Economic Evaluation Supplement
Climate Change Draft Scoping Plan Pursuant to AB 32
The California Global Warming Solutions Act of 2006

Appendix II
Environmental Dynamic Revenue Assessment Model's
Sources And Methods

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Appendix II
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1 INTRODUCTION

This Appendix describes the economic analysis and modeling results of the measures set out in the Preliminary Recommendation of the Draft Scoping Plan, along with a summary of the results for other scenarios that were modeled. The description of the results is followed by documentation for the Environmental-Dynamic Revenue Analysis Model (E-DRAM), the model used for the economic assessment.

Macroeconomic models such as E-DRAM are well suited for analyzing the economy-wide impact of a set of recommended policy measures that either impose costs, provide savings, or both, taking into account their interaction and the shifting of economic activity across sectors. E-DRAM has been used in this fashion for a variety of past economic assessments.

Such models, however, face several challenges in attempting to model market-based policies that provide incentives to discover the least cost options for reducing emission including investments in improving technology. First of all, the macroeconomic tools do not have the ability to predict how firms might invest in cost-effective energy efficient technologies that will result in reduced greenhouse gas emissions and reduced energy-related expenditures. In E-DRAM, such cost-saving investments can only be reflected if they are specified in advance as exogenous inputs to the model, rather than the model endogenously determining the type and level of investment. This can be done for specific measures for which the costs and savings have been estimated. It can also be estimated for some portion of the reductions required from a cap-and-trade program where there is knowledge that sources under the cap have the ability to reduce emissions from well-defined, relatively low-cost investments in their own facilities that end up costing less than purchasing the reductions from the market.

An important characteristic of a market-based approach is the ability to reveal low-cost emission reduction opportunities as a result of market incentives. Because of the broad flexibility allowed by cap and trade, available models do not have a mechanism to properly determine the nature or costs of such "unspecified reductions" needed to meet the cap. By their very nature such reductions cannot be attributed in advance to any specific measures or even source type. To produce additional unspecified reductions the models simulate such reduction by reducing economic output. This type of model is unable to account for the possibility of new investment in some sectors that could increase their energy efficiency and reduce emissions either at a net savings or lower cost than reducing demand through price increases. Instead, these models adjust prices of products so that they reflect the cost of GHG emissions (based upon calculated allowance prices), resulting in reductions in sector production and resulting sector emissions until the required emissions reductions are achieved. Consequently, emission reductions in the model occur in response to reduced demand induced by increased prices. For this reason, these models provide an inaccurate and overly costly picture of how a cap-and-trade system would operate in practice.

In addition, the macroeconomic models operate at the sector level and therefore do not have the ability to capture the heterogeneity of facility-level emission reduction opportunities. One of the primary advantages of market-based approaches is that they take advantage of this heterogeneity to minimize costs. Such savings have been documented by empirical studies. As was noted by the Market Advisory Committee, "This potential for cost savings is not simply a theoretical proposition. Studies indicate substantial cost savings from existing cap-and-trade programs. The two major studies of cost savings for the SO_2 program (Carlson et al., 2000 and Ellerman, 2003b) are in general agreement that savings under the trading program amounted to 43–55 percent of expected compliance costs under an alternative regulatory program that imposed a uniform emission standard. Carlson et al. cite savings of over 65 percent compared to a policy that might have forced post-combustion controls (scrubbers) to achieve the same level of emissions.[1]

The marginal cost of achieving reductions vary significantly among facilities, firms, and regions of the state depending on a host of site, firm, or region-specific factors. Market-based approaches enable the reductions to come from those facilities that can achieve them at lower cost than the market price. However, the models treat all facilities within a sector as similar and therefore cannot account for cost structure differences and as such cannot capture cost reduction opportunities.

Moreover, the models do not fully capture how individual consumers can and will take steps to pursue lower cost options. This is being observed today as consumers change driving habits and make greater use of public transit, carpooling and biking in response to gasoline price increases. In addition, over time market-based approaches provide an incentive to find innovative ways to reduce emissions beyond the level necessitated at an individual firm under a performance standard. Again, available models do not capture how such innovation can reduce cost.

Our E-DRAM modeling of the Preliminary Recommendation attempted to remedy these limitations by searching for measures that are likely to meet the market test of being lower than the carbon price established by the market participants. That is, we have approximated the operation of the cap-and-trade program as well as available modeling

[1] Recommendations for Designing a Greenhouse Gas Cap-and-Trade System for California, Recommendations of the Market Advisory Committee to the California Air Resources Board, June 30, 2007 p. 7

tools allow. To capture how facilities might make technology changes to reduce emissions, the costs and savings of known efficiency measures were identified so that the cost per ton for reductions from those measures could be compared to allowance prices under a cap-and-trade system. It is then assumed that facilities will choose to implement measures that cost less than the anticipated allowance price, to the extent they have been identified. This follows the market rule of selecting low cost options. Therefore, in the analysis of the Preliminary Recommendation, all measures listed as under evaluation in the Draft Scoping Plan that had a net cost that falls below the market price as solved by the model through an iterative process were used as inputs (i.e., because they represent a lower cost path than the market price the measures would be expected to occur).

This approach provides a conservative approximation of how a portion of the reductions will be achieved by industry. This technique partially addresses the model's lack of an internal mechanism to identify efficiency measures, but does not eliminate it. It does not allow for innovation, nor does it address the limitations noted above regarding cost minimization decisions made at the facility level.

Keeping these limitations in mind, our estimate of the economic impact of the Preliminary Recommendation will understate the benefits of market-based approaches including the cap-and-trade program and therefore will understate the positive impact of the Preliminary Recommendation on the California economy. We nevertheless believe that the estimate provides useful information and is a reasonable application of the model.

2 MODELING RESULTS

E-DRAM was used to analyze the Preliminary Recommendation from the Draft Scoping Plan. The input assumptions for this analysis included cost and savings information for specified measures from the Draft Scoping Plan that result in emission reductions of approximately 155 million metric tons of CO_2e ($MMTCO_2e$). These reductions include 134 $MMTCO_2e$ from the specified measures in the Preliminary Recommendation, plus an additional 21 $MMTOC_2e$ that result from low cost measures expected to be pursued under a cap-and-trade program that were included among the other measures under evaluation in the Draft Scoping Plan. The remaining 14 million tons needed to achieve the emission reduction target in 2020 are achieved through the simulation of the cap-and-trade program as described below.

The analysis used the greenhouse gas emission reduction measures presented in the Draft Scoping Plan to characterize the costs, savings and emission reductions. More detailed descriptions of the measures were included in Appendix C to the Draft Scoping Plan. Additional information on the cost and savings estimates used in this modeling effort is presented in Appendix I of this Economic Evaluation Supplement.

