 40,000-mile life of the tires.

Creating a standard for fuel-efficient replacement tires would improve the fuel economy of vehicles already on the road and prevent fuel-economy degradation in new vehicles. In an earlier study, NRDC determined that better tires alone nationally would cut national gasoline consumption by 3 percent, saving 5 billion barrels of oil over the next 50 years. For comparison, this is 70 percent more than the total amount of economically recoverable oil that would likely be available in the Arctic Refuge over that period.[101] California drivers would save approximately 450 million gallons of gasoline and $740 million per year.

The State Can Educate The Public About Smart Driving and Fuel-Efficient-Vehicle Purchasing

The state can develop a permanent public education campaign similar in scale to the highly successful effort it conducted in 2001 to promote electricity conservation. Public service announcements on television and radio could encourage drivers to inflate their tires, obey the speed limit, reduce their trips, and replace their air and oil filters more often. The public should be made aware that tire inflation and obeying the speed limit improves safety as well as fuel economy. The auto, oil, and service station industries should do their part to promote fuel efficiency. Service stations could be able to promote the benefits of proper tire inflation, make air pumps and gauges accessible, and offer discounted tune-ups.

The state should also immediately adopt a program encouraging fuel-efficient replacement tires. Currently, drivers have no way of identifying fuel-efficient replacement tires or even ensuring that their replacement tires are as efficient as the ones that automakers installed on their new cars. The CEC is currently charged by the State Fleets bill of 2001 with crafting recommendations on rating and identifying fuel efficiency for tires and developing a program to promote the purchase of more fuel-efficient replacement tires. This study is due in the legislature on January 31, 2003. Its completion should be expedited to ensure that drivers have some information on fuel-efficient tires at least by the beginning of 2004. Tire manufacturers can assist the state and consumers by identifying and publicizing fuel-efficient replacement tires.

STEP 4: ENCOURAGE SMART-GROWTH PLANNING AND DIVERSE TRANSPORTATION OPTIONS

Reducing gasoline use is one more reason to pursue smart-growth initiatives as an alternative to suburban sprawl and to expand Americans' transportation options. Sprawl has contributed heavily to the rapid rate of increase in our gasoline consumption over the past two decades. As metropolitan areas have spread out helter-skelter, most Americans find themselves driving ever-longer distances in steadily worsening traffic congestion. With homes, workplaces, schools, and stores located far apart, and with the current emphasis on building roads rather than transit options, Americans have little choice but to drive.

If the state supported modestly denser residential growth such as housing developments built at 12 units per acre, the result would be 2.3 billion fewer gallons of gasoline consumed.

California Can Make Wise Planning Choices Now in the Face of a Growing Population

California is expected to add 4.2 million new homes by 2020.[102] By that date, if every new household drove the equivalent number of miles averaged by current residents of a home situated on one-half acre, the state would be incurring an additional 109 billion vehicle miles traveled (VMT) per year. Annually, these additional households would consume an extra 5.4 billion gallons of gasoline. However if the state supported, either through incentives or mandates, modestly denser residential growth such as housing developments built at 12 units per acre, the result would be almost 47 billion fewer VMT per year and 2.3 billion fewer gallons of gasoline consumed—roughly a 12 percent drop in 2020 gasoline demand. Achieving an average density level of 12 units per acre also provides enough potential riders to make a modest transit system practical.

A recent study for the CEC reached a similar conclusion. The study considered four key smart-growth policies:

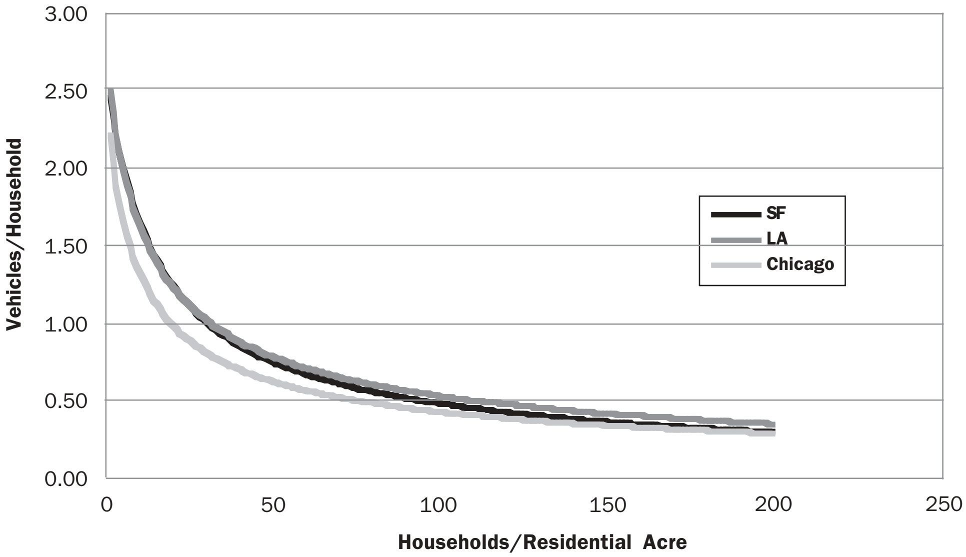
1. city and transit-focused land-use development;
2. increased transit supply;
3. market pricing of parking;
4. improvements in regional job-to-housing ratios.

The study found that if these smart-growth policies were implemented across the state, California could reduce gasoline consumption by 3 to 10 percent by 2020.[103]

Smart Growth Reduces Driving, Pollution, and Drivers' Costs

Examining development patterns in the nine-county Bay Area and the five counties in and around Los Angeles, NRDC researchers have found remarkable similarities

FIGURE 2.4
Auto Ownership vs. Residential Density



Source: Holtzclaw, J. et al., "Location Efficiency: Neighborhood and Socio-Economic Characteristics Determine Auto Ownership and Use—Studies in Chicago, Los Angeles, and San Francisco," *Transportation Planning and Technology*, Vol. 25, No. 1, January 2002.

between ways that density and the urban form influence regional car ownership and driving levels.[104] In areas with smart-growth characteristics such as small lot sizes, transit services, and walkable neighborhoods, families find it less necessary to drive and auto ownership levels are lower. (See Figure 2.4)[105]

Decreased dependence on cars can yield major environmental benefits as well. In fact, recent studies by the EPA have found that "infill" development and redevelopment of older suburbs could reduce VMT per capita by about 15 to 60 percent (depending on the metropolitan area studied) compared to "greenfield" sprawl.[106]

Reduced dependence on cars can also save working families money—and the cost of transportation is not incidental. Nineteen cents out of every dollar of median household spending is spent on transportation.[107] For most families, owning and maintaining an automobile is more costly than using public transportation. Commuting to work using public transportation typically costs from $189 to $2,077 per year depending on fares, surcharges, and discounts.[108] Owning a private vehicle costs from $4,826 to $9,685 per year, depending on the size of the car and mileage driven.[109]

Smart Growth Is Fiscally Responsible

There is a growing body of evidence that suggests that smart-growth planning can achieve substantial cost savings. The concept is easy to grasp: compact, efficient development means fewer miles of roads and sewer lines and reduced overall infrastructure. There are private sector savings as well that are due to reduced per-unit costs for infrastructure, such as power and telephone lines, and more efficient service routes. Analysts can quantify the savings through the lack of infrastructure costs, and some in several Northeastern states have done the calculations.

