

MACROECONOMIC IMPACTS FOR THE STATE ALTERNATIVE-FUELS PLAN

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ABSTRACT

We examined the impact on California real output, employment, and personal income of three potential scenarios for increasing the use of alternative fuels in California. The scenarios are those described in the report of the California Energy Commission (*State Alternative-fuels Plan*, October, 2007, Section 5). The method used to evaluate these scenarios was a computable general equilibrium model (Environmental-Dynamic Revenue Analysis Model). The model was calibrated to project the economic conditions of California for the years 2012, 2017, 2022, 2030, and 2050. The economic effects of the three alternative-fuel scenarios were estimated for each of those base years and compared to the conditions that would be obtained in the absence of policy. The effect on individuals of different incomes and the effect on employment by income class were also calculated. Results were also presented on an industry basis for the most affected industries. The results were tested for sensitivity to increased gas prices, and estimates were made of the cost to the economy of raising the state funds needed to carry out the policies.

KEYWORDS

Macroeconomic impact, computable general equilibrium model, alternative fuels

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EXECUTIVE SUMMARY

We examined the impact on California real output, employment, and personal income of three potential scenarios for increasing the use of alternative fuels in California. The scenarios are those described in the report of the California Energy Commission (*State Alternative-fuels Plan*, October, 2007, Section 5). The method used to evaluate these scenarios was a computable general equilibrium model (Environmental-Dynamic Revenue Analysis Model). The model was calibrated to project the economic conditions of California for the years 2012, 2017, 2022, 2030, and 2050. The economic effects of the three alternative-fuel scenarios were estimated for each of those base years and compared to the conditions that would be obtained in the absence of policy. Broadly, all three scenarios would slightly increase state personal income in almost all years. The maximum increase in personal income was less than 0.2 percent (two-tenths of a percent).

The scenarios were financed by a diversion of funds from other noninfrastructure spending. Two alternative-financing mechanisms were evaluated for funding these programs—an increase in the vehicle license fee and a diversion of funds from infrastructure investment. In both of those cases, the scenarios would be considerably more costly to state personal income than they would be otherwise.

The effect on individuals of different incomes and the effect on employment by income class were also calculated. There was no obvious pattern of effects by income class and, in general, the effects of the scenarios on income per household were quite small.

Results were also presented on an industry basis for the most affected industries. Oil refining, in particular, is substituted away from by the scenarios. As a result, the oil-refining sector is projected to be much smaller with the scenarios than it would be without them. However, other sectors, such as agriculture, which is the source of biofuels, are expected to grow.

The results were tested for sensitivity to increased petroleum prices. As expected, the higher the petroleum prices, the greater are the benefits of strategies to avoid petroleum use. Similarly, the results were tested for sensitivity to higher costs for the vehicles required for the scenarios (and only for those vehicles). A 10 percent increase in that cost significantly decreases the economic benefits of the scenarios, particularly in the later years.

CHAPTER 1: INTRODUCTION

This report presents the methodology and results of assessing the impacts of petroleum-reduction strategies on the California economy. Methodology is discussed first and then results.

The methodology employed is computable general equilibrium (CGE) modeling. The CGE models are designed to capture the fundamental economic relationships between producers, consumers, and government. The models are “computable” because numeric solutions are found using computers rather than solved for algebraically. They are “general” in the sense that all markets and all income flows in the economy are accounted for. They reflect “equilibrium” insofar as prices adjust to equilibrate the demand for and supply of goods, services, and factors of production (labor and capital) of the model.

The specific model employed, here, is a modified version of the Environmental-Dynamic Revenue Analysis Model (E-DRAM). The E-DRAM was built for the California Environmental Protection Agency’s Air Resources Board (ARB) by researchers at the University of California at Berkeley. The E-DRAM evolved from the Dynamic Revenue Analysis Model (DRAM), which was developed jointly by the California Department of Finance (DOF) and Berkeley researchers to perform dynamic revenue analyses of proposed legislation as mandated by California State Senate bill 1837 in 1994. Much of the description of E-DRAM is closely adapted from Berck, Golan, and Smith (1996), which, henceforth, will be referred to as the DRAM Report.¹ The model has been updated to a 2003 base year.

The remainder of this introduction is a nontechnical description of E-DRAM. The next chapter is a description of the modeling issues that pertain to this alternative-fuel study. The final chapter is the results.

A Description of the E-DRAM Model

The E-DRAM describes the relationship among California producers, California households, California governments, and the rest of the world. Rather than tracking each individual producer, household, or government agency in the economy, however, E-DRAM combines similar agents into single sectors. Constructing a cogent sectoring scheme, the first step of model construction, is discussed immediately below; this discussion is followed by a description of the key agents in the economy—producers and consumers.

Aggregation and Data Sources

The E-DRAM, like all other empirical economic models, treats aggregates rather than individual agents. This is done both to provide focus for the analysis and contain the number of variables

¹ The DRAM Report is available at www.dof.ca.gov/HTML/FS_DATA/dyna-rev/dynrev.htm.

in the model. Constructing a cogent aggregation (or sectoring) scheme is critical in the development of a CGE model because it determines the flows that the model will be able to trace explicitly. For the E-DRAM model, the California economy has been divided into 186 distinct sectors: 120 industrial sectors, 2 factor sectors (labor and capital), 9 consumer good sectors, 8 household sectors, 1 investment sector, 45 government sectors, and 1 sector representing the rest of the world. The complete details of the sectoring are given in Chapter II of the DRAM Report.

For industrial sectoring purposes, all California firms making similar products are lumped together. The agriculture sector, for example, contains all California firms producing agricultural products. The output value of that sector is the value of all crops produced by California growers. A sector's labor demand is the sum of labor used by all firms in the sector. Along with agriculture, there are 119 other producer aggregates in the model. These aggregates generally represent the major industrial and commercial sectors of the California economy, though a few are tailored to capture sectors of particular regulatory interest. For instance, production of internal-combustion engines and consumer chemicals are each delineated as distinct sectors at the request of ARB.²

Data for the industrial sectors originate from the U.S. Department of Commerce's Bureau of Economic Analysis and are based on the Census of Business—a detailed survey of U.S. companies conducted every five years.³ The survey contains information about intermediate purchases, factor (labor, capital, land, and entrepreneurship) payments, and taxes. Although quite extensive, the survey only allows inference about groups of firms at the national level. The conversion of national data to updated California data is accomplished using a combination of state-level employment data and estimates from DOF's econometric modeling.

Like firms, households are also aggregated. California households are divided into categories based upon their income. There are eight such categories in the model, each one corresponding to a California Personal-income Tax marginal tax rate (0, 1, 2, 4, 6, 8, 9.3, and a high-income 9.3 percent). Thus, the income from all households in the 1 percent bracket is added together and becomes the income for the "1 percent" household sector. Similarly, all expenditure on agricultural goods by the 1 percent households is added and becomes the expenditure of the 1 percent household sector on agricultural goods. Total household expenditure on agricultural goods is the sum of expenditures by all eight household sectors. Household income data come from the California Franchise Tax Board Personal-income Tax "sanitized" sample. Data on consumption by income class are derived from national survey data.

The government sectors in DRAM are organized so that both government revenue flows and expenditure flows are traced explicitly. The DRAM includes 45 government sectors: 7 federal, 27 state, and 11 local. Government sector data are culled from published federal, state, and local government reports.

² The alcohol, tobacco, and horse-racing sector, distinct in DRAM, has been folded into the foods sector in the latest version of E-DRAM.

³ The survey is conducted in years ending in two and seven, and data are released after processing. The E-DRAM uses data from the 2002 release, which contain processed 1997 survey data.

Producers and Households

Fundamental to the California economy and, hence, E-DRAM, are the relationships between the two principal types of economic agents—producers and households.

Producers, also known as firms, are aggregated into industrial sectors, and each sector is modeled as a competitive firm. For instance, the output of all of California’s agricultural firms is modeled as coming from a single entity—the agriculture sector. Each sector takes the price that it receives for its output and the prices that it pays for its inputs (capital and labor, called “factors of production,” and other inputs, called “intermediate goods”) as fixed. This is the competitive model: Producers do not believe that their decisions have any effect on prices. Each producer is assumed to choose inputs and output to maximize profits. Inputs are labor, capital, and intermediate goods (outputs of other firms). Thus, the producer’s supply of output is a function of price and the producer’s demand for inputs is a function of price. More information on producers is provided in Chapter IV of the DRAM Report.

Households make two types of decisions: They decide to buy goods and services, and they decide to sell labor and capital services. They are assumed to make these decisions in the way that maximizes their happiness (called “utility” in the economics literature). Like firms, they take the prices of the goods that they buy and the wage of the labor that they sell as fixed. In addition to their labor income, households receive dividends and interest from their stocks and bonds and other ownership interests in capital.

Households’ supply of labor, as a function of the wage rate, is called the “labor-supply function.” A more detailed description of the supply of labor is given in Chapter VII of the DRAM Report.

Households’ demand for goods or services, as a function of prices, is simply called the “demand function.” A more detailed description of the demand for goods and services is given in Chapter III of the DRAM Report as well as in Berck, Hess, and Smith, 1997. The latter explains how the distribution of household spending across the 120 industrial sectors via the nine consumer goods sectors is based on analysis of U.S. Bureau of Labor Statistics’ Consumer Expenditure Survey data.