The cap-and-trade component of the Preliminary Recommendation is simulated by increasing the price of electricity, natural gas, and transportation fuels to reflect the carbon content of those fuels. As discussed earlier, this provides a conservative estimate of the benefits of a cap-and-trade approach. All allowance or fee revenues remain in the state and are allocated back to consumers. Per the previous discussion, this approach was used to identify the carbon price necessary to result in reduction of 14 $MMTCO_2e$ in 2020. The subsequent section provides further detail on the approach that was used to model the Preliminary Recommendation.

No additional cost minimizing methods, such as offsets, emission allowance banking or borrowing, are included in the analysis.

2.1 BUSINESS-AS-USUAL BASE CASE

The economic impacts of the Draft Scoping Plan are expressed as changes from a business-as-usual estimate of California's economic growth. As noted, the business-as-usual (BAU) case assumes that none of the measures included in the Draft Scoping Plan are implemented. As Table II-1 below indicates, for the BAU case, Gross State Product is projected to grow by about 2.7 percent annually to a value of nearly $2.6 trillion by 2020. Personal income is projected to grow by approximately 2.8 percent annually and job growth is also expected to continue as we move toward 2020.

Table II-1: Business-as-usual Case for California Economy

Economic Indicator	2007	2020	Change	Average Annual Growth (%)
Real Output ($Billions)	2,535	3,597	1,062	2.7%
Gross State Product ($Billions)	1,811	2,586	775	2.7%
California Personal Income ($Billions)	1,464	2,093	628	2.8%
Income Per Capita ($1000)	38.6	47.6	9	2.8%
Employment (Millions)	16.4	18.41	2	1.6%
Emissions ($MMTCO_2e$)	500[1]	596	96	1.4[1]

[1] Approximate value. The ARB is in process of estimating the GHG emissions for 2007.

2.2 MACRO-ECONOMIC EFFECTS OF THE PRELIMINARY RECOMMENDATION

Table II-2 shows how implementation of the Preliminary Recommendation would impact California's economy relative to a business-as-usual growth trajectory between now and 2020. As indicated in the table, the effects on output, personal income and employment are small but positive. Total output, which represents production activity in the state, increases by 0.8 percent over BAU. This translates into an increase of approximately $27 billion in 2020, which is a relatively minor increase when evaluated in the context of a $2.6 trillion economy. Also represented in Table II-2 are the impacts of the Preliminary Recommendation on Gross State Product, personal income, income per capita, and employment. In each case, the modeling shows a small but positive impact.

Table II-2: E-DRAM Estimates of Economic Impacts of the Draft Scoping Plan Preliminary Recommendation

Economic Indicator	BAU Case	Preliminary Recommendation	Change from BAU	Percent Change from BAU
Real Output ($Billions)	3,597	3,624	27	0.8%
Gross State Product ($Billions)	2,586	2,590	4	0.2%
Personal Income ($Billions)	2,093	2,106	14	0.6%
Income Per Capita ($1000)	47.56	47.72	0.16	0.3%
Employment (Millions)	18.41	18.51	0.1	0.6%
Emissions ($MMTCO_2e$)	596	427	169	-28%
Carbon Price (Dollars)	NA	9.75	NA	NA

The positive impacts are largely attributable to savings that result from reductions in expenditures on energy. These savings translate into increased consumer spending on goods and services other than energy. Many of the measures entail more efficient use of energy in the economy, with savings that exceed their costs. All told, the specified reduction measures in the Draft Scoping Plan's Preliminary Recommendation (not including additional unspecified reductions from cap-and-trade) are expected to reduce emissions of approximately 169 $MMTCO_2e$ in 2020 at a net savings of about $14 billion, which provides a positive stimulus to the economy.

When modeling the Preliminary Recommendation the model should reflect the fact that facilities will pursue emission reduction options that have a cost per ton that is lower than the market price. In the absence of complete information on what those options might be, we included in the model runs the technical options that have been identified as part of the additional measures under consideration that cost less than the allowance price (other than feebates, because of the regulatory structure that would be necessary to implement that measure). This is an incomplete list, and the model does not have the capability to adequately reflect the full set of options that are available to covered sectors under cap and trade. Thus this approach provides a rough approximation of how a portion of the reductions from the market approach would be achieved. This approach resulted in measures that provided an additional 21 $MMTCO_2e$ in reductions being included in the model run of the Preliminary Recommendation, with only the final 14 $MMTCO_2e$ of reductions achieved by pricing mechanisms within the model itself that moderated consumer demand. Appendix I provides a complete list of the measures included in this modeling run.

The modeling results presented for the cap-and-trade component of the Preliminary Recommendation reflect a carbon price of slightly less than $10 per ton of $MTCO_2e$. It is important to note that the $10 per ton figure does not reflect the cost of the program; rather it is the maximum price at which reductions to achieve the cap are pursued. We will continue to evaluate these results and anticipate that modeling efforts currently underway in the Western Climate Initiative will also provide useful additional information. We also encourage any interested stakeholders to conduct their own analyses and share their results.

As discussed in the Draft Scoping Plan, a properly designed offset program can play a valuable role within a cap-and-trade program. Offsets offer the opportunity to achieve reductions from sectors outside of the cap, often at costs lower than reductions from within the cap. This can be a key driver in moderating allowance prices, particularly in the early years of a program. Offsets also provide incentives for entities to develop and implement innovative strategies to reduce emissions outside of the capped sectors, which can have additional economic and environmental benefits.

As previously discussed, the estimated allowance price for a cap-and-trade program was slightly less than $10 per ton. As such, when we ran the E-DRAM with offsets only assumed to be available at $20 per ton, there was no demand. Nevertheless we believe that a limited availability of high quality offsets is advisable in light of the uncertainty associated with program implementation. As we work on further analysis related to the allowance price in a cap-and-trade program, we will continue to evaluate the economic impact of offsets as well.

2.3 SECTOR-LEVEL EFFECTS OF THE PRELIMINARY RECOMMENDATION

The E-DRAM provides a detailed picture of the California economy that includes 120 distinct industrial sectors. For the industrial sectoring, a grouping of firms all of which make similar, though by no means identical, products is referred to as a sector. The model's input dataset is an explicit representation of the inter-sector flows of value within the California economy in 2003. The sectoral linkages established in this dataset determine how policy effects are transmitted through the economy. Sectors are affected directly by a specific policy and indirectly through sector linkages.

A model such as E-DRAM is most useful for characterizing economic impacts at the state level. It can also be informative at the sector level with the understanding that some sectoral details that may be important in characterizing how producers will respond to a policy change may not be fully reflected in the model. For example, the industrial sectors, as represented in the model, produce a single good utilizing the same production technology that is sold at a single price. Issues that may be particularly important to individual sectors will likely have to be more thoroughly assessed using other methods as individual regulations targeting the sector are developed.