▶ Grow Smart Rhode Island commissioned a study contrasting smart growth and sprawl scenarios from 2000 to 2020 and found that smart-growth initiatives could achieve a staggering savings of $1.43 billion, an amount nearly equal to the state's current annual budget.[110]
▶ Researchers at Rutgers University assessed possible savings if New Jersey adhered to its state plan rather than allowing current development trends to continue. They found that if the state did not build transportation and water infrastructure required by current sprawling development trends, it could accrue savings of $2.32 billion.[111]
▶ Looking back over a 20-year period (1975–1995), Maine's state planning office found that in spite of a decline of 27,000 public school students, the state spent $338 million building new school facilities in fast-growing areas. [112]

Reducing oil demand is just one more reason for state and local policymakers to rewrite the rules and introduce incentives to prevent continued sprawled growth patterns.

Some state officials understand the need to change with the times. Remarkably, in the midst of a multi-billion-dollar budget crunch, 57 percent of California voters voted for Proposition 40 in early March 2002, which raised $2.6 billion worth of bond authority for measures to protect open space and natural resources. Even more remarkable was the support the measure received from the state treasurer, Philip Angelides. He wrote an endorsement letter stating that the measure would "enhance growth in the economy and protect our standard of living." He concluded, "These investments are fiscally sound and urgently needed." As the chief financial officer of our most populous state, Angelides realized that investments like those provided by Proposition 40 would pay off in the long run by ensuring that California attracts and retains high-quality companies and workers. Given that corporations are more mobile than ever, quality of life weighs heavily as a factor when companies decide to relocate or open a satellite facility. This became clear to sprawling Atlanta in 1999 when Hewlett Packard declined to construct a second office tower in the region because of traffic congestion and air quality.

Policies Exist to Get Us There

States interested in smart growth can specifically address the challenges posed by suburban sprawl by changing the basic ground rules for local planning. If done right, smart-growth planning can both reduce sprawl *and* increase the supply of affordable housing by directing growth to certain locations—using such smart-growth strategies as comprehensive planning, adequate public facilities ordinances, and zoning tools. However, a growing body of research shows that rules that attempt to control growth through building-permit caps or mandated low-density zoning are not only exclusionary but also likely to increase suburban sprawl.[113]

One creative way to change the rules is through regional revenue-sharing arrangements, by which cities split revenues from new development to revitalize older communities, thereby reducing the need to chase more development.[114] Regions grow haphazardly, in part because they compete for new development to ensure an adequate tax base that will pay for public services. But state legislators are considering a proposal to introduce revenue sharing to the Sacramento area, which may become the only region besides Minneapolis-St. Paul to adopt such a strategy.

The Location Efficient Mortgage℠ offers incentives for smart growth. One innovative, market-based incentive for smart growth is the Location Efficient Mortgage℠ (LEM), developed by NRDC and others. The rationale is simple and compelling: homes located near public transportation and in areas of greater density allow families to get where they need to go—to work, schools, stores, and cultural and entertainment centers—with less driving and lower transportation costs. And families that spend less on transportation are able to put more money towards a mortgage. As a result, mortgage lending rules should give more favorable lending terms to families buying these homes, by qualifying them to carry bigger mortgages.

At this time, the LEM is only being offered only through Fannie Mae, whose loan limit is not appropriate for the California real estate market. Major banks, with the support and encouragement of Fannie Mae, the state treasurer, and the Legislature, should expand the Location Efficient Mortgage℠ offerings by allowing LEM loans above $300,700, the current loan limit imposed by Fannie Mae.[115]

Reducing oil demand is just one more reason for state and local policymakers to rewrite the rules and introduce incentives to prevent continued sprawled growth patterns. While expanding LEMs is a good start, much more must be done to redirect investments towards the communities that reduce auto dependency. Envisioning and creating a different pattern of growth is vital to the well-being of California's environment and economy.

CHAPTER 3

Oil Savings and Economic Benefits

To demonstrate the effects of different policy choices on California's gasoline use and its environment, we model their impact on the California light-duty-vehicle sector. Calibrated using the most recent projections from the California Energy Commission, our model provides estimates of gasoline, oil, and greenhouse gas emission impacts of policy-driven technology introductions.[116] It also accounts for the incremental vehicle costs, fuel savings, and air pollution externality savings.

ROUTES TO A CLEAN AND RELIABLE FUEL SUPPLY

Step 1: High Fuel Economy

We assume that passenger-vehicle-fleet fuel economy will increase from 24 mpg to 42 mpg between 2006 and 2015. Automakers will meet these higher levels by directing new investments and technologies toward fuel economy while maintaining the performance and vehicle mix of today's fleet. The mix of vehicle types (i.e., cars, SUVs, minivans, and pickups) will be unaffected since, according to ACEEE, automakers can raise fleet fuel economy of the average gasoline-powered vehicle to 42 mpg without changing the vehicle sales lineup.[117] For the incremental cost of this new technology, we use the ACEEE "advanced package" results for fuel economy and incremental costs by vehicle class.[118]

Step 2: Fuel-Cell and Zero-Emission Vehicles

We assume that automakers will comply with California's ZEV production requirements, which begin in 2003. Because fuel-cell technology is not as mature as battery-electric technology, the majority of ZEV sales in the period from 2003 to 2006 will be battery-electric vehicles. As the production requirements rise, fuel-cell vehicles will increasingly meet the growth in sales volumes, but battery electrics will continue to be sold.

The fuel-cell commercialization pathway is based on a recent study commissioned by the California Fuel Cell Partnership.[119] Pilot testing begins in the period 2004–2006 with 1,000 vehicles, market introduction occurs during 2006–2008, and volume production begins in 2009. By 2010, annual sales reach 40,000, ramping up to more than 100,000 by 2012. Between 2012 and 2020, we assume a simple linear increase in sales, resulting in 385,000 vehicles sold in 2020 and an on-road stock of about 2.4 million vehicles.

For hydrogen refueling stations, we assume decentralized hydrogen production from natural gas. We estimate that the total cost of the infrastructure to support the 2020 sales level of 385,000 vehicles to be about $2.3 billion, or a present value of $1.4 billion.[120] This does not include the cost for new or expanded natural gas pipelines. We assume that the natural gas pipeline infrastructure will be expanded to accommodate higher growth already expected over the next decade due to electricity power plant demand. Total natural gas demand in 2010 for the fuel-cell fleet will be equivalent to 0.1 percent of total forecast demand for that year.

In this analysis, we assume that fuel cells meet cost targets and that technology rapidly progresses toward projected long-term cost and performance goals. For our analysis, we assume that in 2005 fuel-cell vehicles will initially cost $10,000 more than a conventional car; $4,200 more in 2010;[121] and then just $1,000 more in 2020. We assume an efficiency that is 2.5 times higher than a comparable gasoline vehicle and a hydrogen cost equivalent to $2.53 per gallon of gasoline based on CEC estimates.[122] Consequently fuel cell vehicles in 2020 are cheaper to own and operate than gasoline vehicles. Drivers save about $2,800 over the life of the vehicle.