Equilibrium

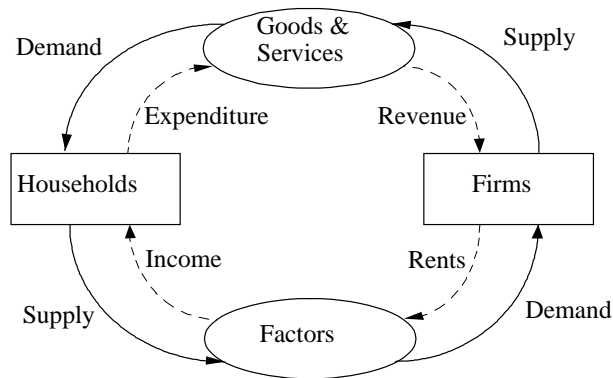
So far, two types of agents have been described: firms and households. It remains to be explained how these agents relate. They relate through two types of markets: factor markets and goods-and-services markets. Firms sell goods and services to households on the goods-and-services markets. Households sell labor and capital services to firms on the factor markets. There is a price in each of these markets. There is a price for the output of each of the 120 industrial sectors. There is a price for labor, called the “wage,” and a price for capital services, called the “rental rate.” Equilibrium in a market means that the quantity supplied (which is a function of price) is equal to the quantity demanded (which is also a function of

price) in that market. Equilibrium in the factor markets for labor and capital and in the goods-and-services markets for goods and services defines a simple general equilibrium system. That is, there are 122 prices (the wage, the rental rate, and one for each of the 120 goods made by the 120 sectors) and these 122 prices have the property that they equate quantities supplied and demanded in all 122 markets. They are market-clearing prices.

These relationships are shown in more detail in Figure 1, called a “circular-flow diagram.” The outer set of flows, shown as solid lines, are the flows of “real” items, goods, services, labor, and capital. The inner flows, shown as broken lines, are monetary flows. Thus, firms supply goods and services to the goods-and-services market in return for revenues that they receive from the goods-and-services markets. Firms demand capital and labor from the factor markets and in return pay wages and rents to the factor markets.

Households, the other type of agent in a simple model, buy, or in economic parlance, demand, goods and services from the goods-and-services markets and give up their expenditure as compensation. They sell capital and labor services on the factor markets and receive income in exchange.

Figure 1: The Basic Circular-Flow Diagram

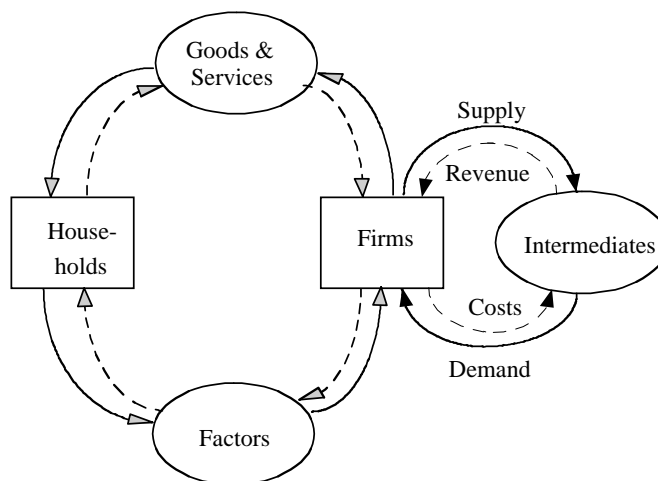


Source: Berck, Golan, and Smith, 1996.

Intermediate Goods

The economy of California is far more complex than that shown in Figure 1. There are not only final goods-and-services markets but also intermediate-goods markets in which firms sell to firms. A typical example of this would be chemicals sold to agricultural firms. The final output of the chemical industry (perhaps fertilizer) is said to be an intermediate good in the agricultural industry. This type of market is demonstrated in Figure 2. Here, part of the supply of a firm (chemical industry in the example) is not sold to households but rather to another firm in exchange for revenue. From the other firm’s point of view, it buys an input to production from a firm rather than from a household. The expense of buying the input is a cost of production. Chapter IV of the DRAM Report contains the model specification for these types of transactions, which are based upon a national input-output table.

Figure 2: The Circular-Flow Diagram with Intermediate Goods

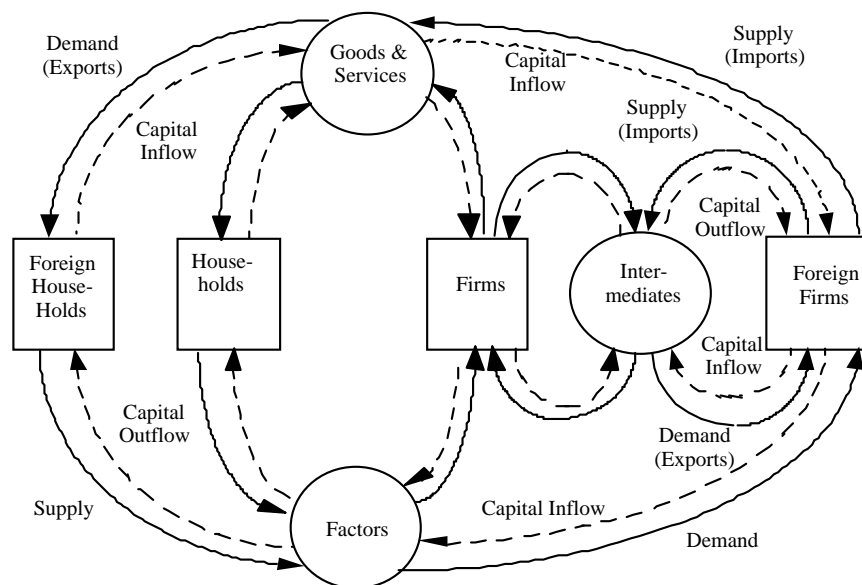


Source: Berck, Golan, and Smith, 1996.

Rest of the World

California is an open economy, which means that it trades goods, services, labor, and capital readily with neighboring states and countries. In this model, all agents outside California are modeled in one group called “Rest of World.” No distinction is made between the rest of the United States and foreign countries. California interacts with two types of agents: foreign consumers and foreign producers. Taking the producers first, Figure 3 shows that the producers sell goods on the (final) goods-and-services markets and on the intermediate markets, i.e., they sell goods to both households and firms. The model takes these goods as being imperfect substitutes for the goods made in California. Agricultural products from outside of California (e.g., feed grains, bananas) are taken as being close to, but not identical to, California-grown products (e.g., avocados, fresh chicken). The degree to which foreign and domestic goods substitute for each other is very important, and the evidence is described in Chapter V of the DRAM Report. Foreign households buy California goods and services on the goods-and-services markets. They and foreign firms both can supply capital and labor to the California economy, and domestic migration patterns are described in Chapter VIII.

Figure 3: The Circular-Flow Diagram with Intermediate Goods and Trade

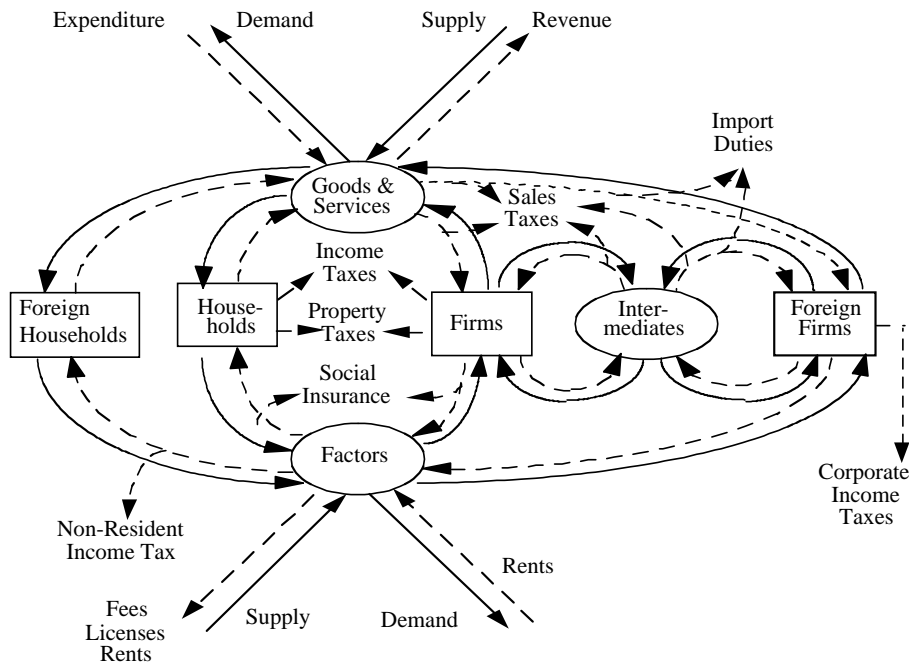


Source: Berck, Golan, and Smith, 1996.

Government

Finally, government is considered. Combining the taxing and spending effects of the three levels of government (federal, state, and local) gives the additional flows in Figure 4. Beginning at the top, the figure shows that government buys goods and services and gives up expenditure. It supplies goods and services for which it may or may not receive revenue. Government also supplies factors of production, such as roads and education. The model does not currently include goods such as K-12 education as such goods are not always traded in organized markets. Government also makes transfers to households, which are not shown in the diagram. The middle section of the diagram shows the myriad of ways in which government raises revenue through taxation. Chapter II of the DRAM Report includes a detailed description of the government activities in the model.

Figure 4: The Complete Circular-Flow Diagram



Source: Berck, Golan, and Smith, 1996.