With an individual measure, understanding which sectors are affected and why is straightforward. However, given the number of measures in the Preliminary Recommendation presented in the Draft Scoping Plan, breaking out exactly how and why a specific sector is affected can be challenging. Many of the individual measures affect prices in opposite directions. For example, an efficiency measure causes less energy to be purchased, which would have the effect of reducing the price of energy. A fee would do the opposite by raising the price of energy. However, when the measures are run together, as is the case for the analysis presented in this supplement, the effect on energy prices of an efficiency measure and a fee measure would depend on which measure produces the stronger effect.

Finally, with 120 industrial sectors, the volume of information produced can make interpretation of results difficult. Results are therefore aggregated by industry type corresponding to the 2-digit North American Industry Classification System (NAICS). Aggregation of related sectors is a useful approach for gaining insights into the "big picture" impacts of the policies. Further detail for each of the aggregated sectors is discussed in the remainder of this document.

Tables II-3 and II-4 present the change in Average Weighted Prices, Real Output and Employment for the sector aggregations for the Preliminary Recommendation. The values reported in the tables for Real Output and Employment are simply summations of Output and Employment for the individual sectors. Price changes are weighted based on the individual sectors' share of output in the aggregate sector so that the price change is reflective of the price change that occurs in the larger sectors.

All changes are discussed in relation to the business-as-usual case, so when it is stated that a sectors grows, it means that it grows in excess of the BAU growth.[2] A brief discussion of aggregated sectors within the model follows.

[2] All individual sectors grow in the business-as-usual case with the exception of the Petroleum and Natural Gas Extraction sector, which declines by assumption.

Table II-3: E-DRAM 2020 Business-as-usual Prices, Output and Employment

Sector	Prices*	Output (Billions 2007 $)	Employment (Thousands)
Agriculture, Forestry and Fishing	1.0	109	449
Mining	1.0	29	26
Utilities	1.0	72	67
Construction	1.0	164	929
Manufacturing	1.0	943	2,046
Wholesale Trade	1.0	171	791
Retail Trade	1.0	296	1,901
Transportation and Warehousing	1.0	109	503
Information	1.0	235	448
Finance, Insurance and Real Estate	1.0	559	1,026
Services	1.0	910	6,729
Government	-	-	3,491
Total	**-**	**3,597**	**18,405**

* All prices are normalized to 1.0 in the Business as Usual case.

Table II-4: E-DRAM 2020 Estimates the Changes in Prices, Output and employment for the Preliminary Recommendation

Agriculture, Forestry and Fishing	1.0	113	464
Mining	1.0	30	26
Utilities	1.1	61	58
Construction	1.0	166	933
Manufacturing	1.0	947	2,055
Wholesale Trade	1.0	173	792
Retail Trade	1.0	291	1,915
Transportation and Warehousing	1.0	110	506
Information	1.0	238	450
Finance, Insurance and Real Estate	1.0	571	1,044
Services	1.0	925	6,769
Government	-	-	3,503
Total	**-**	**3,624**	**18,514**
	Percent change from BAU		
Agriculture, Forestry and Fishing	0.0	3.7	3.4
Mining	0.8	4.5	0.4
Utilities	8.6	-15.9	-13.8
Construction	0.1	1.5	0.5
Manufacturing	0.2	0.4	0.4
Wholesale Trade	-0.5	0.8	0.0
Retail Trade	-0.4	-1.5	0.7
Transportation and Warehousing	0.1	1.0	0.5
Information	-0.3	1.0	0.4
Finance, Insurance and Real Estate	-0.2	2.1	1.8
Services	-0.4	1.7	0.6
Government	-	-	0.3
Total	**-**	**0.8**	**0.6**

2.3.1 AGRICULTURE, FORESTRY AND FISHING (NAICS CODE 11)

The Agriculture, Forestry and Fishing sector comprises establishments primarily engaged in growing crops, raising animals, harvesting timber, and harvesting fish and other animals from a farm, ranch, or their natural habitats. The Agriculture, Forestry and Fishing sector is comprised of four individual E-DRAM sectors.

Overall, prices in the Agriculture, Forestry and Fishing sector remain unchanged from the BAU case. Output and employment both increase by more than 3 percent from the BAU case. Much of the overall sector growth can be attributed to increased producer energy efficiency and an increase in the demand for agricultural output as feedstock for the production of ethanol. Output and employment in all of the individual sectors in this grouping grow.

2.3.2 MINING (NAICS CODE 21)

The Mining, Quarrying, and Oil and Gas Extraction sector comprises establishments that extract naturally occurring mineral solids, such as coal and ores; liquid minerals, such as crude petroleum; and gases, such as natural gas. The term mining is used in the broad sense to include quarrying, well operations, beneficiating (e.g., crushing, screening, washing, and flotation), and other preparation customarily performed at the mine site, or as a part of mining activity. The Mining sector is comprised of two individual E-DRAM sectors.

Overall, prices in the Mining sector increase slightly, while output increases by 4.5 percent and employment increases by 0.4 percent. The Petroleum and Natural Gas Extraction sector accounts for all of the growth in the Mining sector. The reason for the increased growth in the Petroleum and Natural Gas Extraction sector is directly related to the Oil and Gas Extraction Emission Reduction measure that is estimated to provide savings that greatly exceed the costs of implementation (i.e., net savings of about $167 million). Output and employment decreases in the other mining sector primarily because of the increased price of electricity.

2.3.3 UTILITIES (NAICS CODE 22)

The Utilities sector comprises establishments engaged in the provision of the following utility services: electric power, natural gas, steam supply, water supply, and sewage removal. Within this sector, the specific activities associated with the utility services provided vary by utility: electric power includes generation, transmission, and distribution; natural gas includes distribution; steam supply includes provision and/or distribution; water supply includes treatment and distribution; and sewage removal includes collection, treatment, and disposal of waste through sewer systems and sewage treatment facilities. The Utilities sector is comprised of three individual E-DRAM sectors.

Prices in the Utilities sector increase, with the price of electricity increasing by 11 percent and the price of natural gas increasing by 8 percent. Output and employment in the Utilities sector decreases by 15.9 percent and 13.8 percent respectively. The negative output and employment effects in the Utilities sector result from consumers purchasing less electric power and natural gas because of implementing the energy efficiency measures and because of higher prices. Decreases in the demand for electricity and natural gas translates into decreases in employment for the Electrical Power Generation and Distribution (-32 percent) and Natural Gas Distribution sectors (-7 percent). Most utility sector jobs are linked to the delivery of power and maintaining the system and not in the actual running of power plants. So it is likely that the number of jobs in this sector will remain relatively unchanged even though the model estimates a decreased number of jobs. However, it should be noted that the Utility sector is relatively small in terms of overall employment.