Consequently fuel cell vehicles in 2020 are cheaper to own and operate than gasoline vehicles.

Step 3: Public Education Campaign and Fuel-Efficient Replacement Tires

We assume that an aggressive public education program advocating inflating tires, reducing driving speeds, reducing trips voluntarily, and improving maintenance will begin in 2003. We assume it will achieve 30 percent of the technical potential for these four programs in the first year and a maximum of 50 percent of the technical potential by 2005. For replacement tires, we assume a program to promote purchasing of fuel-efficient tires will not begin until 2004, and that it will take until 2010 to capture its full benefits (3 percent fleet-wide fuel savings). As a result, the gasoline consumption reductions for the combined programs will be about 1.6 percent in the first year, rising to 5.5 percent by 2010.

Step 4: Smart Growth and Enhanced Transit

To estimate the total potential for petroleum reduction, we rely on the recent study for the CEC, which found that California could reduce statewide gasoline consumption by 3 to 10 percent by 2020 if smart-growth policies were implemented across the state.[123] For the purposes of this analysis, we assume an average of the range: 6 percent. For simplicity, we assume that the policies will begin to take effect in 2010 and linearly increase to 6 percent by 2020.

TALLYING THE RESULTS OF NRDC'S FOUR-STEP PLAN TO REDUCE OIL DEPENDENCE

Reductions in Gasoline and Oil Dependence

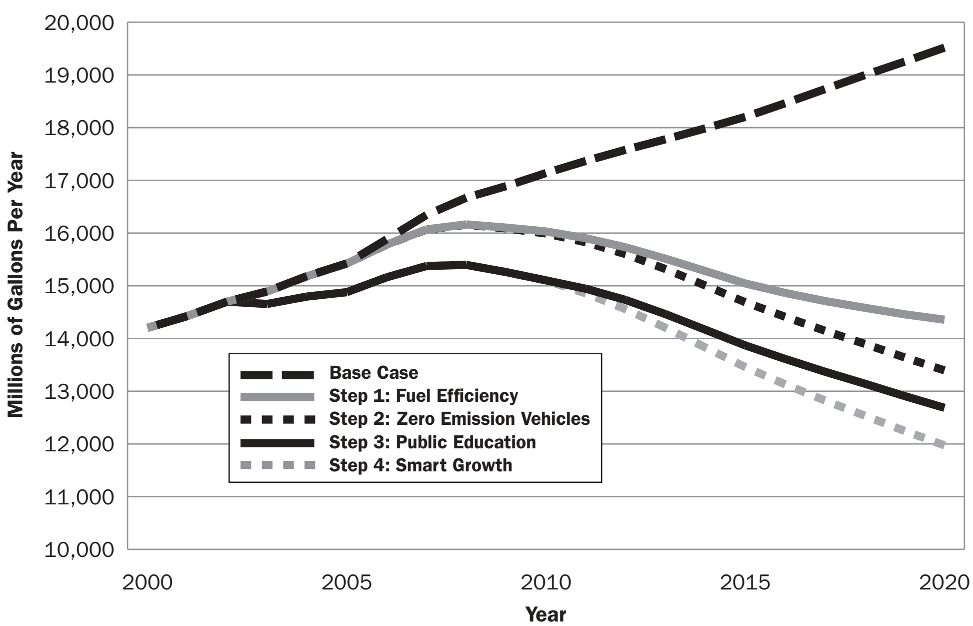
The package of policies has the combined effect of reducing California's gasoline use by 2 billion gallons—a 12 percent reduction from projected 2010 consumption levels. By 2020, consumption would be reduced by 7.5 billion gallons, equivalent to a 39 percent reduction in projected demand.

By 2010, the benefits are divided equally between higher fuel economy and the combined public-education/fuel-efficient-tire program. In 2020, fuel economy benefits still constitute two-thirds of the savings (about 5.2 billion gallons). The remainder of the benefits are divided roughly equally among fuel cells, public education, and smart growth.

These results show that fuel economy is the foundation of any policy to reduce oil dependence and that it is critical for California to begin focusing its policy efforts on increasing the supply of fuel-efficient cars to the states. It is essential that automakers step up and make the necessary commitments to raising fuel economy.

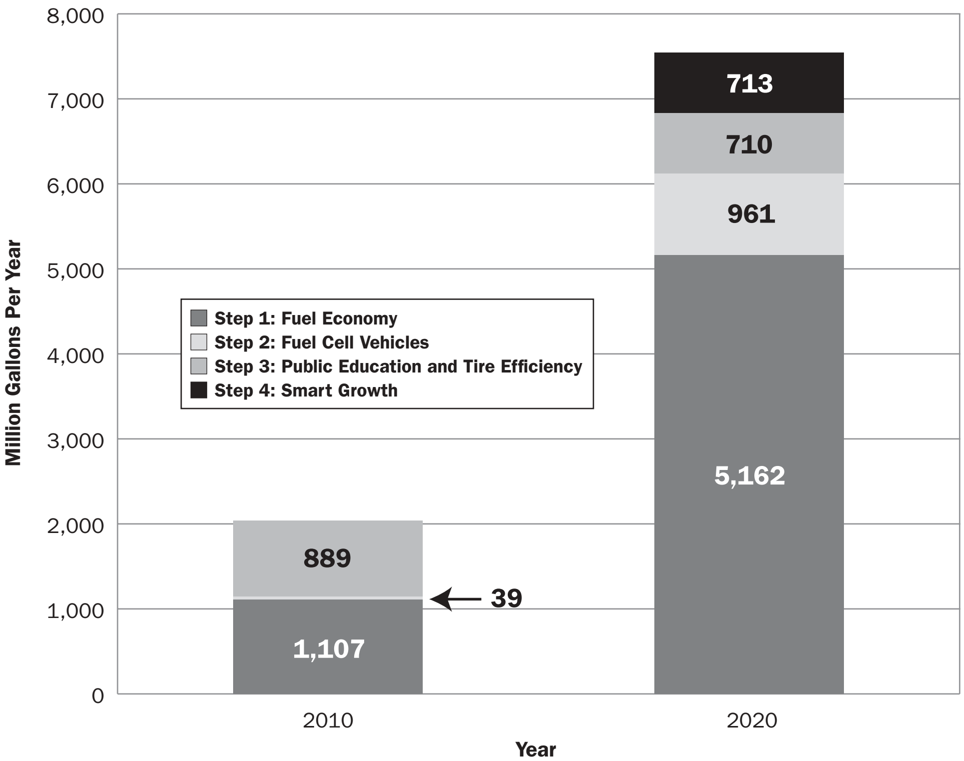
This analysis demonstrates that fuel cells are an important part of California's longer-term strategy to move toward oil independence. The benefits of gasoline displacement from a fleet of fuel-cell vehicles emerge rapidly after 2015 and begin to accrue even faster after 2020. This is particularly important since, as shown in Figure 3.1, the benefits of higher fuel efficiency begin to slow around 2020 as rising VMT begins to outstrip the fuel economy improvements. Analysis in a previous NRDC report, *Dangerous Addiction*, shows that gasoline demand will begin to rise sometime in the 2010- to 2020-timeframe, as fuel economy potential is reached and VMT continues to grow.[124] Fortunately, if the policy recommendations in this report are followed, fuel cell market penetration will be at the point where the oil displacement benefits continue to grow, enabling a continuous decline in overall gasoline consumption in the post-2010 timeframe.[125]

FIGURE 3.1
Gasoline Demand as Projected by NRDC's Four-Step Plan to Reduce Oil Dependence



Source: NRDC analysis.