Data Organization: The Social Accounting Matrix

The first step in constructing a CGE model is to organize the data. The traditional approach to data organization for a CGE model is to construct a Social Accounting Matrix (SAM). A SAM is a square matrix consisting of a row and column for each sector of the economy. Each entry in the matrix identifies an exchange of goods and services purchased by one sector from another sector (or itself). The entries along a row in the SAM show each payment received by that particular row sector from each column sector. Summing across the row gives total payments made to that row sector by all column sectors. The entries down a column in the SAM show the expenditures made by that particular column sector to all row sectors. Summing down a column gives total expenditures by that column sector to all row sectors. For accounting purposes, a SAM must “balance,” i.e., each row sum and corresponding column sum must be equal. This balancing ensures that no money “leaks” out of the economy, i.e., that all money received by firms (row sum) is spent by them (column sum).

Regional and National Model Differences

There have been hundreds of CGE models built and used for analyzing public policy at the national and international level. Regional, or subnational, CGE models are very similar in design to national and international models but exhibit major differences in several key

assumptions. The seven most important differences between national and regional CGE models are discussed below.

The first, and maybe most important, difference is that regional CGE models do not require that regional savings equal regional investment. When Californians save more than California investors want to use, excess savings flow out of the state. When the converse is true, savings flow into the state. Rational economic agents would not accept less interest on their savings from California investors if higher interest rates were available in other states or countries. Conversely, rational investors in California would not pay higher interest for the use of Californian savings if other states or countries offered lower rates.

The second difference is that regional economies trade a larger share of their output. Therefore, trade is more important in regional models. Note that interstate trade is part of the Rest of World for California but ignored in national considerations of trade.

The third difference is that regional economies face larger and more volatile migration flows than nations. Regional and international migration to California is a major factor in the State's economy.

The fourth difference between national and regional CGEs is that regional economies have no control over monetary policy. The Federal Reserve is responsible for monetary policy and is a national institution.

The fifth difference is that in regional models taxes are interdependent through deductibility. Some local taxes are deductible from incomes subject to California Personal-income Taxes and Bank and Corporation Taxes. Some local and state taxes are deductible from incomes subject to Federal Personal-income Tax and may be eligible for deduction from corporate incomes for federal purposes. In E-DRAM, the personal-tax deductibility is explicitly modeled. Since corporate deductibility is more uncertain and since the apportionment rules may reduce the connection to federal corporate taxes, corporate deductibility has not been included in E-DRAM.

Sixth, while good data for a CGE are hard to find at the national level, in many cases they are nonexistent for regional economies. The E-DRAM uses published economic and statistical literature to simulate much of the data important to our model. In some cases, such as labor supply, a wide variety of results are presented in the literature. This problem is addressed in three ways: (1) values are chosen so as to avoid the extremes; (2) the model is tested to determine the degree to which results are dependent upon our assumptions (this process is called "sensitivity analysis"); and (3) the use of published literature, especially of national results, has been minimized.

Seventh, the California CGE differs from a national CGE in that California faces a balanced-budget requirement. Even if this is ignored in the short run, bond markets tend to reflect this fact. When California issued bonds to cover short-term deficit spending in the early 1990s, bond ratings forced up the cost of borrowing. Ultimately, California would face unreasonable borrowing costs should it decide to maintain this level of borrowing.

Other Considerations and Model Building

The CGE models are not forecasting models; they are calibrated to reproduce a base year. In the case of E-DRAM, the model is constructed to exactly reproduce the economic conditions of fiscal year 1998-99. Of course, there are forecasting models. However, such models typically do not have the level of detail needed to examine dynamic policy effects. Given the paucity of California-specific data, it seems a better compromise to use a forecasting model, such as the one maintained by DOF, to set a base case and then use a policy model, such as DRAM, to analyze deviations from that case.

The E-DRAM model incorporates two assumptions that require some comment. It assumes competitive behavior in all private sectors. This is a good first approximation, particularly at the level of a sector. The alternative, oligopoly behavior, may well be present, but the degree of markup of price over marginal cost is not likely to be significant. The second assumption is that involuntary unemployment is constant. This is unlikely to be strictly true. The model has voluntary unemployment, which are agents deciding to work less when the wage is lower. This assumption is common to all equilibrium models. Technical issues of model closure are described in Chapter IX of the DRAM Report.

Once the major agents in the economy have been identified and the relationship between these agents has been specified, the model can be built. In E-DRAM, the algebraic representation of the relationships between the agents in the California economy is achieved with the General Algebraic Modeling System (GAMS). The model currently has 1,100+ equations, exclusive of definitions and of the code to read in and organize the data. All of the model's equations and GAMS code are detailed in Chapter X.

Further Documentation

Fuller description of common features shared by E-DRAM and DRAM is available in the report cited above. The primary contents of that report, the presentation of which mirrors the sequence of tasks involved in building DRAM, are as follows. In Chapter II of the DRAM Report, the major agents in the economy are identified and aggregated into sectors. These aggregates are constructed to focus the model on the major industries, taxpayers, and government agencies in the California economy. Data sources are also identified.

Chapters III through VIII of the DRAM Report review the literatures, functional forms, and elasticities relevant to the six primary behavioral equations that link all the various sectors of the model and drive its results. Chapter III of the DRAM Report reviews the literature on the economic behavior of households with respect to consumption and savings decisions. The literature on the production decisions of firms is examined in Chapter IV of the DRAM Report. Chapter V of the DRAM Report summarizes the literature on international and interregional trade. Investment theory is discussed in Chapter VI of the DRAM Report. Chapter VII of the DRAM Report covers the literature on regional labor-supply response to taxation and economic

growth, while the literature on migration and economic growth is examined in Chapter VIII of the DRAM Report.

After establishing the sectoring scheme, data sources, and behavioral equations for the model, all that remains before the actual model can be built is a description of the model-closure rules. Closure rules concern the mathematics of insuring that a solution exists to the 1,100+ equations of the model. Model closure is developed in Chapter IX of the DRAM Report.

Chapter X of the DRAM Report describes the mathematical and corresponding GAMS notation for each equation in DRAM. It is a technical description of the complete California DRAM.⁴ Chapter XI of the DRAM Report presents some preliminary sensitivity analyses.

Appendices follow Chapter XI of the DRAM Report. They include the original literature search by Dr. Berck and Mr. Dabalén in the Summer of 1995, explanations of notational methods used, lists of parameter and variable names used in the mathematical and software input files, and printed copies of the input files themselves.

The updating to the 2003 base year is documented at http://are.berkeley.edu/~peter/Research/DRAM03B/OverviewIII_1018.doc.

The most recent updating is documented at http://are.berkeley.edu/~peter/Research/2003_sam_and_edram.htm.

Particularly, see “Construction of SAM” for technical details and spread sheet models. See SAM120 for the basic models. See “Predicting Future Years” for an explanation of how the future SAMs were calibrated to data on employment, income, and the like.

CHAPTER 2: MODELING ISSUES FOR THE ALTERNATIVE-FUELS STUDY

For examining alternative-fuel issues in particular, the E-DRAM built for ARB as described in Berck and Hess (2000) is enhanced in three ways. First, petroleum sector data are modified. Second, the 2003 base-year model is extrapolated out to 2050 based on state population, personal income, and industry-specific forecasts. Third, parameters to adjust for technological change in the form of increased fuel efficiency and fuel displacement are incorporated into the model. Each of these enhancements is discussed in turn in the following subsections.

⁴ See Berck, Hess, and Smith (1997) for revisions to the consumer demand portion of the model. Modification of equations from DRAM to E-DRAM are discussed in Berck and Hess (2000). Changes introduce parameters that facilitate running policy scenarios as some combination of price, intermediate good, and/or investment changes.

Petroleum Sector Base Data Modification

E-DRAM's original industrial accounts are national accounts scaled to the state level using California employment data. These accounts do not give the same values as the Energy Information Administration does for California energy usage and production. We have used the Energy Information Administration data for these accounts in preference to the estimates derived from the industrial accounts.

Extrapolation from 2003 to 2050

The E-DRAM is not a forecasting model but, rather, a model constructed to exactly reproduce the economic conditions of fiscal year 2003. To answer questions concerning the impacts of petroleum-dependency reduction strategies far into the future, E-DRAM must be augmented to reflect future conditions. To "rebase" E-DRAM, i.e., move from a model of the 2003 economy to models of the economy in 2012, 2017, 2022, 2030, and 2050,⁵ E-DRAM's input data must be modified to reflect economic conditions in those "out years." The following process leaves the basic structure of economic relationships intact while scaling up 2003 monetary and employment data using state personal income (SPI), population, and industry-specific forecasts.

The transformation of the 2003 SAM into the 2050 SAM was based on the projected changes to personal income, population, and energy. The sources for these projections were as follows:

1. Personal-income growth.

The California Personal-income Growth data and California Consumer Price Index data are taken from the DOF. The annual percentage change of both is taken, and then the real growth percentage is determined by taking the differences of the percentage changes. This is done for years 2004-2020. The remaining years assume a 2.63 percent real growth rate.

2. Refinery growth.

The factors assume a 0.5 percent growth rate in the refining and gas-producing sectors.

3. Oil and gas extraction growth.

The growth rates are based on the assumption that the gas and oil extraction sector of California will halve its production by 2020 (starting 2003). This is equivalent to a 4 percent fall in output each year and continues after 2020 at the same rate.

⁵ For reasons of numerical stability, we used the 2013 model for our 2012 runs.

4. Working population growth (ages 18-64).

The California working population forecast through 2050 is from the DOF.

5. Natural gas per dollar efficiency.

The natural gas per unit of gross state product is calculated from the University of California, Davis, Advanced Energy Pathways baseline demand scenario reports.