2.3.4 CONSTRUCTION (NAICS CODE 23)

The construction sector comprises establishments primarily engaged in the construction of buildings or engineering projects (e.g., highways and utility systems). Establishments primarily engaged in the preparation of sites for new construction and establishments primarily engaged in subdividing land for sale as building sites also are included in this sector. The Construction sector is comprised of five individual E-DRAM sectors.

Prices in the Construction sector remain virtually unchanged, increasing by 0.1 percent. Output and employment in the Construction sector increase slightly: 1.5 percent for output and 0.5 percent for employment. Increases in output for the Residential, Nonresidential and Other Construction sectors, however, offsets reductions in Street and Bridge (-0.2 percent) and Utility Infrastructure Construction (-10 percent). The growth in output is potentially the result of the residential and commercial building efficiency strategies increasing the demand for new and retrofit construction. Reduced demand for electricity and natural gas reduces the need for new Utility Infrastructure construction which translates into less employment for this sector (-11 percent).

2.3.5 MANUFACTURING (NAICS CODES 31-33)

The Manufacturing sector comprises establishments engaged in the mechanical, physical, or chemical transformation of materials, substances, or components into new products. The Manufacturing sector is comprised of 42 individual E-DRAM sectors.

Prices in the Manufacturing sector increase by 0.2 percent. Output and employment in the Manufacturing sector increase slightly: 0.4 percent for both output and employment. Most of the individual sectors grow with the exception of Oil Refineries, Apparel Manufacturing, Automobile Manufacturing and Other Vehicle Manufacturing. The negative effect on Oil Refineries (-25 percent) is a direct response to the transportation and fuel policies that explicitly state that less transportation fuel will be purchased in California. However, we believe that virtually all of the change in output in the refinery sector will be the result of reduced imports of refined gasoline and not the result of reduced in-state production. Therefore, it is unlikely that the projected number of jobs would be reduced significantly from the business-as-usual case. Additionally, it should be noted that the Refining sector is relatively small in terms of overall state employment.

The effect on the remaining sectors is less straightforward. The Apparel Manufacturing, Automobile Manufacturing and Other Vehicle Manufacturing sectors are all sectors where a large share of the California demand is met by imported products. Any increase in the California price will further increase the demand for imported products at the expense of California production. In the Apparel sector, demand for apparel increases as expenditures shift away from energy to other goods. The increased demand for apparel increases the California price relative to the import price which causes output to decrease by 14 percent and employment to decrease from 15 percent.

A similar pattern is exhibited in the Automobile Manufacturing and Other Vehicle Manufacturing sectors. Increases in the price of vehicles that result from the motor vehicle measures increases the demand for imported vehicles at the expense of domestically produced vehicles which causes output and employment to decrease. In the Automobile Manufacturing sector output decreases by 3 percent and employment decreases by 4 percent, while in the Other Vehicle Manufacturing sector output decrease by 5 percent and employment decreases by 6 percent.

2.3.6 WHOLESALE TRADE (NAICS CODES 42)

The Wholesale Trade sector comprises establishments engaged in wholesaling merchandise, generally without transformation, and rendering services incidental to the sale of merchandise. The merchandise described in this sector includes the outputs of agriculture, mining, manufacturing, and certain information industries, such as publishing. The wholesaling process is an intermediate step in the distribution of merchandise. The Wholesale Trade sector is comprised of five individual E-DRAM sectors.

Prices in the Wholesale Trade sector decrease by 0.5 percent. Output increases slightly (0.8 percent) while employment is unchanged. Sector growth can likely be attributed to increased energy efficiency within the sector and to increased consumer spending brought on by shifting expenditures away from energy to other goods and services.

2.3.7 RETAIL TRADE (NAICS CODES 44-45)

The Retail Trade sector comprises establishments engaged in retailing merchandise, generally without transformation, and rendering services incidental to the sale of merchandise. The retailing process is the final step in the distribution of merchandise; retailers are, therefore, organized to sell merchandise in small quantities to the general public. The Retail Trade sector is comprised of 12 individual E-DRAM sectors.

Prices in the Retail Trade sector decrease by 0.4 percent. Output decreases by 1.5 percent, while employment increases by 0.7 percent. However, most of the individual sectors grow with the exception of the Retail Gasoline sector. The large negative effect on the Retail Gasoline sector (-16 percent) is the result of reduced purchases of transportation fuel that occur because of the transportation and fuel measures.

Growth in the other sectors can likely be attributed increased energy efficiency within the sector and to increased consumer spending brought on by shifting expenditures away from energy to other goods and services.

2.3.8 TRANSPORTATION AND WAREHOUSING (NAICS CODES 48-49)

The Transportation and Warehousing sector includes industries providing transportation of passengers and cargo, warehousing and storage for goods, scenic and sightseeing transportation, and support activities related to modes of transportation. Establishments in these industries use transportation equipment or transportation related facilities as a productive asset. The type of equipment depends on the mode of transportation. The modes of transportation are air, rail, water, road, and pipeline. The Transportation and Warehousing sector is comprised of eight individual E-DRAM sectors.

Prices in the Transportation and Warehousing sector increase slightly (0.1 percent). Output and employment increase by 1.0 and 0.5 percent respectively. No individual sectors are adversely affected. Sector growth can be attributed to increased vehicle efficiency which reduces the price of providing transportation related services and the decreased price of transportation fuels.

2.3.9 INFORMATION (NAICS CODE 51)

The Information sector comprises establishments engaged in the following processes: (a) producing and distributing information and cultural products, (b) providing the means to transmit or distribute these products as well as data or communications, and (c) processing data. The Information sector is the aggregation of four individual E-DRAM sectors.

Prices in the Information sector decrease by 0.3 percent. Output (1.0 percent) and employment (0.4 percent) both increase. No individual sectors are adversely affected. Sector growth can likely be attributed to increased energy efficiency within the sector and to increased consumer spending brought on by shifting expenditures away from energy to other goods and services.

2.3.10 FINANCE, INSURANCE AND REAL ESTATE (NAICS CODES 52-53)

The Finance and Insurance sector comprises establishments primarily engaged in financial transactions (transactions involving the creation, liquidation, or change in ownership of financial assets) and/or in facilitating financial transactions. The Real Estate and Rental and Leasing sector comprises establishments primarily engaged in renting, leasing, or otherwise allowing the use of tangible or intangible assets, and establishments providing related services. The Finance, Insurance and Real Estate sector is comprised of five individual E-DRAM sectors.

Prices in the Finance, Insurance and Real Estate sector decrease by 0.2 percent. Output and employment increase by 2.1 percent and 1.8 percent respectively. No individual sectors are adversely affected. Sector growth can likely be attributed to increased energy efficiency within the sector and to increased consumer spending brought on by shifting expenditures away from energy to other goods and services.