FIGURE 3.2
Gasoline Savings as Projected by NRDC's Four-Step Plan to Reduce Oil Dependence



Source: NRDC analysis.

We have conservatively estimated in this analysis that smart growth will reach a maximum reduction in 2010 of 6 percent. However, the upper range of the CEC consultant report estimated a 10 percent reduction.[126] Furthermore, we expect that, as communities develop and as people become more familiar with the benefits of compact development, the 10 percent reduction may not fully represent the longer-term potential for smart growth.

Increased supply reliability: freedom from gasoline imports and reductions in crude oil imports. By adopting the recommendations in this report, California can reverse the trend toward greater dependence on imported supplies of gasoline. In fact, by 2011—less than ten years after implementing the program—California could become independent of gasoline imports and eliminate the $.15 per gallon import surcharge on gasoline (see Figure 3.3). By 2014, California's refinery system would have a 90 percent capacity utilization factor, thus allowing suppliers to respond more quickly to unexpected refinery or other supplies shortages. This would help eliminate price spikes and reduce average gasoline prices by about $.05 per gallon. California would avoid spending $3.3 billion on imported gasoline in 2010 and $7 billion in 2020.

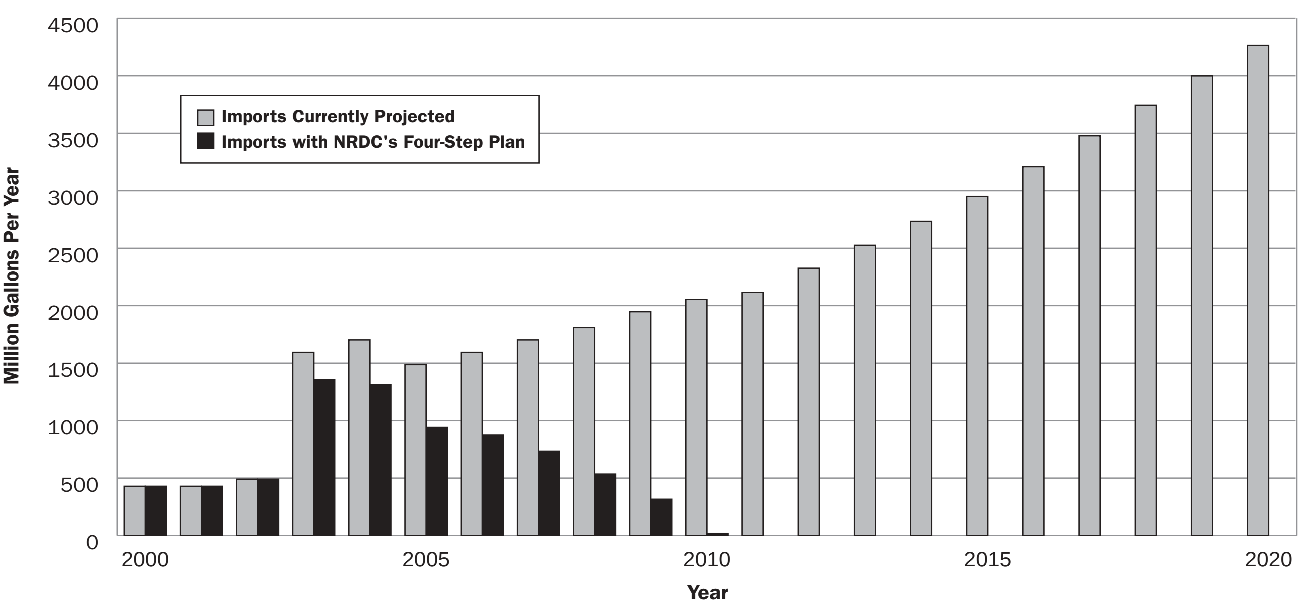
By 2020, demand for gasoline would be 15 percent less than 2000 levels. California could eliminate the need to import the equivalent of 80 million barrels per year of crude oil—more than the amount of crude oil California imported in 2000 from Iraq and Saudi Arabia combined. At $25 per barrel, this scenario would prevent our sending $2 billion overseas to the Middle East and other foreign oil producers.

Consumer savings and economic benefits. Consumers will directly benefit from these policies (see Figure 3.2). Drivers will see lower prices at the gasoline pump and the elimination of gasoline imports and price shocks. California's economy will benefit as less of the state's wealth is put toward imported gasoline and oil. Higher efficiency and reduced demand for driving will save drivers $49 billion in fuel costs over the period from 2002 to 2020 (see Figure 3.4).[127] This savings easily compensates for the increased purchase costs of $21 billion for fuel-efficient vehicles, better tires, and fuel-cell vehicles; the total net savings to consumers afforded by NRDC's Four-Step Plan to Reduce Gasoline Dependence would be about $28 billion.

Fuel-efficient cars and trucks. The higher purchase cost of the more fuel-efficient fleet is easily outweighed by fuel cost savings. In 2010, the net consumer cost savings will be $440 million, rising to $5.9 billion by 2020. Cumulatively for the period from 2006 to 2020, the net present value of the consumer savings will be $14 billion at a 5 percent discount rate. This calculation does not include the fuel savings after 2020 from (fuel-efficient) vehicles sold before 2021 and therefore underestimates the potential fuel savings.

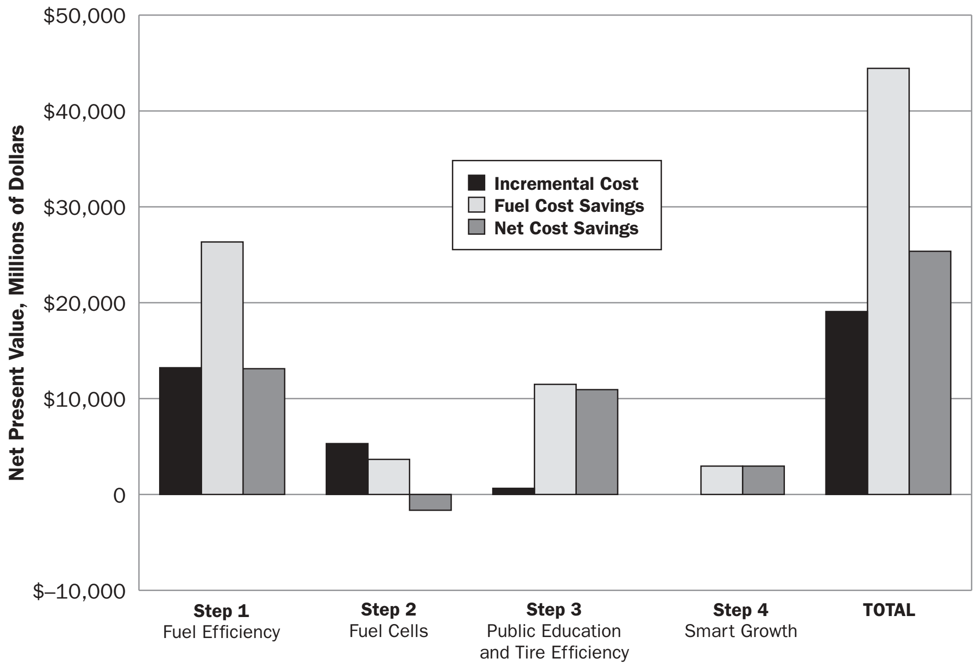
Fuel cells. Very roughly, the total present value of the fuel cell incremental purchase cost would be about $5.8 billion, and the fuel savings through 2020 would be about $4.0 billion. However the fuel savings calculation does not include the fuel savings after 2020 from vehicles sold before 2021. As mentioned earlier, at 2020

FIGURE 3.3
Projected Need for Gasoline Imports Under Base Case vs. Under NRDC's Four-Step Plan



Source: NRDC analysis.