6. Electricity per dollar efficiency.

The electricity per unit of gross state product is calculated from the University of California, Davis, Advanced Energy Pathways baseline demand scenario reports.

7. Fuel per dollar efficiency.

The California Energy Commission estimates of total fuel use (gas and diesel) for future years are used to calculate the per unit of gross state product usage of fuel.

The basic method of projection is first to increase the size of all values in the SAM by the projected increase in personal income and then to increase or reduce the rows and columns pertaining to the specific energy sectors by their intensities.

The result of this exercise is that California in the future is predicted to have the same basic industrial structure as it does today, except that the named sectors generally grow more slowly than the economy as a whole. As a result, California is predicted to be more energy efficient over time.

Adjusting for Technological Change

The alternative-fuels scenarios call for policies that change the production policies of transportation fuels and rearrange government spending. As described in Berck and Hess (2000), the original E-DRAM allows for changes in production technology. Each industrial sector in E-DRAM is implicitly characterized by a production function that relates output to factor (capital and labor) and intermediate inputs. Technological change is modeled by altering the relationships of input mix per unit of output as follows. Industry J 's demand for intermediates from industry I per unit of output is governed by production parameters $AD(I,J)$, which are input-output coefficients calculated from primary data contained in the SAM. These coefficients can be altered via technology multiplier parameters $REG1(I,J)$. Changing $REG1(I, \text{industry } J \text{ label})$ from its default setting of unity to 0.9, for example, simulates a technological change enabling one unit of industrial good J to be produced using only 90 percent of the intermediate inputs (from all 120 industries) previously required. Specifying $AD(\text{industry } I$

$label, industry J label) = 0.9$, in contrast, simulates a technological change enabling one unit of good J to be produced using 90 percent of the intermediate inputs previously required from industry I (with inputs from the 119 other industries unchanged).

Similarly, there are expenditure pattern multipliers for government spending. For state spending, REG18(I,G) increases the expenditure from government G to sector I while decreasing the expenditure to all other sectors so as to keep the total expenditure constant. The REG188(I,G) does the same for a federal spending sector.

CHAPTER 3: RESULTS

Modeling the Policies

The policy mixes consist of measures to promote six different alternative fuels: renewable diesel, propane, natural gas, E85, hydrogen, and electricity. The policy measures include federal and state subsidy of vehicles, refueling infrastructure investments, and research and development cost sharing for vehicle and component technologies. There are also private investments in vehicles and infrastructure.

Making and using these fuels result in a different cost (in dollars per gallon of gasoline equivalent) than would the use of gasoline.

These policy measures and changes in expenditure patterns are captured in the E-DRAM model of the California economy as changes in technology and changes in government and personal expenditure patterns.

All expenditures are on a yearly basis. Expenditures for capital are recorded as the annual cost of capital services taking account of depreciation and interest. They are the amount of money, which, when paid annually over the life of the capital item exactly, recovers its cost. We have treated all the government expenditures and all expenditures for vehicles in this fashion. The usable life of trucks is 19 years; of cars, 16 years; and of refueling infrastructure, 15 years in these calculations. The interest rate was 7 percent real.

The scenario mix calls for the state and federal government to subsidize the purchase of alternative-fuel vehicles. These policies are modeled by diverting money from other government expenditures to these purposes. The sensitivity results reported below include estimates of the cost to the economy of either raising the necessary funds through a tax on automobiles or by forgoing other infrastructure investments.

Both businesses and individuals spend more on vehicles. For individuals, this is modeled by requiring more vehicle expenditure per unit of transportation (e.g., more money spent on cars per vehicle mile traveled). For businesses, it is modeled as an increase in the expenditure on vehicles required per unit of output.

Infrastructure investment by governments is, again, modeled as a diversion of government funds from other purposes to infrastructure.

In the model, motor fuel is produced in the refinery sector. The policies are to buy less fuel from the refinery sector and more from other sources. The alternate-fuels programs are modeled as sourcing those fuels in different sectors. Natural gas and propane are sourced directly from gas production,⁶ electric fuel from electricity distribution sector, ethanol from the agricultural sector for fuel stock and the chemical (chemical basic) sector for processing, and hydrogen from the chemical sector. The result of the resourcing of these fuels is to change the price that businesses and consumers pay for vehicle fuel.

We evaluated three scenarios. These are examples in the report of the California Energy Commission (2007, p. 34). The first example is the ethanol and hydrogen fuel cell vehicle example. The second is the advanced biofuels and partial hybrid electric vehicle example. The third is the biofuels and hydrogen fuel cell vehicle example. They differ in the availability of advanced biofuels and the reliance on partial hybrid electric or fuel cell vehicles. For each scenario, we present three tables. The first is the expenditures called for in that scenario by category of expenditure and year. The second is the private and public expenditures by year. Negative numbers in both tables refer to savings. The third table is the results and presents what real output, SPI, and employment would have been without and with the scenario. A row in the table gives the percentage change between with and without scenario.

Table 1 shows the amounts of money saved or expended on the various sectors as a result of the policies in Scenario 1. These are the amounts that were entered in the E-DRAM model in the ways described previously.

Table 1: Expenditures for Scenario 1

	Year				
	2012	2017	2022	2030	2050
	billions of 2007 dollars				
Policy					
State Vehicle Subsidy	0.316	0.831	1.860	4.308	9.293
Federal Vehicle Subsidy	0.316	0.742	1.673	4.177	9.333
Private Vehicle Purchase	0.003	0.111	0.451	1.897	1.727

(Continued on next page.)

⁶ Most propane, today, is a refinery product. Since we predict minimal refinery growth, we predict that additional propane supplies will be a byproduct from natural gas production.

Table 1 continued.

	Year				
	2012	2017	2022	2030	2050
	billions of 2007 dollars				
Business Vehicle Purchase	0.002	0.038	0.143	0.582	0.537
State Infrastructure Spending	0.000	0.001	0.002	0.002	0.002
Federal Infrastructure Spending	0.001	0.003	0.005	0.006	0.007
Avoided Purchases of Petroleum Products	-1.743	-4.059	-19.041	-24.580	-36.903
Additional Purchase of Natural Gas & Propane	0.616	1.371	2.436	4.299	7.734
Additional Purchases from Chemical Industry	0.326	0.752	6.198	7.669	12.862
Additional Purchases from Agriculture	0.324	0.818	8.439	8.392	9.205
Additional Purchases from Electric	0.025	0.077	0.191	0.408	0.357

Source: California Energy Commission, 2007.

For comparison, the total consumption of refinery products (including gas and diesel, jet fuel, etc.) in the milestone years is \$53 billion, \$58 billion, \$65 billion, \$78 billion, and \$131 billion. So in 2050, the avoided petroleum purchases are 28 percent of refinery output.

In Table 2 we show the sum of the net costs to the economy as a whole and to the private sector.

Table 2: Public and Private Expenditure for Scenario 1

	Year				
	2012	2017	2022	2030	2050
	billions of 2007 dollars				
Private-sector Expenditure	-0.45	-0.89	-1.18	-1.33	-4.48
Public-sector Expenditure	0.63	1.58	3.54	8.49	18.64
Total Expenditures	0.19	0.68	2.36	7.16	14.16

Source: Computed.

The last line in this table is the total net expenditure for the scenario. The costs of the measures are substantially greater than the savings from avoided petroleum products. In this scenario, the private sector always saves more in avoided petroleum than it expends in additional vehicle and other costs. The public expenditure is financed by shifting expenditure from current priorities to those in the scenario. Thus, there is no drag on the economy from additional taxation.

Table 3 shows that, in this scenario, with the exception of real output for 2022 and 2030, all indicators of welfare increase with the scenario. In 2050, the gain in real income is \$3.5 billion—a little less than the savings to the private sector from the scenario (\$4.5 billion). However, either \$18.64 billion in government services are foregone or taxes must be levied that will raise \$18.64 billion.

Table 3: E-DRAM Results for Scenario 1

		Year				
		2012	2017	2022	2030	2050
SPI	BAU	1745.997	1936.728	2147.314	2640.422	4431.305
	SCEN 1	1746.200	1938.505	2148.229	2644.108	4434.831
	% Change	0.01%	0.09%	0.04%	0.14%	0.08%
Real Output	BAU	2997.952	3318.904	3672.232	4499.976	7503.398
	SCEN 1	3000.392	3322.429	3668.059	4498.201	7518.874
	% Change	0.08%	0.11%	-0.11%	-0.04%	0.21%
Employment	BAU	17.634	18.121	18.584	19.249	21.393
	SCEN 1	17.646	18.137	18.612	19.280	21.425
	% Change	0.06%	0.09%	0.15%	0.16%	0.15%

Note: Business as usual (BAU) is in billions of 2007 dollars. The SPI is in billions of 2007 dollars. Real output is in billions of 2007 dollars. Employment is in millions of jobs.

Source: Computed.

Table 4 shows the expenditure pattern for policy Scenario 2.