2.3.11 SERVICES (NAICS CODES 54-81)

The service sector comprises establishments primarily engaged in the provision of services to their customers. These include Professional, Scientific, and Technical Services, Management Services, Administrative Services, Educational Services, Health Services, Arts, Entertainment, and Recreation, Accommodation and Food Services and Other Services. All service sectors are aggregated in a single sector. The Service sector is comprised of 29 individual E-DRAM sectors.

Prices in the Service sector decrease by 0.4 percent. Output (1.7 percent) and employment (0.6 percent) both increase. Most individual sectors respond positively to the Scoping Plan measures except for Amusement Parks and Hospitals. The reason for the negative result in these two sectors is potentially the response to higher electricity prices since purchases from the Electrical Power Generation and Distribution make up a large share of these sectors' operating expenses. Growth in the other sectors can likely be attributed increased energy efficiency within the sector and to increased consumer spending brought on by shifting expenditures away from energy to other goods and services.

2.4 ECONOMIC ANALYSIS OF OTHER SCENARIOS

2.4.1 VALID COMPARISON OF SCENARIOS NOT POSSIBLE

The limitations of the available modeling tools noted above prevent a comparison from being made between market-based approaches and alternative strategies, such as one that relies only on direct regulation. It is worth noting that to our knowledge such a comparison has not been provided in previous work in any rigorous way that incorporates the costs and savings of specific reduction measures. Other studies have either only modeled variations on one approach, typically one that includes market-based measures, or have used a broad-brush surrogate for a regulatory approach such as uniform percentage reductions employed at the sector level, rather than incorporating the detailed cost and savings information from individual measures. It is important to understand as well as possible the potential impacts of the various options available, and we devoted considerable time and effort to analyze alternatives to the preliminary recommendation. We have ultimately concluded, however, that tools are not available to make a valid comparison of one approach to the others. Therefore, it is inappropriate and misleading to provide the results in the form of a direct comparison, and we do not report results in that fashion in this document.

2.4.2 SECTOR-BASED REGULATION SCENARIO

Table II-5 presents the projected economic impacts of a sector-based regulatory approach. In this approach, additional sector-based regulatory measures were modeled above and beyond those included in the Preliminary Recommendation so that the 2020 emission reduction target is fully achieved through specified measures. Thus, all measures identified in the plan as "Under Evaluation" were included in the analysis at a level that would result in meeting the target. The modeling assumptions for these measures are discussed in Appendix I.

The estimated economic impacts from implementation are all small but positive. Real output grows by about $32 billion or about 1 percent. The Gross State Product remains constant, while personal income grows by about $9 billion or about 0.5 percent over the BAU case. Similarly, average per capita income increases by 0.2 percent, and jobs grow by about 0.7 percent compared to business-as-usual. Table II-6 shows the sector-level results for this scenario.

Table II-5: E-DRAM Estimates of Economic Impacts of the Sector-Based Regulation Scenario

Economic Indicator	BAU Case	Regulatory Scenario	Change	Percent Change
Real Output ($Billions)	3,597	3,629	32	0.9%
Gross State Product ($Billions)	2,586	2,585	-0.6	0.0%
Personal Income ($Billions)	2,093	2,102	9	0.5%
Income Per Capita ($1,000)	47.6	47.64	0.1	0.2%
Employment (Millions)	18.41	18.53	0.1	0.7%
Emissions (MMTCO_2e)	596	427	169	- 28%

Table II-6: E-DRAM 2020 Estimates of the Changes in Prices, Output and employment for the Sector-Based Regulations Approach

Agriculture, Forestry and Fishing	1.0	114	467
Mining	1.0	30	26
Utilities	1.1	58	56
Construction	1.0	167	936
Manufacturing	1.0	950	2,057
Wholesale Trade	1.0	173	791
Retail Trade	1.0	292	1,923
Transportation and Warehousing	1.0	110	507
Information	1.0	237	449
Finance, Insurance and Real Estate	1.0	572	1,046
Services	1.0	926	6,767
Government	-	-	3,502
Total	**-**	**3,629**	**18,526**
	Percent change from BAU		
Agriculture, Forestry and Fishing	-0.1%	4.4%	4.0%
Mining	1.3%	5.4%	1.2%
Utilities	5.7%	-18.9%	-16.8%
Construction	0.2%	1.9%	0.8%
Manufacturing	0.0%	0.7%	0.5%
Wholesale Trade	-0.6%	0.8%	-0.1%
Retail Trade	-1.1%	-1.4%	1.1%
Transportation and Warehousing	-0.1%	1.0%	0.7%
Information	-0.4%	0.8%	0.2%
Finance, Insurance and Real Estate	-0.2%	2.3%	2.0%
Services	-0.5%	1.8%	0.6%
Government	-	-	0.3%
Total	**-**	**0.9%**	**0.7%**

2.4.3 CARBON FEE SCENARIO

As part of our effort to identify the carbon fee level needed to hit the 2020 target we also evaluated the effect of assessing a carbon fee at $10 per ton of CO_2e. From a modeling and economic perspective, a carbon fee is the exact equivalent of a cap-and-trade system that achieves the same level of emissions. Because the modeling of the Preliminary Recommendation resulted in a carbon price just under $10 per ton, the results for this scenario are virtually identical to those for the Preliminary Recommendation. The results for this scenario are presented in Tables II-7 and II-8 below.

Table II-7: E-DRAM Estimates of Economic Impacts for the Carbon Fee Scenario*

Economic Indicator	BAU Case	Carbon Fee Scenario	Change	Percent Change
Real Output ($Billions)	3,597	3,612	32	0.8%
Gross State Product ($Billions)	2,586	2,592	-0.6	0.2%
Personal Income ($Billions)	2,093	2,108	9	0.7%
Income Per Capita ($1,000)	47.6	47.78	0.1	0.3%
Employment (Millions)	18.41	18.48	0.1	0.6%
Emissions ($MMTCO_2$e)	596	401	169	- 28%

* The carbon fee scenario was modeled with a fee of $10/$MMTCO_2$E, which is equivalent from a modeling perspective to a cap-and-trade program that results in a $10/$MMTCO_2$E carbon price.