FIGURE 3.4
Total Private Costs and Savings to Consumers, 2000 to 2020



Note: Does not include the fuel savings after 2020 from fuel-efficient vehicles or fuel-cell vehicles—and therefore underestimates the total fuel savings attributable to these measures.

Source: NRDC analysis. All values are in 2002 dollars and assume a 5 percent discount rate. Costs of smart growth are not estimated.

mature cost levels, drivers would save about $2,800 over the life of the vehicle. It also does not include the benefits of reduced air pollution and global warming emissions, the reduced likelihood of oil and gasoline spills, and the countless other environmental and public health benefits that would be realized through the commercialization of fuel-cell vehicles.

If the federal tax incentive proposal is passed (i.e., the CLEAR Act), then purchasers of fuel cells will receive a $4,000 to $8,000 tax credit, offsetting a major portion of the initial purchase cost. Furthermore, if automakers are serious about producing fuel cells this decade, we believe that they will view a portion of the initially higher production costs as a strategic investment and absorb some of the cost.[128] This is exactly what Toyota and Honda are doing with their early generation hybrids.

Public education. A public education program will be highly cost effective. In the first year, with $50 million in program costs, drivers can save almost $400 million in reduced fuel costs. As the program matures and reaches its maximum reduction of 7 percent, drivers will save about $1.5 billion in 2010. Including program costs, the present value of the total savings over the period from 2002 to 2020 will be almost $12 billion in reduced gasoline bills.

Smart growth. Smart growth will save drivers another $3.3 billion in fuel costs (present value). We did not quantify the costs of smart-growth programs. However,

Higher efficiency and reduced demand for driving will save drivers $49 billion in fuel costs over the period from 2002 to 2020.

smart growth can reduce the cost of new infrastructure—such as water, streets, and electricity—associated with increased suburban sprawl.

Reduction in import and volatility costs. Finally, the above calculations do not account for the cost reductions due to elimination of the import and volatility costs. Assuming that starting in 2011 the import fee of $0.15 per gallon is eliminated, the present value of drivers' savings will be an additional $270 million.

Petroleum Demand Model

We developed with the assistance of the Tellus Institute a detailed fuel economy stock model for California light-duty vehicles to estimate pollution emissions and fuel demand in baseline and alternative scenarios. The model uses a bottom-up approach to predict vehicle population by size class and model year and VMT accumulation, and it predicts gasoline consumption in future years for different scenarios, each based on different fuel efficiency assumptions. The primary model outputs are gasoline consumption, fuel expenditures, and incremental vehicle cost by vehicle size segment for the years from 2000 to 2020.

BASELINE FORECAST

For baseline data on the current California vehicle stock, we relied upon the following sources of data:

▸ vehicle populations for calendar year 2000 by vehicle class and model year were supplied by CEC forecasting group and are based on California vehicle registration data;
▸ historical fuel efficiencies by model year and vehicle class were obtained from the annual EPA fuel economy trends report;[129]
▸ on-road fuel economy correction factors by vehicle class were obtained from the Energy Information Agency (EIA) (AEO2001);[130]
▸ vehicle miles traveled (VMT) per vehicle estimates were obtained from CARB's EMFAC2000 model output for VMT by passenger car and light truck. The total VMT was then adjusted to calibrate the gasoline demand to CEC's most recent forecast being developed for the petroleum dependency study required by AB2076.

For forecasts of future trends, we assumed the following:

▸ passenger car and light truck total sales forecasts were obtained from AEO2001 for the Pacific Region (EIA, 2001), scaled to California's calendar-year-2000 portion of the market;
▸ sales fractions by vehicle class (e.g., compact car, midsize car) were held constant based on model-year-2000 fractions from CEC;

- fuel efficiency forecasts by passenger car and light truck classes were held constant at model-year-2000 levels for the entire baseline forecast period, essentially assuming that the past two decades in fuel economy trends continue;
- sales of zero emission vehicles (ZEVs) and Advanced Technology Partial ZEVs (AT PZEVs)—which were assumed to be hybrid vehicles due to the ZEV program requirements—were obtained from CARB.[131] Fuel efficiency of hybrids was based on ACEEE's analysis of full hybrids;
- VMT forecasts came from CARB's EMFAC2000 model output for VMT by passenger car and light truck. Total VMT was adjusted to calibrate the gasoline demand to CEC's most recent forecast, developed for the petroleum dependency study required by AB2076;
- a 10 percent "rebound" or take-back effect was assumed for VMT for the fuel efficiency cases, based on a recent analysis by fuel economy benefits at the national level;
- a simple stock turnover was then constructed, assuming a constant age distribution over time with a power function representing retirement by model year.[132] Fuel demand was then calculated using the following relationship:

$$(\text{Fuel Demand})_{ijk} = \frac{(\text{Population Fraction})_{ijk}\ (\text{Vehicle Population})_{jk}\ (\text{VMT})_{ijk}}{(\text{Fuel Economy})_{ijk}}$$

where i, j, and k, refer to model year, calendar year, and vehicle size class, respectively.

UPSTREAM EMISSION FACTORS

Criteria Pollutants

The significant upstream criteria air pollutants are non-methane organic gases (NMOG), nitrogen oxides (NOx), and carbon monoxide (CO). For these pollutants, we started with the emission factors (in grams per gallon) developed by Acurex Environmental Corporation for CARB.[133] The Acurex 1996 study has outlined emission factors for every process within each of the upstream steps, decomposed into processes that take place within California, within the United States, and throughout the rest of the world. The emission factors we used were developed for the calendar year 2010 scenario, since most of our fuel efficiency scenario benefits accrue in the 2010- to 2020-timeframe. Emission factors were updated using estimates supplied by CARB and AD Little.

Many analysts distinguish between "average" and "marginal" emissions. Average emissions are the total average emissions associated with the entire production and delivery of gasoline to the fuel tank. Marginal emissions are those emissions that are likely to be reduced if a gallon of gasoline consumption is reduced. If reduced gasoline consumption only displaces imported gasoline, then emissions from refineries will not be avoided, but emissions from marketing and distribution would be reduced.