Table 4: Expenditures for Scenario 2

	Year				
	2012	2017	2022	2030	2050
	billions of 2007 dollars				
Policy					
State Vehicle Subsidy	0.094	0.425	0.734	1.023	0.739
Federal Vehicle Subsidy	0.094	0.336	0.546	0.892	0.779
Private Vehicle Purchase	0.003	0.111	0.451	1.897	8.049
Business Vehicle Purchase	0.002	0.038	0.143	0.582	2.426
State Infrastructure Spending	0.000	0.001	0.002	0.002	0.002
Federal Infrastructure Spending	0.001	0.003	0.005	0.006	0.007
Avoided Purchases of Petroleum Products	-1.627	-3.806	-18.291	-22.787	-31.287
Additional Purchase of Natural Gas & Propane	0.616	1.371	2.436	4.299	7.734
Additional Purchases from Chemical Industry	0.199	0.503	5.291	5.491	6.017
Additional Purchases from Agriculture	0.324	0.818	8.607	8.933	9.789
Additional Purchases from Electric	0.025	0.077	0.191	0.408	0.854

In contrast to Scenario 1, the second scenario in 2050 has considerable costs for the private sector in 2050. Table 5 shows that, except for the year 2050, the expenditures in this scenario are modest as is the amount of public subsidy. Most of the costs of this scenario are incident on the private sector. The total expenditures are negative (a savings) in the early years at least partially because the capital costs are amortized over the useful life of the vehicles.

Table 5: Public and Private Expenditure for Scenario 2

	Year				
	2012	2017	2022	2030	2050
	billions of 2007 dollars				
Private-sector Expenditure	-0.46	-0.89	-1.17	-1.18	3.58
Public Expenditure	0.19	0.76	1.29	1.92	1.53
Total Expenditures	-0.27	-0.13	0.11	0.75	5.11

The results are, again, in Table 6.

Table 6: E-DRAM Results for Scenario 2

		Year				
		2012	2017	2022	2030	2050
SPI	BAU	1745.997	1936.728	2147.314	2640.422	4431.305
	SCEN 2	1746.372	1938.53	2148.221	2643.692	4427.214
	% Change	0.02%	0.09%	0.04%	0.12%	-0.09%
Real Output	BAU	2997.952	3318.904	3672.232	4499.976	7503.398
	SCEN 2	2999.814	3322.524	3668.307	4498.052	7485.753
	% Change	0.06%	0.11%	-0.11%	-0.04%	-0.24%
Employment	BAU	17.634	18.121	18.584	19.249	21.394
	SCEN 2	17.643	18.137	18.612	19.279	21.393
	% Change	0.05%	0.09%	0.15%	0.15%	0.00%

Note: The BAU is in billions of 2007 dollars. The SPI is in billions of 2007 dollars. Real output is in billions of 2007 dollars. Employment is in millions of jobs.

Source: Computed.

Table 6 shows that this scenario makes little difference to income, output, and employment. The only year with an income loss is 2050. If one values the public expenditure foregone to subsidize alternative fuels at face value, and counts in the other monetary incentives, then this scenario is closer to break even in the early years and more negative in 2050.

Table 7 shows the amounts of money saved or expended on the various sectors as a result of the policies in Scenario 3.

Table 7: Expenditures for Scenario 3

	Year				
	2012	2017	2022	2030	2050
	billions of 2007 dollars				
Policy					
State Vehicle Subsidy	0.316	0.831	1.860	4.308	9.293
Federal Vehicle Subsidy	0.316	0.742	1.673	4.177	9.333
Private Vehicle Purchase	0.005	0.133	0.500	2.007	1.967
Business Vehicle Purchase	0.003	0.044	0.158	0.615	0.609
State Infrastructure Spending	0.001	0.008	0.016	0.012	0.002
Federal Infrastructure Spending	0.001	0.007	0.013	0.018	0.023
Avoided Purchases of Petroleum Products	-1.873	-5.424	-11.061	-22.225	-42.107
Additional Purchase of Natural Gas & Propane	0.616	1.371	2.436	4.299	7.734
Additional Purchases from Chemical Industry	0.383	1.362	3.070	6.695	14.781
Additional Purchases from Agriculture	0.418	1.810	3.350	6.807	12.327
Additional Purchases from Electric	0.025	0.077	0.191	0.408	0.357

From Table 7, one can calculate the private and total expenditure in each of the scenario years. It is shown in Table 8.

Table 8: Public and Private Expenditure for Scenario 3

	Year				
	2012	2017	2022	2030	2050
	billions of 2007 dollars				
Policy					
Private-sector Expenditure	-0.42	-0.63	-1.36	-1.39	-4.33
Public-sector Expenditure	0.63	1.58	3.54	8.49	18.64
Total Expenditures	0.21	0.96	2.20	7.12	14.32

Total expenditure is positive and increasing in this scenario. Most notably, like Scenario 1, there is substantial public expenditure that represents public services foregone or a need to raise additional revenue. Since the effects of the policies are to rearrange government spending, at no cost to the economy, and to save the private-sector money, the scenario is expansionary and ought to lead to an increase in state income. Table 9 shows the results of this scenario.

Table 9: E-DRAM Results for Scenario 3

		Year				
		2012	2017	2022	2030	2050
SPI	BAU	1745.997	1936.728	2147.314	2640.422	4431.305
	SCEN 3	1746.201	1937.603	2150.016	2644.559	4433.633
	% Change	0.01%	0.05%	0.13%	0.16%	0.05%
Real Output	BAU	2997.952	3318.904	3672.232	4499.976	7503.398
	SCEN 3	2999.819	3319.944	3675.148	4500.688	7513.875
	% Change	0.06%	0.03%	0.08%	0.02%	0.14%

(Continued on next page.)

Table 9 continued.

		Year				
		2012	2017	2022	2030	2050
Employment	BAU	17.634	18.121	18.584	19.249	21.394
	SCEN 3	17.645	18.134	18.609	19.280	21.424
	% Change	0.06%	0.08%	0.14%	0.16%	0.14%

Note: The BAU is in billions of 2007 dollars. The SPI is in billions of 2007 dollars. Real output is in billions of 2007 dollars. Employment is in millions of jobs.

Source: Computed.

While this scenario raises personal income, one, again, must keep in mind that there is a substantial (in 2050, \$18 billion) reduction in public services other than alternative-fuel provision.

To facilitate comparing the scenarios, Table 10 provides the same results as above for all scenarios and years, but it is organized by year.

Table 10: E-DRAM Results by Year

	BAU	SCEN 1	SCEN 2	SCEN 3
2012				
Real Output	2997.952	3000.392	2999.814	2999.819
SPI	1745.997	1746.2	1746.372	1746.201
Employment	17.63434	17.64552	17.64347	17.64489
2017				
Real Output	3318.904	3322.429	3322.524	3319.944
SPI	1936.728	1938.505	1938.53	1937.603
Employment	18.12059	18.13664	18.13652	18.13419

(Continued on next page.)

Table 10 continued.

	BAU	SCEN 1	SCEN 2	SCEN 3
2022				
Real Output	3672.232	3668.059	3668.307	3675.148
SPI	2147.314	2148.229	2148.221	2150.016
Employment	18.58364	18.61164	18.61166	18.60897
2030				
Real Output	4499.976	4498.201	4498.052	4500.688
SPI	2640.422	2644.108	2643.692	2644.559
Employment	19.24925	19.28002	19.279	19.28045
2050				
Real Output	7503.398	7518.874	7485.753	7513.875
SPI	4431.305	4434.831	4427.214	4433.633
Employment	21.39352	21.42473	21.39343	21.42347

Note: The BAU is in billions of 2007 dollars. The SPI is in billions of 2007 dollars. Real output is in billions of 2007 dollars. Employment is in millions of jobs.

Source: Computed.

Income by Household

The scenarios change both income and number of households, generally in the same direction. Table 11 shows income per household for BAU and for the scenarios. The households were classified by their marginal tax rates, so those with low marginal tax rates also have low incomes. Low- (HOUS2), moderate- (HOUS6), and high- (HOUS9) income households are shown in Table 11. The BAU column shows the average income for each household type, while the scenario columns show the income that would be obtained if the scenarios were carried out. The table is remarkable for the trivial variation in per household income across the scenarios. Often, the differences are on the order of \$10. The numbers are income, to be distinguished from income plus transfers, which aggregates to SPI, and personal disposable income, which includes transfers and taxes.

Table 11: Average Household Income by Household Type, Scenario, and Year

	BAU	SCEN 1	SCEN 2	SCEN 3
2012				
HOUS2	30.688	30.667	30.675	30.669
HOUS6	78.979	78.926	78.945	78.929
HOUS9	183.306	183.180	183.227	183.189
2017				
HOUS2	32.564	32.574	32.575	32.563
HOUS6	83.809	83.835	83.836	83.806
HOUS9	194.506	194.568	194.570	194.501
2022				
HOUS2	34.291	34.282	34.281	34.309
HOUS6	88.256	88.229	88.228	88.302
HOUS9	204.817	204.765	204.763	204.929
2030				
HOUS2	39.216	39.241	39.236	39.247
HOUS6	100.935	100.996	100.983	101.013
HOUS9	234.227	234.382	234.352	234.419
2050				
HOUS2	57.814	57.829	57.768	57.814
HOUS6	148.811	148.847	148.688	148.809
HOUS9	345.291	345.384	345.022	345.300

Note: Incomes are in thousands of 2007 dollars.

Source: Computed.

Table 12 shows the number of working households by household type. The table, above, gives the incomes for these household types.

Table 12: Number of Working Households by Household Type

	BAU	SCEN 1	SCEN 2	SCEN 3
2012				
HOUS2	3.132	3.133	3.133	3.133
HOUS6	2.197	2.198	2.198	2.198
HOUS9	1.983	1.986	1.986	1.986
2017				
HOUS2	3.219	3.221	3.221	3.220
HOUS6	2.258	2.260	2.260	2.260
HOUS9	2.038	2.042	2.042	2.041
2022				
HOUS2	3.219	3.221	3.221	3.220
HOUS6	2.258	2.260	2.260	2.260
HOUS9	2.038	2.042	2.042	2.041
2030				
HOUS2	3.421	3.424	3.424	3.424
HOUS6	2.399	2.403	2.403	2.403
HOUS9	2.166	2.172	2.171	2.172
2050				
HOUS2	3.803	3.806	3.802	3.806
HOUS6	2.667	2.671	2.667	2.671
HOUS9	2.408	2.414	2.408	2.413

Note: Millions of households.