Table II-8 E-DRAM 2020 Estimates of the Changes in Prices, Output and employment for the Carbon Fee Scenario*

Agriculture, Forestry and Fishing	1.0	113	464
Mining	1.0	30	26
Utilities	1.1	61	58
Construction	1.0	166	933
Manufacturing	1.0	947	2,055
Wholesale Trade	1.0	173	792
Retail Trade	1.0	291	1,915
Transportation and Warehousing	1.0	110	506
Information	1.0	238	450
Finance, Insurance and Real Estate	1.0	571	1,044
Services	1.0	925	6,769
Government	-	-	3,502
Total	**-**	**3,612**	**18,514**
	Percent change from BAU		
Agriculture, Forestry and Fishing	0.0%	3.7%	3.4%
Mining	0.8%	4.5%	0.4%
Utilities	8.6%	-15.8%	-13.8%
Construction	0.1%	1.5%	0.5%
Manufacturing	0.2%	0.4%	0.4%
Wholesale Trade	-0.5%	0.8%	0.0%
Retail Trade	-0.4%	-1.5%	0.7%
Transportation and Warehousing	0.1%	1.0%	0.5%
Information	-0.3%	1.0%	0.4%
Finance, Insurance and Real Estate	-0.2%	2.1%	1.8%
Services	-0.4%	1.7%	0.6%
Government	-	-	0.3%
Total	**-**	**0.8%**	**0.6%**

* The carbon fee scenario was modeled with a fee of $10/MMTCO2E, which is equivalent from a modeling perspective to a cap-and-trade program that results in a $10/MMTCO2E carbon price.

3 OVERVIEW OF THE ENVIRONMENTAL-DYNAMIC REVENUE ANALYSIS MODEL

Computable General Equilibrium (CGE) 3 models represent explicitly the utility and profit maximizing behavior of households and firms and estimate how policy impacts affect agents both directly and indirectly. 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 described here is a modified version of the Environmental-Dynamic Revenue Analysis Model (E-DRAM). The E-DRAM was built for the California 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 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.4 The model has been updated to a 2003 base year.

The remainder of this Appendix is a non-technical description of E-DRAM.

3.1 DESCRIPTION OF E-DRAM

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 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.

3.1.1 AGGREGATION AND DATA SOURCES

The E-DRAM, like all other empirical economic models, treats aggregates rather than individual agents. Aggregation is done both to provide focus for the analysis and constrain the number of variables in the model. Constructing an 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

[3] For E-DRAM's sources and methods discussed in this Appendix, an unpublished paper by Professor Peter Berck is liberally quoted.
[4] The DRAM Report is available at www.dof.ca.gov/HTML/FS_DATA/dyna-rev/dynrev.htm.

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 aggregated together. The agriculture sector, for example, contains all California firms producing agricultural products. The output value of that sector is the value of all output produced by California agricultural producers. 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, as requested by ARB.5

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. 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 disaggregation of national data to a California level is accomplished using a combination of state-level employment data and estimates from California Department of Finance.

Like firms, households are also aggregated. California households are divided into categories based upon their income. The model includes eight such categories, 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 E-DRAM are organized so that both government revenue flows and expenditure flows are traced explicitly. The E-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.

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

3.1.2 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 are aggregated into industrial sectors,. For example, 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 given. The model assumes perfect competition which means that producer purchase decisions have no effect on input 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 its product price and the prices of inputs. More information on producers is provided in Chapter IV of the DRAM Report.

Households make two types of decisions: they buy goods and services and they sell labor and capital. Households are assumed to make these decisions in the way that maximizes their well-being (called "utility" in the economics literature). Like firms, consumer purchases have no effect on product prices. 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 (demand function?) 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. {This sentence is unclear-needs revision but I can't tell what it is trying to say}

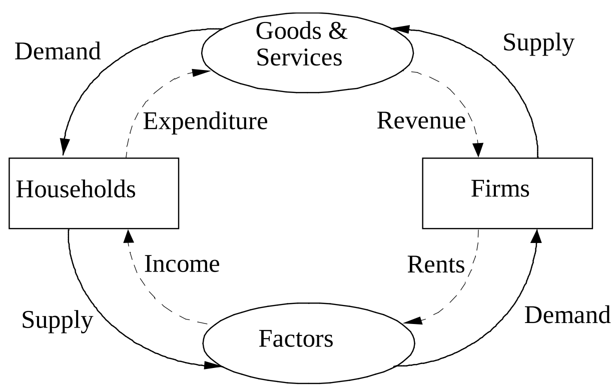
3.1.3 EQUILIBRIUM

So far, two types of agents have been described: firms and households. It remains to be explained how these agents relate. Agents relate through two types of markets: factor markets and goods-and-services markets. Firms sell goods and services to households in the goods-and-services markets. Households sell labor and capital services to firms in 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, called the "rental rate." Equilibrium in the market means that the quantity supplied is equal to the quantity demanded. Equilibrium in the factor markets for labor and capital and in the markets for goods and services defines a simple general equilibrium. 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.

These relationships are shown in more detail in Figure II-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 goods and services from the goods-and-services markets. Households sell capital and labor on the factor markets and receive income in exchange.

Figure II-1: The Basic Circular-Flow Diagram

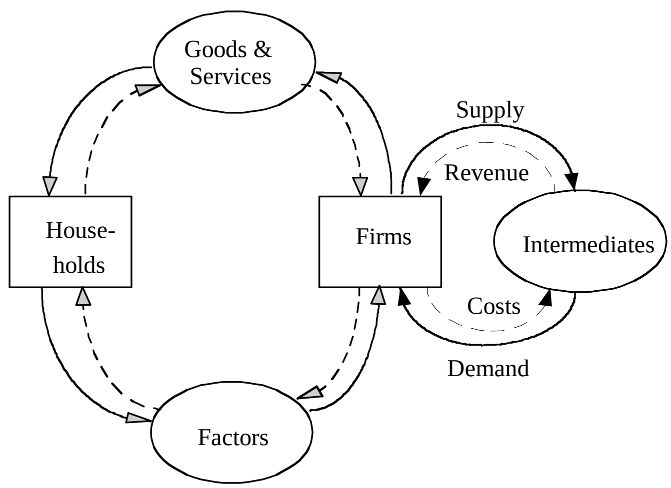


Source: Berck, Golan, and Smith, 1996.