However, if refinery capacity is constrained (as is currently the case), then infrastructure must be expanded to supply the additional gasoline, resulting in additional

TABLE A.1
Upstream Emission Factors for Gasoline
(grams per gallon)

	NMOG South Coast	NMOG California	NMOG U.S.	NMOG Rest of World
Extraction	0.1435	0.4592	0.9537	0.6732
Tanker Ship	0.0008	0.0014	0.0005	0.0864
Refinery	0.4281	0.0441	0.1429	0.1055
Storage at Production	0.0901	0.0000	0.0000	0.0000
Transport to Bulk	0.0000	0.0000	0.0000	0.0000
Bulk Storage	0.0160	0.0000	0.0000	0.0000
Local Transport	0.0770	0.0000	0.0000	0.0000
Fueling Station	0.7317	0.0000	0.0000	0.0000
Total	1.4872	0.5047	1.0971	0.8651
	NOx South Coast	**NOx California**	**NOx U.S.**	**NOx Rest of World**
Extraction	0.0072	0.0229	0.1158	0.0817
Tanker Ship	0.0086	0.0241	0.0055	1.5100
Refinery	0.2463	0.1945	0.4599	0.1554
Storage at Production	0.0000	0.0000	0.0000	0.0000
Transport to Bulk	0.0000	0.0000	0.0000	0.0000
Bulk Storage	0.0000	0.0000	0.0000	0.0000
Local Transport	0.0553	0.0000	0.0000	0.0000
Fueling Station	0.0000	0.0000	0.0000	0.0000
Total	0.3174	0.2415	0.5812	1.7471

Source: Acurex, *Evaluation of Fuel-Cycle Emissions on Reactivity Basis*, September 19, 1996.

emissions beyond marketing. Gasoline supply can be expanded either by adding refinery capacity or by importing more gasoline. Imported gasoline must be delivered to the California market by either marine tanker or pipeline. For imported gasoline, marketing emissions (from bulk storage, local transport, and fuel stations) are identical to emissions from gasoline produced in-state. We also assume the tanker-ship emission factor will be identical to the upstream factor for gasoline produced in-state. Extraction emissions will occur either outside of California in the United States or overseas. We arbitrarily assume that it will be extracted overseas and combine all extraction emissions from Table A.1 into a single factor for the "rest of world." For refineries, we assume the South Coast and California refinery emissions occur elsewhere in the United States.

Air Toxics

Emission factors for four air toxics (acetaldehyde, benzene, butadiene, and formaldehyde) were taken from a recent Argonne National Laboratory (ANL) study.[134] The emission factors in this study were lumped together for the total fuel cycle (including tailpipe emissions) and presented in terms of mg/mile

TABLE A.2
Emission Factors for Gasoline Supplies Imported by Marine Tanker
(grams per gallon)

	NMOG South Coast	NMOG California	NMOG U.S.	NMOG Rest of World
Extraction	0.0000	0.0000	0.0000	2.2296
Tanker Ship	0.0008	0.0014	0.0005	0.0864
Refinery	0.0000	0.0000	0.6151	0.1055
Storage at Production	0.0901	0.0000	0.0000	0.0000
Transport to Bulk	0.0000	0.0000	0.0000	0.0000
Bulk Storage	0.0160	0.0000	0.0000	0.0000
Local Transport	0.0770	0.0000	0.0000	0.0000
Fueling Station	0.7317	0.0000	0.0000	0.0000
Total	0.9156	0.0014	0.6156	2.4215

	NOx South Coast	NOx California	NOx U.S.	NOx Rest of World
Extraction	0.0000	0.0000	0.0000	0.2275
Tanker Ship	0.0086	0.0241	0.0055	1.5100
Refinery	0.0000	0.0000	0.9007	0.1554
Storage at Production	0.0000	0.0000	0.0000	0.0000
Transport to Bulk	0.0000	0.0000	0.0000	0.0000
Bulk Storage	0.0000	0.0000	0.0000	0.0000
Local Transport	0.0553	0.0000	0.0000	0.0000
Fueling Station	0.0000	0.0000	0.0000	0.0000
Total	0.0639	0.0241	0.9062	1.8929

Source: NRDC estimate based on emission factors listed in Table A.1.

emissions, which were then converted to g/gallon of gasoline, using a nominal fuel economy of 19 mpg.[135] The ANL study does not provide emission factors for different elements of the fuel-cycle, nor does it provide the California specific fractions of these emissions.

Toxic emissions within California can be approximated by multiplying emission factors by the volume of gasoline refined in California, using the following assumptions: a) the majority of upstream (i.e., non-tailpipe) toxic emissions are associated with refinery operations and b) there is no significant difference in toxic emission factors in these steps within and outside of California.

	Benzene	Butadiene	Acetaldehyde	Formaldehyde
Emission Factor, grams/gallon	0.004036	0.000762	0.000952	0.004653
Cancer Unit Risk Factor	8.30E-06	2.60E-04	2.20E-06	1.30E-05

Greenhouse Gas Emission Factors

Greenhouse gas emissions estimated are carbon dioxide (CO_2), methane (CH_4), and nitrous oxide. For upstream CO_2, CH_4 and N_2O emissions, we ran the GREET 1.5a

Table A.4
Emission Factors for Greenhouse Gases
(grams per gallon)

	CO_2	CH_4 *CO2–eq*	N_20 *CO2–eq*	Total *CO2–eq*
Upstream	2,393	271.0	61	2,725
Vehicle	8,085	18.7	210	8,314
Total	10,478	289.7	271	11,039

1. 1. Source: NRDC runs of GREET 1.5a.
2. 2. For comparison, Acurex, 1996, emission factor is 1,343 grams per gallon.
3. 3. NRDC estimates based on emission estimates for Low Emission Vehicle cars and trucks in U.S. EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–1997*, April 1999, Table C-10.

that was developed by ANL for California RFG 2 using ethanol as the oxygenate additive. For vehicle emissions, we again ran GREET 1.5a for CO_2. For methane and CH_4, we converted the grams-per-kilometer emissions factors in the most recent U.S. EPA national inventory of greenhouse gases into grams per gallon. We assumed Low Emission Vehicles with the fleet average fuel economies of 27.5 mpg for cars and 20.7 for light trucks. In addition, we assumed a 15 percent on-road adjustment factor to the rated fuel economies to reflect real-world usage.

APPENDIX B

Hydrogen Infrastructure Cost Estimate

This section describes the assumptions we made in order to compare the total capital costs of gasoline and hydrogen infrastructures.

EXPANSION OF GASOLINE INFRASTRUCTURE

New refineries are extremely capital intensive. No new refineries have been built in the United States in more than 25 years. However, with the United States importing an increasing amount of refined petroleum products from overseas, the oil industry has made it clear that it believes expansion of domestic refining capacity is desirable.[136] The most likely location for a new refinery in the United States is the Gulf Coast.

Stillwater Associates, a consultant to the California Energy Commission (CEC), has estimated the cost of a new refinery large enough to supply 200 to 300 TBD of gasoline to be "in excess of $3 billion."[137] This estimate is consistent with oil industry estimates of between $2 and $4 billion to build a new refinery.[138] Since the cost for a new refinery could be higher than $3 billion, we conservatively assume that a refinery producing 250 TBD would cost $3 billion.