Source: Computed.

Only in Scenario 2 for 2050 is there a decrease in the number of working households in the group, HOU2—the least well off of the households. The table shows that the scenarios do not have a negative disparate impact on poorer Californians.

Sensitivity Analysis

In this section we test the sensitivity of the results to increases in fuel prices and we quantify the effect of financing the state’s portion of the scenario specific expenditures by either reducing infrastructure spending or raising taxes on vehicles.

Increases in Fuel Prices

The benefits of the three scenarios are dependent upon the price of fuel and relation of that price to the price of alternative fuels, which is the margin on alternative fuels. In these experiments, the world price of fuel (the oilgas, oilref, and retgas sectors of the E-DRAM model) is increased by 5 percent. This increase happens without a corresponding increase in the price of outputs sold by California, so the experiment creates a substantial competitive disadvantage for California. At the same time, the value of the fuel savings to California from the three scenarios also increases by 5 percent. The BAU column of Table 13 is the values when the price of petroleum is 5 percent higher. By comparing the results in Table 10 to those in Table 13, one can see that, absent policy changes, a petroleum price increase decreases the value of macro indicators for California.

Table 13. Results with Five-percent Higher Petroleum Price

Scenario	BAU + 5%	SCEN 1	SCEN 2	SCEN3
2012				
Real Output	2981.823	2984.626	2984.06	2984.12
SPI	1741.71	1742.141	1742.277	1742.147
Employment	17.57733	17.58854	17.58679	17.58816
2017				
Real Output	3301.454	3306.265	3306.265	3304.301
SPI	1928.167	1930.439	1930.433	1929.704
Employment)	18.0687	18.08802	18.08765	18.0868
2022				
Real Output	3653.159	3655.586	3655.568	3659.787
SPI	2136.865	2140.287	2140.191	2141.069
Employment	18.53328	18.57648	18.57582	18.56713

(Continued on next page.)

Table 13 continued.

Scenario	BAU + 5%	SCEN 1	SCEN 2	SCEN3
2030				
Real Output	4476.815	4483.24	4482.469	4484.919
SPI	2626.926	2633.919	2633.285	2634.105
Employment	19.19858	19.24542	19.24307	19.24418
2050				
Real Output	7465.028	7490.744	7456.087	7487.087
SPI	4407.515	4415.346	4407.176	4414.587
Employment	21.33759	21.38242	21.3488	21.38289

Note: The BAU is in billions of 2007 dollars. The SPI is in billions of 2007 dollars. Real output is in billions of 2007 dollars. Employment is in millions of jobs.

Source: Computed.

Table 14 compares the personal income in the BAU scenarios with and without the petroleum price increase. Personal income decreases by over \$4 billion in the near term and over \$23 billion by 2050.

Table 14: Effect of Increased Petroleum Prices in BAU Case

Year	Difference in SPI: BAU
2012	-4.29
2017	-8.56
2022	-10.45
2030	-13.50
2050	-23.79

Note: In billions of 2007 dollars.

These numbers represent between a quarter- and half-percent decrease in personal income as a result of a 5 percent increase in the price of petroleum. The table shows that an increase in petroleum prices, in the absence of any of the scenarios, is bad for California personal income.

Now, comparing personal income in the BAU + 5 percent scenario to Scenarios 1-3, with the exception of 2050 for Scenario 2, the scenarios improve upon personal income. The price of petroleum is 5 percent higher and, therefore, the value of avoided petroleum purchases is also 5 percent higher.

One way to show this effect is to see how much better the scenarios are with higher fuel prices than they were with the original fuel prices. To do this, we first start with Table 15—the original no fuel price increase case. Focusing on personal income, we find the difference between SPI in the scenarios and in the base case.

Table 15: SPI Difference Between Scenario and BAU: Original

Year	SCEN 1	SCEN 2	SCEN 3
2012	0.203	0.375	0.204
2017	1.777	1.802	0.875
2022	0.915	0.907	2.702
2030	3.686	3.270	4.136
2050	3.526	-4.091	2.328

Note: In billions of 2007 dollars.

Source: Computed.

Now, we do the same in the case where petroleum costs 5 percent more. Looking at Tables 15 and 16, we see that the advantage of the policies is much greater when the price of petroleum is higher. For instance, in 2050, the advantage of Scenario 3 over BAU is \$7 billion with higher petroleum prices while it is only \$2 billion with the original petroleum prices. Thus, the higher petroleum prices add almost \$5 billion to the advantage of Scenario 3 in 2050. By subtracting Table 15 from Table 16, we find how much increased petroleum prices increase the advantage of the scenarios. The results are in Table 17.

Table 16: SPI Difference Between Scenario and BAU: Five-percent Increase

Year	SCEN 1	SCEN 2	SCEN 3
2012	0.431	0.567	0.436
2017	2.272	2.267	1.537
2022	3.423	3.326	4.205
2030	6.994	6.360	7.179
2050	7.831	-0.339	7.072

Note: In billions of 2007 dollars.

Source: Computed.

Table 17: Effect of Petroleum Price Increase on Scenarios SPI

Year	SCEN 1	SCEN 2	SCEN 3
2012	0.23	0.19	0.23
2017	0.50	0.46	0.66
2022	2.51	2.42	1.50
2030	3.31	3.09	3.04
2050	4.30	3.75	4.74

Note: In billions of dollars. The difference in the gain in SPI over BAU is between 5 percent higher and normal petroleum price.

Increases in petroleum price definitely favor the scenarios, and larger price increases would be even more favorable to the scenarios over base case. The higher is the price of petroleum, the larger are the benefits of the scenarios. However, higher prices of petroleum are not otherwise good for the California economy, leading to lower SPI, employment, etc. Although the scenarios help to mitigate these effects of higher fuel prices on the California economy, they do not mitigate those effects completely

Financing the State Expenditure

We considered two possibilities for financing state expenditure: taking it from existing transportation spending, particularly from infrastructure, and raising the funds by taxing vehicles as a license fee. The experiment for the license fee was to double the existing charge. Table 18 shows, for each year, how much money is raised from this fee and how much SPI changes.

Table 18: The License Fee

	Change	Percent Change
2012		
Funds Raised	2.64	90.64%
SPI	-2.01	-0.12%
2017		
Funds Raised	2.93	90.59%
SPI	-3.42	-0.18%
2022		
Funds Raised	3.25	90.64%
SPI	-4.07	-0.19%
2030		
Funds Raised	4.01	90.76%
SPI	-5.27	-0.20%
2050		
Funds Raised	6.75	90.99%
SPI	-9.37	-0.21%

Note: In billions of 2007 dollars.

Source: Computed.

Table 18 shows that a doubling of the tax rate nearly doubles (90 percent increase) the tax take from this license fee in all base years. As a result of the tax increase, SPI decreases \$2 billion in

2012 and \$9 billion in 2050. The percent of SPI that is lost because of the tax increases over time as well. It is 0.12 percent (12/100 of 1 percent) in 2012 and 0.21 percent in 2050. The ratio of the change in SPI from the tax to the tax take (2.01/2.64) begins at .8 in 2012 and increases to 1.4 in 2050. So, if the State's share of these scenarios were to be financed by this tax, SPI would be less than that stated in Table 10 by these multipliers (.76, 1.17, 1.25, 1.31, and 1.39, respectively, for the model years) times the amount of money that needed to be raised.

For completeness, Table 19 shows the changes in magnitudes of employment and real output for the increase in the tax.

Table 19: Doubling the License Fee

	BAU	License-fee Increase
2012		
Real Output	2997.952	2985.78
SPI	1745.997	1743.987
Employment	17.63434	17.60984
2017		
Real Output	3318.904	3305.954
SPI	1936.728	1933.307
Employment	18.12059	18.09991
2022		
Real Output	3672.232	3658.047
SPI	2147.314	2143.243
Employment	18.58364	18.56395
2030		
Real Output	4499.976	4482.44
SPI	2640.422	2635.157
Employment	19.24925	19.22933

(Continued on next page.)

Table 19 continued.

	BAU	License-fee Increase
2050		
Real Output	7503.398	7473.223
SPI	4431.305	4421.93
Employment	21.39352	21.37081

Note: The BAU is in billions of 2007 dollars. The SPI is in billions of 2007 dollars. Real output is in billions of 2007 dollars. Employment is in millions of jobs. License-fee increase is the BAU scenario with a doubling of the license fee.

Source: Computed.

An alternative form of financing would be to decrease the spending on infrastructure. Table 20 shows the change and percentage change in SPI incident upon a one-half-billion-dollar sustained decrease in the level of infrastructure spending. The model assumes that infrastructure is a 2.5 percent share of output.

Table 20: SPI Change with Infrastructure Diversion of \$0.5 Billion

Year	Change SPI	Percent Change
2012	-1.29172	-0.07%
2017	-1.98669	-0.10%
2022	-2.11319	-0.10%
2030	-2.20792	-0.08%
2050	-2.32688	-0.05%

Note: Change in the BAU scenario SPI.