3.1.4 INTERMEDIATE GOODS

The economy of California is far more complex than that shown in Figure II-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 a market for intermediate goods would be fertilizer sold to agricultural firms. A final output of the chemical industry is fertilizer, which is an intermediate good in the agricultural industry. This type of market interaction is demonstrated in Figure II-2. Here, part of the output of a chemical firm (chemical industry in the example) is not sold to households but rather to another firm. 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 II-2: The Circular-Flow Diagram with Intermediate Goods

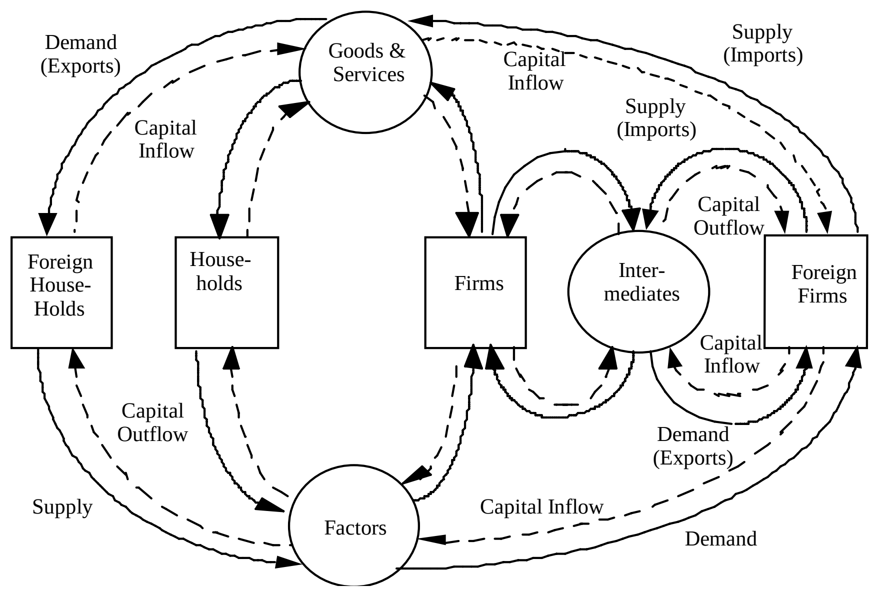


Source: Berck, Golan, and Smith, 1996.

3.1.5 REST OF THE WORLD

California is an open economy, which means that it trades goods, services, labor, and capital 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 II-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 II-3: The Circular-Flow Diagram with Intermediate Goods and Trade

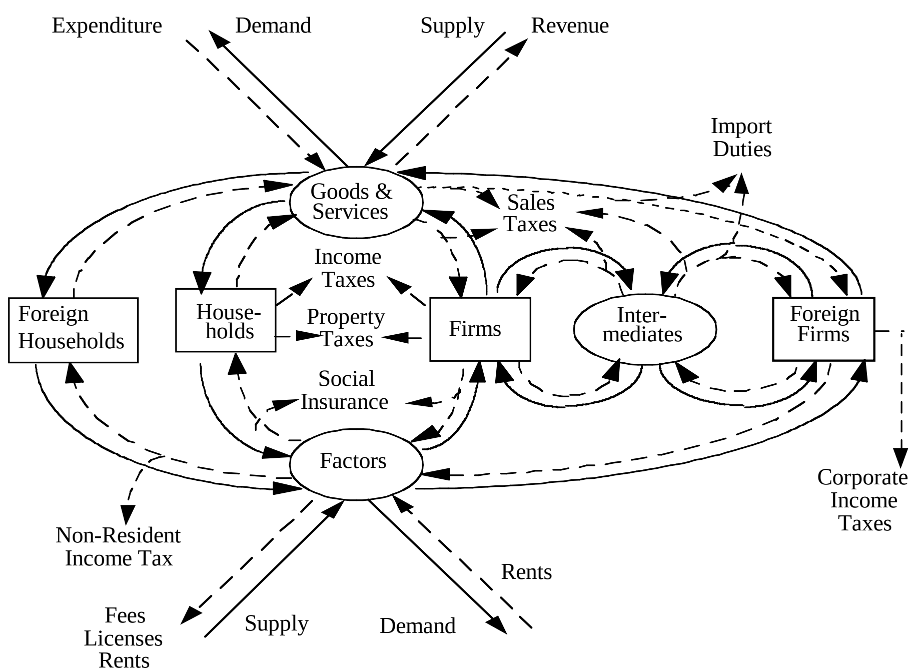


Source: Berck, Golan, and Smith, 1996.

3.1.6 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 II-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. 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 II-4: The Complete Circular-Flow Diagram



Source: Berck, Golan, and Smith, 1996.

3.1.7 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).

3.1.8 OTHER CONSIDERATIONS AND MODEL BUILDING

Computable General Equilibrium 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 calendar year 2003. 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, market power, may well be present, but the degree of non-competitive pricing is not likely to be significant in aggregated sectors. The second assumption is that involuntary unemployment is constant. This assumption 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 of the DRAM Report.

3.1.9 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.6 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. Dabalen 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.

3.2 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

[6] 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.

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.

3.2.1 EXTRAPOLATION FROM 2003 TO 2020

The E-DRAM is not a forecasting model but, rather, a model constructed to exactly reproduce the economic conditions of calendar year 2003. To answer questions concerning the impacts of emission 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 model of the economy in 2020, 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 2020 SAM was based on the projected changes to personal income, population, and energy. The sources for these projections were as follows:

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.

Working population growth (ages 18-64).
The California working population forecast through 2050 is from the DOF.

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

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.

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.

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.

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.

3.2.2 ADJUSTING FOR TECHNOLOGICAL CHANGE

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's 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, industry J 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(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.

3.3 CONCLUSION

This model overview summarizes the essence of the E-DRAM for the California economy. As stated earlier, E-DRAM describes the relationship among California producers, California households, California governments, and the rest of the world. The E-DRAM, like all other empirical economic models, treats aggregates rather than individual agents. For this it combines similar agents into single sectors. In the E-DRAM model, the California economy has been divided into 186 distinct sectors.

To answer questions concerning the impacts of emission reduction strategies far into the future, the model uses specific growth factors to model future years. To "rebase" E-DRAM, i.e., move from a model of the 2003 economy to model of the economy in 2020, E-DRAM's input data must be modified to reflect economic conditions in those "out years." This process leaves the basic structure of economic relationships intact while scaling up. Overall, the measures and changes in expenditure patterns are captured in the E-DRAM model as changes in technology and changes in government and personal expenditure patterns.

Attachment 1. Sectors Used for the E-DRAM Model

SECTOR DESCRIPTION
Agriculture
Cattle
Dairy
Forestry
Petroleum and Natural Gas Extraction
Mining
Electrical Power Generation and Distribution
Natural Gas Distribution
Water Distribution and Sewage Treatment
Residential Construction
Nonresidential Construction
Street and Bridge Construction
Utility Infrastructure Construction
Other Construction-related Industry
Food Manufacturing
Food Processing
Other Food Related Industry
Beverage and Tobacco Products
Textile and Leather Manufacturing
Apparel Manufacturing
Wood Products Manufacturing
Pulp and Paper Mills
Paper Products Manufacturing
Printing
Oil Refineries
Industrial Gas
Chemical and Drugs Manufacture
Basic Chemical Manufacture
Soaps and Detergents Manufacture
Other Chemical Products Manufacture
Plastics Manufacture
Glass Products Manufacture
Cement
Concrete
China and Clay Products
Primary Metals
Aluminum
Metal Fabrication