Transporting the gasoline to California will also require additional investments. According to CEC consultants, there is an impending shortage of tankers available to transport gasoline from the Gulf Coast to California. Either more tankers must be built or a new pipeline must be constructed from Texas to California. Another CEC consultant has estimated the cost of a new pipeline to be $1.6 billion.[139]

Finally, refueling station capacity must be expanded to support the additional demand for gasoline. To build a new gasoline service station costs around $100,000. There are currently approximately 10,000 stations in California and 20 million light-duty vehicles. Each station, then, supports around 2,000 vehicles. This is somewhat higher than Dr. C.E. Thomas's estimate that each gasoline station can support 1,400 vehicles.[140] Using the higher, 2,000 vehicle-per-station cost results in a more conservative gasoline infrastructure cost estimate.

A 250 TBD refinery would support a fleet of around 6.13 million gasoline vehicles. We assume an average new passenger vehicle fuel economy of 24 miles per gallon (current U.S. fleet average), an on-road fuel economy adjustment factor of

15 percent, and an average annual mileage of 13,600 miles per vehicle.[141,142,143] At 2,000 vehicles per station, about 3,070 additional gasoline stations would be needed, costing a total of $307 million.

The total, undiscounted capital cost for the construction of a new refinery in the Gulf Coast, a pipeline from Texas to California, and additional service stations would be about $4.9 billion.

HYDROGEN INFRASTRUCTURE COSTS

Many experts agree that the most likely transition pathway for producing hydrogen for fuel cells will be through the use of small, decentralized stations that generate hydrogen from natural gas. These stations would be compact enough to be installed at existing gasoline stations, initially replacing just one gasoline pump with a hydrogen dispenser.[144] The hydrogen would be generated using a well-established process known as "steam methane reforming" that essentially strips the hydrogen from the methane molecules.

The cost of these stations will initially be high, primarily because of the reformer cost at low production volumes. As volume increases to hundreds or thousands of units, costs are forecast to drop rapidly.[145]

There are major financial advantages to building a distributed hydrogen infrastructure over an oil refinery.

A consultant to the California Fuel Cell Partnership recently completed a study of fuel infrastructure costs for a large-volume market introduction of fuel cells in California.[146] The study assumed 500 stations would need to support an annual sales volume of 40,000 vehicles. This estimate is driven by an assumption that purchasers would need a minimum distribution of refueling stations to feel comfortable using a fuel cell vehicle. Five hundred stations represents about 10 percent of the total number of gasoline stations in California's metropolitan areas and is roughly equal to the number of stations that offer diesel fuel to passenger vehicles. These stations are estimated to cost $450,000 each, for a total capital cost of $225 million.[147] These early stations would have a single nozzle capable of refueling 50 vehicles per day. At eight days between refueling, the 500 stations would be capable of refueling a fleet of 200,000 fuel-cell vehicles. The total on-road fleet by that time would be roughly 75,000 vehicles, so in the early years the capacity would outstrip demand.[148]

The California Fuel Cell Partnership fuel study estimates that, as the market grows, the cost for new stations will be about $670,000. This is equal to the $450,000 for a station with one hydrogen dispenser plus another $220,000 for an additional dispenser, capable of refueling another 60 vehicles per day, for a total of 110 vehicles per day and a fleet of 880 fuel-cell vehicles.[149] The total cost to support a fleet of 6.2 million fuel cells would be $4.8 billion.[150]

According to a recent report by Dr. C.E. Thomas, the cost could even be lower when production levels mature. Dr. Thomas estimates the cost to be $760,000 for a station roughly twice as large, capable of supporting 1,440 fuel-cell vehicles.[151] At this price, the total capital cost would be about $3.4 billion—$1.4 billion less.

Finally, there are major financial advantages to building a distributed hydrogen infrastructure over an oil refinery. The hydrogen mini-refineries and refueling stations can be added gradually, matched to the needs of the evolving fuel-cell vehicle market. Large, up-front capital investments are not needed. Using a discount rate of 5 percent (average return on capital for oil and gas industry over the last 5 years) and assuming it will take about 25 years to reach a fleet of 6.2 million fuel cells, the present value of the capital cost of the hydrogen infrastructure is $2.4 billion (using the Fuel Cell Vehicle Partnership cost estimates), versus the undiscounted capital cost of $4.8 billion.[152]

CAPITAL COST OF FEEDSTOCK TRANSPORT

It is beyond the scope of this study to estimate the capital cost of transporting the crude oil or natural gas feedstocks to the refinery. In the case of gasoline, the cost would entail building additional marine tankers to transport crude oil from the Middle East and other foreign sources. For the case of hydrogen, the cost would entail expanding the natural gas inter- and intra-state transmission and distribution system.

While California's natural gas pipeline is at capacity, major expansions are underway or planned. By the end of 2002, California's interstate natural gas system capacity will be almost 8,000 million cubic feet per day (MMcfd).[153] The CEC projects demand in 2010 to total about 7,000 MMcfd.[154] The CEC has identified over 5,000 MMcfd of planned and proposed expansions that could be completed over the next several years.[155]

A fleet of 75,000 fuel cells would use about 0.1 percent of the projected California natural gas demand in 2010. We estimate that in another 15 years, a projected on-road fleet of 6.2 million fuel cells would use roughly 750 MMcfd. This would lead to growth in demand of about 0.6 percent per year over 2010 levels if all the demand were met by hydrogen derived from natural gas. In the post-2020 timeframe, we anticipate that other sources of hydrogen will become available—such as electrolysis, which uses renewable electricity, and the conversion of biomass or municipal solid waste—which will replace some of the demand for natural gas.[156]

ENDNOTES

1 Includes the additional cost of new technologies and programs, and the fuel cost savings at the pump. Net savings calculated using a 5 percent discount rate.

2 The cost would be roughly half if discounted at 5 percent, approximately the rate of return on capital for the refinery industry over the past several years (see Appendix B).

3 Parsons Brinkerhoff, "California Smart Growth Energy Savings MPO Survey Findings," September 21, 2001.

4 Stillwater Associates, *MTBE Phaseout in California,* consultant report, California Energy Commission, March 2002, p. 45.

5 Ibid., p. 45.

6 Ibid., p. 19.

7 MTBE currently makes up about 11 percent of gasoline supply. Ethanol is limited to 5.7 percent of gasoline by volume, so replacing MTBE with ethanol immediately causes a loss of output of 5 percent by volume. Ethanol has a higher oxygen content than MTBE. The amount of oxygen allowed is capped by federal law since adding oxygen to gasoline decreases hydrocarbons and carbon monoxide emissions but increases tailpipe emissions of nitrogen oxides, another important precursor to ground-level ozone (i.e., smog). In addition, refiners must remove an amount of lighter, more volatile molecules equal to the volume of ethanol added, resulting in total output loss of about 10 percent. However, according to a consultant for the CEC, California's refineries are in the process of slightly expanding their gasoline production capacity by about 5 percent; this will result in a net loss of 5 percent in production capacity (Stillwater, 2002).

8 In 2000, California imported about 30 TBD of finished gasoline from foreign countries and other states, or about 3 percent of its total consumption (NRDC estimate based on Stillwater, 2002, p. 21, Figure 3.2).

9 Stillwater, 2002, Figure 3.2.

10 Another option, a gasoline reserve, would serve to buffer supply during shortages (study required by AB2076 [Shelley]), but it does not address the fundamental issue of reducing the shortfall.