Table 20 shows the cost in billion dollars lost SPI per half-billion dollars diverted, so a diversion from infrastructure results in between a \$2.6 and \$4.6 billion decrease in SPI per billion dollars diverted. For completeness, the Table 21 shows the values for employment and SPI.

Table 21: Infrastructure Diversion of \$0.5 Billion

	BAU	Infrastructure Decrease
2012		
Real Output	2997.952	2995.422
SPI	1745.997	1744.705
Employment	17.63434	17.62304
2017		
Real Output	3318.904	3316.553
SPI	1936.728	1934.741
Employment	18.12059	18.11177
2022		
Real Output	3672.232	3669.937
SPI	2147.314	2145.2
Employment	18.58364	18.57589
2030		
Real Output	4499.976	4497.679
SPI	2640.422	2638.214
Employment	19.24925	19.24278
2050		
Real Output	7503.398	7501.034
SPI	4431.305	4428.978
Employment	21.39352	21.38907

Note: The BAU is in billions of 2007 dollars. The SPI is in billions of 2007 dollars. Real output is in billions of 2007 dollars. Employment is in millions of jobs. Infrastructure decrease is the BAU scenario with \$500 million diverted from infrastructure spending.

Source: Computed.

Higher Costs for Autos

We have also run these scenarios with a 10 percent higher cost for vehicles required by the scenarios. The costs of other vehicles were held constant. For instance, considering Scenario 1, we ran E-DRAM with the values in the first four lines of Table 1 increased by 10 percent: Table 22 shows the results for SPI by scenario and year for these runs. The increased cost is expected to reduce the benefits of the alternative-fuel scenarios. In order to find the effects of this increased cost, one must compare Table 22 to Table 10.

Table 22: Ten-percent Increase

Scenario	BAU	SCEN 1	SCEN 2	SCEN 3
2012				
Real CA Output (\$Billion)	2997.952	3000.426	2999.824	2999.816
CA Personal Income	1745.997	1746.192	1746.37	1746.2
Labor Demands (Millions)	17.63434	17.64556	17.64349	17.64488
2017				
Real CA Output (\$Billion)	3318.904	3322.408	3322.481	3319.885
CA Personal Income	1936.728	1938.493	1938.513	1937.577
Labor Demand (Millions)	18.12059	18.13658	18.13639	18.13402
2022				
Real CA Output (\$Billion)	3672.232	3667.879	3668.127	3674.947
CA Personal Income	2147.314	2148.144	2148.135	2149.92
Labor Demand (Millions)	18.58364	18.61118	18.61119	18.60845
2030				
Real CA Output (\$Billion)	4499.976	4497.469	4497.319	4499.913
CA Personal Income	2640.422	2643.739	2643.324	2644.17
Labor Demand (Millions)	19.24925	19.27849	19.27746	19.27882

(Continued on next page.)

Table 22 continued.

Scenario	BAU	SCEN 1	SCEN 2	SCEN 3
2050				
Real CA Output (\$Billion)	7503.398	7519.59	7482.831	7514.499
CA Personal Income	4431.305	4434.02	4425.61	4432.774
Labor Demand (Millions)	21.39352	21.42383	21.38921	21.42244

Note: The BAU is in billions of 2007 dollars. The SPI is in billions of 2007 dollars. Real output is in billions of 2007 dollars. Employment is in millions of jobs.

Source: Computed.

To get a sense of these magnitudes, we compare them to the SPI in the same scenarios in the original—no change in costs runs. For example, we took the SPI for 2012 for Scenario 1 for this case (Table 20) and subtracted the SPI for the original case (Table 10). The differences are in Table 23.

Table 23: Differences in SPI Incident on Ten-percent Increased Vehicle Costs

Year	SCEN 1	SCEN 2	SCEN 3
2012	-0.00782	-0.0022	-0.00025
2017	-0.01208	-0.01734	-0.02601
2022	-0.08527	-0.08513	-0.09558
2030	-0.36887	-0.36798	-0.38851
2050	-0.81109	-1.60439	-0.85884

Note: In billions of 2007 dollars.

Finally, in Table 24, the differences are expressed as a percent of the cost savings of the scenario (i.e., the SPI in the scenario less that in BAU with the original costs).

Table 24: Percent of Increased Effect

Year	SCEN 1	SCEN 2	SCEN 3
2012	-3.85%	-0.59%	-0.12%
2017	-0.68%	-0.96%	-2.97%
2022	-9.32%	-9.39%	-3.54%
2030	-10.01%	-11.25%	-9.39%
2050	-23.00%	-39.22%	-36.90%

In the later years, a 10 percent increase in costs uses up a large part of the benefits of the scenarios. The reason why this happens in the later years is that the costs are amortized and weigh more heavily in the later years when both earlier and current costs are being paid off.

REFERENCES

Berck, Peter; Golan, Elise; and Smith, Bruce. *Dynamic Revenue Analysis for California*. Report to the California Department of Finance, Sacramento, California, Summer, 1996.

Berck, Peter, and Hess, Peter. "Developing a Methodology for Assessing the Economic Impacts of Large Scale Environmental Regulations," University of California at Berkeley, Department of Agricultural and Resource Economics, [CUDARE Working Paper Series](#) No. 924, February, 2000.

Berck, Peter; Hess, Peter H.; and Smith, Bruce. *Estimation of Household Demand for Goods and Services in California's Dynamic Revenue Analysis Model*, September, 1997, currently available at www.are.berkeley.edu/~phess/demand.pdf.

California Energy Commission. *State Alternative-fuels Plan*. Committee Draft Report, CEC 600-2007-011 CTD, October, 2007.

APPENDIX A

SECTORAL DETAIL

Appendix Table 1 shows the output by sector for the most directly affected sectors. It also shows the change in output between the scenarios and BAU runs of the model. The change in output is followed by the change in capital stock and then the level of employment and the change in the level of employment. All the change variables are in percent.

Appendix Table 1: Sectoral Detail for 2012

	BAU	SCEN 1	SCEN 2	SCEN 3
AGRIC				
Output (\$Billion)	75.592	75.971	75.706	76.080
% Change Output	0.000	0.502	0.151	0.645
% Change Capital	0.000	0.484	0.139	0.627
Jobs (Millions)	0.362	0.364	0.362	0.364
% Change Jobs	0.000	0.563	0.189	0.709
DISTEL				
Output (\$Billion)	24.518	24.390	24.675	24.394
% Change Output	0.000	-0.520	0.642	-0.505
% Change Capital	0.000	-0.526	0.629	-0.510
Jobs (Millions)	0.021	0.021	0.021	0.021
% Change Jobs	0.000	-0.497	0.693	-0.483
OILREF				
Output (\$Billion)	45.988	44.623	44.693	44.477
% Change Output	0.000	-2.970	-2.816	-3.287
% Change Capital	0.000	-2.943	-2.787	-3.254
Jobs (Millions)	0.014	0.013	0.013	0.013
% Change Jobs	0.000	-3.022	-2.872	-3.350

(Continued on next page.)

Appendix Table 1 continued.

	BAU	SCEN 1	SCEN 2	SCEN 3
CHMBAS				
Output (\$Billion)	9.210	9.633	9.454	9.697
% Change Output	0.000	4.594	2.651	5.293
% Change Capital	0.000	4.499	2.592	5.187
Jobs (Millions)	0.014	0.015	0.014	0.015
% Change Jobs	0.000	4.742	2.741	5.457
AUTOMF				
Output (\$Billion)	10.408	10.440	10.440	10.440
% Change Output	0.000	0.306	0.307	0.302
% Change Capital	0.000	0.270	0.277	0.268
Jobs (Millions)	0.009	0.009	0.009	0.009
% Change Jobs	0.000	0.339	0.334	0.334
VEHPRT				
Output (\$Billion)	5.620	5.975	5.744	5.648
% Change Output	0.000	6.316	2.202	0.502
% Change Capital	0.000	6.036	2.087	0.441
Jobs (Millions)	0.028	0.029	0.028	0.028
% Change Jobs	0.000	6.377	2.227	0.515
2017				
AGRIC				
Output (\$Billion)	83.851	84.827	84.827	85.965
% Change Output	0.000	1.164	1.163	2.521
% Change Capital	0.000	1.147	1.147	2.493
Jobs (Millions)	0.372	0.376	0.376	0.381
% Change Jobs	0.000	1.221	1.220	2.619

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Appendix Table 1 continued.

	BAU	SCEN 1	SCEN 2	SCEN 3
DISTEL				
Output (\$Billion)	27.182	26.850	26.850	26.966
% Change Output	0.000	-1.221	-1.222	-0.792
% Change Capital	0.000	-1.215	-1.216	-0.788
Jobs (Millions)	0.021	0.021	0.021	0.021
% Change Jobs	0.000	-1.244	-1.245	-0.809
OILREF				
Output (\$Billion)	46.827	43.622	43.876	42.007
% Change Output	0.000	-6.844	-6.300	-10.293
% Change Capital	0.000	-6.747	-6.211	-10.143
Jobs (Millions)	0.013	0.012	0.012	0.012
% Change Jobs	0.000	-7.028	-6.469	-10.576
CHMBAS				
Output (\$Billion)	10.197	11.159	10.852	11.934
% Change Output	0.000	9.437	6.422	17.036
% Change Capital	0.000	9.271	6.308	16.737
Jobs (Millions)	0.014	0.016	0.015	0.017
% Change Jobs	0.000	9.693	6.598	17.499
AUTOMF				
Output (\$Billion)	11.551	11.696	11.698	11.685
% Change Output	0.000	1.256	1.276	1.163
% Change Capital	0.000	1.216	1.235	1.130
Jobs (Millions)	0.009	0.009	0.009	0.009
% Change Jobs	0.000	1.295	1.315	1.195

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Appendix Table 1 continued.