SECTOR DESCRIPTION
Machinery Manufacture
Refrigeration and Air Conditioning
Computer Manufacture
Communications Equipment Manufacture
Electronic Components Manufacture
Electronic Instruments Manufacture
Electronic Recording Media Manufacture
Electrical Equipment Manufacture
Automobile Manufacturing
Other Vehicle Manufacture
Motor Vehicle Body Manufacture
Motor Vehicle Parts Manufacture
Ship Building and Repair
Other Vehicle Manufacture
Aerospace Manufacture
Furniture
Laboratory and Dental Equipment
Miscellaneous Manufacturing
Vehicle Services
Wholesale Durable Goods
Wholesale Non Durable Goods
Wholesale Gas
Wholesale Trade
Transportation
Air Transportation
Railroad Transportation
Waterway Transportation
Truck Transportation
Public Transportation
Other Transportation
Vehicle Transportation
Retail Vehicles and Parts
Retail Furniture
Retail Electronics and Appliances
Retail Building Materials
Retail Food and Beverage
Retail Health and Personal Care
Retail Gasoline Stations

SECTOR DESCRIPTION
Retail Clothing and Accessories
Retail Sporting Goods and Books and Music
Retail General Merchandise
Retail Miscellaneous
Retail Nonstore
Motion Picture Industry
Other Broadcasting and Recording Industry
Telecommunications
Internet and Information Services
Financial Securities
Insurance
Banking
Real Estate
Other Financial
Legal Services
Accounting
Architecture
Design
Computer Related Services
Consulting
Research
Advertising
Other Professional Services
Business Services
Temporary Administrative Services
Security Services
Building Maintenance
Other Administrative Services
Waste Management
Landfills
Education
Medical Services
Hospitals
Nursing
Day Care
Recreation and Entertainment
Amusement Parks
Hotels
Full Service Restaurants
Fast Food
Caters and Mobile Food Services

SECTOR DESCRIPTION
Drinking Establishments
Personal Services
FACTOR FACTOR LABOR
FACTOR FACTOR ALL OTHER FACTORS COMBINED AS CAPITAL
COMMODITY FOOD AND BEVERAGE
COMMODITY SHELTER
COMMODITY FUEL AND UTILITIES
COMMODITY HOUSEHOLD FURNISHING AND OPERATION
COMMODITY APPAREL AND ITS UPKEEP
COMMODITY TRANSPORTATION
COMMODITY MEDICAL CARE
COMMODITY ENTERTAINMENT
COMMODITY OTHER GOODS AND SERVICES
HOUSEHOLD 0.0 PERCENT MARGINAL CA PIT
HOUSEHOLD 1.0 PERCENT MARGINAL CA PIT
HOUSEHOLD 2.0 PERCENT MARGINAL CA PIT
HOUSEHOLD 4.0 PERCENT MARGINAL CA PIT
HOUSEHOLD 6.0 PERCENT MARGINAL CA PIT
HOUSEHOLD 8.0 PERCENT MARGINAL CA PIT
HOUSEHOLD 9.3 PERCENT MARGINAL CA PIT UNDER 200K
HOUSEHOLD 9.3 PERCENT MARGINAL CA PIT OVER 200K
INVESTMENT
GOVERNMENT FEDERAL TAX SOCIAL SECURITY
GOVERNMENT FEDERAL TAX PERSONAL INCOME TAX
GOVERNMENT FEDERAL TAX PROFITS
GOVERNMENT FEDERAL TAX DUTY
GOVERNMENT FEDERAL TAX MISCELLANEOUS
GOVERNMENT CALIFORNIA TAX VARIOUS HOUSEHOLD TAXES
GOVERNMENT CALIFORNIA TAX

SECTOR DESCRIPTION
ALCOHOL TAXES
GOVERNMENT CALIFORNIA TAX CIGARETTE TAXES
GOVERNMENT CALIFORNIA TAX HORSE RACING
GOVERNMENT CALIFORNIA TAX ESTATE TAXES
GOVERNMENT CALIFORNIA TAX TRAILER FEES
GOVERNMENT CALIFORNIA TAX MOTOR VEHICLE LICENSE FEES
GOVERNMENT CALIFORNIA TAX DIESEL FUEL TAXES
GOVERNMENT CALIFORNIA TAX MOTOR VEHICLE REGISTRATION FEES
GOVERNMENT CALIFORNIA TAX MISCELLANEOUS
GOVERNMENT CALIFORNIA TAX INSURANCE GROSS PREMIUM TAX
GOVERNMENT CALIFORNIA TAX GASOLINE FUEL TAXES
GOVERNMENT CALIFORNIA TAX SALES AND USE TAXES
GOVERNMENT CALIFORNIA TAX BANK AND CORPORATION TAX
GOVERNMENT CALIFORNIA TAX LABOR TAXES UI AND WORKERS COMP
GOVERNMENT CALIFORNIA TAX PERSONAL INCOME TAX
GOVERNMENT CALIFORNIA TAX REGULATORY LICENSES AND FEES
GOVERNMENT CALIFORNIA TAX SERVICES TO THE PUBLIC
GOVERNMENT CALIFORNIA TAX USE OF PROPERTY AND MONEY
GOVERNMENT CALIFORNIA GENERAL FUND
GOVERNMENT LOCAL TAX PROPERTY

SECTOR DESCRIPTION
GOVERNMENT LOCAL TAX SALES AND USE
GOVERNMENT LOCAL TAX MISCELLANEOUS ON FIRMS
GOVERNMENT LOCAL TAX MISCELLANEOUS ON HOUSEHOLDS
GOVERNMENT LOCAL TAX MISCELLANEOUS ON FIRMS AND HOUSEHOLDS
GOVERNMENT FEDERAL SPENDING DEFENSE
GOVERNMENT FEDERAL SPENDING NON DEFENSE
GOVERNMENT CALIFORNIA SPENDING TRANSPORTATION
GOVERNMENT CALIFORNIA SPENDING CORRECTIONS
GOVERNMENT CALIFORNIA SPENDING K TO 14 EDUCATION
GOVERNMENT CALIFORNIA SPENDING UNIVERSITIES
GOVERNMENT CALIFORNIA SPENDING WELFARE
GOVERNMENT CALIFORNIA SPENDING HEALTH
GOVERNMENT CALIFORNIA SPENDING OTHER
GOVERNMENT LOCAL SPENDING TRANSPORTATION
GOVERNMENT LOCAL SPENDING CORRECTIONS
GOVERNMENT LOCAL SPENDING K TO 14 EDUCATION
GOVERNMENT LOCAL SPENDING WELFARE
GOVERNMENT LOCAL SPENDING HEALTH
GOVERNMENT LOCAL SPENDING OTHER
REST OF WORLD