11 Energy Information Agency (EIA), *Annual Energy Outlook 2002*, U.S. Department of Energy, December 2001, Table A11.

12 Stillwater, 2002, p 2.

13 Stillwater, 2002, p 32.

14 NRDC estimate based on 275,000 barrels per tanker.

15 Laughlin, D., *Marine Product Tanker Fundamentals, Economics & Outlook*, consultant report, California Energy Commission, March 2002, p. 12.

16 Ibid., 2002, p. 6.

17 Cook, J., "Petroleum Outlook: More Volatility?" presentation at the NPRA annual meeting, New Orleans, Louisiana, Energy Information Agency, March 19, 2001.

18 Stillwater, 2002, p. 41.

19 Oliver, C., "Fewer Refineries Means Less Gas; So Why Isn't the U.S. Building More?" *Investor's Business Daily*, June 12, 2001.

20 Interliance LLC, *Gulf Coast to California Pipeline Feasibility Study*, consultant report to the California Energy Commission, March 2002.

21 American Petroleum Institute, "U.S. Refining Industry: A System Stretched to the Limit," 2001, http://api-ec.api.org/.

22 Two proposals in the Los Angeles area appear to have been abandoned: one was a proposal by CENCO to reopen a refinery in Santa Fe Springs; the other was a proposal by Ultramar to expand its operations in Wilmington significantly. A third proposal appears to be still under consideration. According to a consultant to CEC, Stillwater Associates, one company is considering re-starting an idle facility (a recently purchased Bay Area refinery), but the project has marginal economics. It would come on-line no sooner than 2005.

23 Stillwater, 2002, Figure 3.2, p. 21.

24 California Energy Commission (CEC), "Table 1—Base Case Prices.xls," spreadsheet of base case price forecasts for 2001 to 2020 for AB2076 study, 2001.

25 According to a recent CEC consultant report, the cost of shipping gasoline from the Gulf Coast by marine tanker is about $5.60 per barrel, or 13.3 cents per gallon (Laughlin, 2002, p. 11).

26 CEC, 2001, p. 6.

27 Stillwater, 2002, p. 34.

28 Schremp, G., "MTBE Phaseout Update—Costs, Supply, Logistics & Key Challenges," California Energy Commission, presentation at the California Air Resources Board Hearing, San Francisco, CA, July 26, 2001.

29 California Energy Commission (CEC), *California Energy Outlook 2000, Volume II—Transportation Energy Systems*, executive summary, July 2000.

30 NRDC estimate based on a price "elasticity" of -0.14 (Little, A.D., *Task 3: Petroleum Reduction Options*, 2002, consultant report, California Energy Commission, Option 3A) and 2001 average gasoline price of $1.71 per gallon (CEC website, "1997–2001 Average Branded Gasoline Retail Price Breakdown," page updated May 2, 2002, http://www.energy.ca.gov/fuels/gasoline/margins/1997-2001_branded_graphs.gif).

31 Energy Information Agency (EIA), *Electricity Shortage in California: Issues for Petroleum and Natural Gas Supply*, U.S. Department of Energy, http://www.eia.doe.gov/emeu/steo/pub/special/california/june01article/casummary.html, updated June 12, 2001.

32 Stillwater, 2002, p. 12.

33 CEC, 2000, p. 18.

34 See Bayles, F., "Gas May Approach $3 a Gallon in Summer," *USA Today*, April 11, 2001; Gilpin, K. N., "Market Insight: Everything is Rising Fast in Oil, Except Stock Prices," *New York Times on the Web*, May 6, 2001; Kraul, C., "State Barreling Ahead Toward Fuel Shortage," *Los Angeles Times*, October 15, 2000.

35 The oxygenate mandate in the federal Clean Air Act of 1990 requires gasoline for highly smoggy regions to contain 2 percent oxygen by weight. Oxygenates are octane-boosting fuel additives that help gasoline combust more cleanly, resulting in lower pollution emissions. About 70 percent of gasoline sold in California is affected by the oxygenate requirement. That number will increase to 80 percent when the U.S. EPA downgrades San Joaquin Valley's air quality status.

36 The two principle oxygenates used are methyl tertiary butyl ether (MTBE) and ethanol. Most reformulated gasoline in California contains MTBE (about 85 percent); only 8 percent contains ethanol.

37 Schremp, 2001.

38 Renewable Fuels Association, "Ethanol Industry Sets Annual Production Record in 2001," press release, January 28, 2002, http://www.ethanolrfa.org/pr020128.html.

39 Schremp, 2001.

40 Ibid.

41 Stillwater Associates, *MTBE Phaseout in California*, draft report for the California Energy Commission, February 18, 2002.

42 This delay does not solve the problem, but it may help alleviate the scarcity of imports. Beginning in 2004, sulfur levels will be reduced nationwide, bringing nationwide gasoline formulation much closer to California's needs. If excess volume is available, this should make it easier to import gasoline from the Gulf Coast on a periodic basis.

43 California Energy Commission website, "1997–2001 Average Branded Gasoline Retail Price Breakdown," updated May 2, 2002, http://www.energy.ca.gov/fuels/gasoline/margins/1997-2001_branded_graphs.gif

44 California Attorney General's Office, *Report on Gasoline Pricing in California*, staff report, May 2000.

45 Ibid.

46 California Air Resources Board (CARB), *Proposed Clean Air Plan: Strategies for a Healthy Future, 2002–2020*, March, 15, 2002, p. ES-1.

47 NRDC estimate based on data in CARB, 2002, p. II-4.

48 California Air Resources Board (CARB), "Air Resources Board's Clean Air Plan: Strategies for a Healthy Future," staff presentation at the Concepts Workshop, Sacramento, California, May 21–24, 2001.

49 CARB 2002.

50 NRDC calculation based on upstream emission factors described in Appendix A and passenger vehicle gasoline demand from the draft CEC forecast for AB2076. Vehicle emissions are output from EMFAC2000v2.02, adjusted to match the CEC forecast of VMT.

51 It is worth noting that gasoline use also contributes significantly to diesel particulate emissions, through the necessity of transporting crude oil to refineries and gasoline to service stations.

52 CARB, 2002, p. I-E-9.

53 CARB, 2002 , p. ES-2.

54 The Clean Air Act air toxics provision requires limits on exposure to air toxics to levels posing no more than one additional cancer case per one million for the most exposed individuals (Clean Air Act Amendments of 1990, § 112(f)(2)(A) hazardous air pollutant emission standards).

55 Center for Energy Efficiency and Renewable Technologies (CEERT), *Crude Reckoning*, 2000, http://www.ceert.org/pubs/crrp/petro/Reckoning.pdf.

56 Ibid.

57 Natural Resources Defense Council, "A Decade after the *Exxon Valdez*: Inadequate Federal Action on Oil Spill Prevention," March 1999.

58 U.S. Coast Guard, "Polluting Incident Compendium: Cumulative Data and Graphics for Oil Spills, 1973–2000." http://www.uscg.mil/hq/gm/nmc/response/stats/summary.htm, accessed December 20, 2001.

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62 Kay, J., "Governor Pledges to Fight Bush on Drilling," *San Francisco Chronicle*, January 15, 2002.

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