	BAU	SCEN 1	SCEN 2	SCEN 3
VEHPRT				
Output (\$Billion)	6.235	6.313	6.314	6.298
% Change Output	0.000	1.251	1.275	1.009
% Change Capital	0.000	1.189	1.212	0.963
Jobs (Millions)	0.028	0.029	0.029	0.029
% Change Jobs	0.000	1.265	1.289	1.018
2022				
AGRIC				
Output (\$Billion)	92.933	102.846	103.050	96.929
% Change Output	0.000	10.667	10.886	4.301
% Change Capital	0.000	10.568	10.785	4.259
Jobs (Millions)	0.381	0.423	0.424	0.398
% Change Jobs	0.000	11.011	11.240	4.445
DISTEL				
Output (\$Billion)	30.101	29.636	29.649	29.589
% Change Output	0.000	-1.546	-1.502	-1.699
% Change Capital	0.000	-1.524	-1.481	-1.684
Jobs (Millions)	0.022	0.022	0.022	0.022
% Change Jobs	0.000	-1.631	-1.585	-1.760
OILREF				
Output (\$Billion)	47.889	29.515	30.303	38.149
% Change Output	0.000	-38.368	-36.723	-20.337
% Change Capital	0.000	-37.885	-36.254	-20.049
Jobs (Millions)	0.012	0.008	0.008	0.010
% Change Jobs	0.000	-39.271	-37.601	-20.880

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Appendix Table 1 continued.

	BAU	SCEN 1	SCEN 2	SCEN 3
CHMBAS				
Output (\$Billion)	11.275	19.336	18.207	15.257
% Change Output	0.000	71.494	61.477	35.312
% Change Capital	0.000	70.051	60.271	34.663
Jobs (Millions)	0.015	0.025	0.024	0.020
% Change Jobs	0.000	73.741	63.352	36.317
AUTOMF				
Output (\$Billion)	12.812	13.225	13.229	13.219
% Change Output	0.000	3.228	3.261	3.183
% Change Capital	0.000	3.178	3.210	3.113
Jobs (Millions)	0.009	0.009	0.009	0.009
% Change Jobs	0.000	3.275	3.310	3.250
VEHPRT				
Output (\$Billion)	6.912	7.073	7.076	7.078
% Change Output	0.000	2.331	2.379	2.401
% Change Capital	0.000	2.290	2.335	2.323
Jobs (Millions)	0.029	0.030	0.030	0.030
% Change Jobs	0.000	2.340	2.389	2.418
2030				
AGRIC				
Output (\$Billion)	114.193	124.229	124.884	122.398
% Change Output	0.000	8.789	9.362	7.186
% Change Capital	0.000	8.720	9.286	7.130
Jobs (Millions)	0.395	0.431	0.433	0.424
% Change Jobs	0.000	9.029	9.627	7.382

(Continued on next page.)

Appendix Table 1 continued.

	BAU	SCEN 1	SCEN 2	SCEN 3
DISTEL				
Output (\$Billion)	36.938	36.132	36.268	36.190
% Change Output	0.000	-2.183	-1.813	-2.026
% Change Capital	0.000	-2.149	-1.783	-1.997
Jobs (Millions)	0.023	0.022	0.022	0.022
% Change Jobs	0.000	-2.315	-1.931	-2.141
OILREF				
Output (\$Billion)	49.685	26.424	28.328	29.214
% Change Output	0.000	-46.818	-42.986	-41.202
% Change Capital	0.000	-46.270	-42.462	-40.694
Jobs (Millions)	0.011	0.006	0.006	0.006
% Change Jobs	0.000	-47.841	-43.964	-42.153
CHMBAS				
Output (\$Billion)	13.807	23.865	21.090	22.605
% Change Output	0.000	72.844	52.744	63.719
% Change Capital	0.000	71.391	51.758	62.474
Jobs (Millions)	0.015	0.027	0.023	0.025
% Change Jobs	0.000	75.106	54.276	65.655
AUTOMF				
Output (\$Billion)	15.761	17.017	17.002	17.036
% Change Output	0.000	7.966	7.874	8.087
% Change Capital	0.000	7.822	7.730	7.931
Jobs (Millions)	0.009	0.010	0.010	0.010
% Change Jobs	0.000	8.103	8.011	8.236

(Continued on next page.)

Appendix Table 1 continued.

	BAU	SCEN 1	SCEN 2	SCEN 3
VEHPRT				
Output (\$Billion)	8.496	8.914	8.906	8.914
% Change Output	0.000	4.922	4.830	4.922
% Change Capital	0.000	4.819	4.726	4.805
Jobs (Millions)	0.030	0.032	0.032	0.032
% Change Jobs	0.000	4.944	4.852	4.948
2050				
AGRIC				
Output (\$Billion)	191.250	202.077	202.864	205.690
% Change Output	0.000	5.661	6.072	7.550
% Change Capital	0.000	5.616	6.037	7.487
Jobs (Millions)	0.439	0.465	0.466	0.473
% Change Jobs	0.000	5.820	6.194	7.772
DISTEL				
Output (\$Billion)	61.686	58.922	62.649	58.235
% Change Output	0.000	-4.480	1.562	-5.594
% Change Capital	0.000	-4.436	1.570	-5.540
Jobs (Millions)	0.025	0.024	0.026	0.024
% Change Jobs	0.000	-4.654	1.529	-5.806
OILREF				
Output (\$Billion)	54.696	19.292	25.960	13.002
% Change Output	0.000	-64.729	-52.538	-76.229
% Change Capital	0.000	-64.140	-51.961	-75.681
Jobs (Millions)	0.008	0.003	0.004	0.002
% Change Jobs	0.000	-65.819	-53.615	-77.234

(Continued on next page.)

Appendix Table 1 continued.

	BAU	SCEN 1	SCEN 2	SCEN 3
CHMBAS				
Output (\$Billion)	22.966	39.878	30.730	42.388
% Change Output	0.000	73.637	33.803	84.564
% Change Capital	0.000	72.142	33.234	82.801
Jobs (Millions)	0.017	0.030	0.023	0.032
% Change Jobs	0.000	75.967	34.685	87.314
AUTOMF				
Output (\$Billion)	26.464	35.867	31.063	36.113
% Change Output	0.000	35.533	17.379	36.462
% Change Capital	0.000	34.608	17.008	35.515
Jobs (Millions)	0.010	0.014	0.012	0.014
% Change Jobs	0.000	36.421	17.734	37.372
VEHPRT				
Output (\$Billion)	14.241	28.322	16.276	28.426
% Change Output	0.000	98.879	14.291	99.614
% Change Capital	0.000	94.147	13.853	94.851
Jobs (Millions)	0.033	0.067	0.038	0.067
% Change Jobs	0.000	99.925	14.387	100.667

Note: The sectors are agriculture (AGRIC); electricity distribution (DISTEL); oil refining (OILREF); basic chemicals, excluding consumer chemicals (CHMBAS); auto manufacturing (AUTOMF); and, finally, vehicle parts (VEHPRT).

The pattern, here, is simply that those sectors that were targeted for more expenditure (see Tables 1, 4, and 7) grew while those, such as oil, that were substituted away from shrank. There is also some evident second-round effects in the scenarios. Oil refining is a major consumer of electricity, so the electric sector experiences a drop in demand from the decreased demand for oil.

Finally, the detail for the oil refining sector, for all years and scenarios is in Appendix Table 2.

Appendix Table 2: Oil-Refining Sector Detail For All Years and Scenarios

	BAU	SCEN 1	SCEN 2	SCEN 3
2012				
OILREF				
Output (\$Billion)	45.988	44.623	44.693	44.477
Jobs (Millions)	0.014	0.013	0.013	0.013
Imports (\$Billion)	14.169	14.168	14.168	14.168
Exports (\$Billion)	7.302	7.305	7.305	7.305
2017				
OILREF				
Output (\$Billion)	46.827	43.622	43.876	42.007
Jobs (Millions)	0.013	0.012	0.012	0.012
Imports (\$Billion)	19.616	19.613	19.613	19.612
Exports (\$Billion)	8.033	8.038	8.038	8.039
2022				
OILREF				
Output (\$Billion)	47.889	29.515	30.303	38.149
Jobs (Millions)	0.012	0.008	0.008	0.010
Imports (\$Billion)	25.476	25.507	25.500	25.472
Exports (\$Billion)	8.816	8.772	8.782	8.822
2030				
OILREF				
Output (\$Billion)	49.685	26.424	28.328	29.214
Jobs (Millions)	0.011	0.006	0.006	0.006
Imports (\$Billion)	39.965	40.096	40.051	40.032
Exports (\$Billion)	10.774	10.629	10.678	10.699

(Continued on next page.)

Appendix Table 2 continued.

	BAU	SCEN 1	SCEN 2	SCEN 3
2050				
OILREF				
Output (\$Billion)	54.696	19.292	25.960	13.002
Jobs (Millions)	0.008	0.003	0.004	0.002
Imports (\$Billion)	94.328	95.046	94.581	95.488
Exports (\$Billion)	18.232	17.671	18.032	17.336

Because California refinery capacity does not grow as fast as usage of fuel, California imports are expected to grow over time. None of the scenarios has much of an effect on imports or exports. Most of the effect, within the model, of the use of alternative fuels is to reduce California production of petroleum based fuels.