UPDATED MACROECONOMIC ANALYSIS OF CLIMATE STRATEGIES PRESENTED IN THE MARCH 2006 CLIMATE ACTION TEAM REPORT

PUBLIC REVIEW DRAFT

PREPARED BY:

ECONOMICS SUBGROUP

CLIMATE ACTION TEAM

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Acknowledgements

The Economics Subgroup was created under the Climate Action Team to examine economic impacts of achieving the State's climate goals. The Subgroup was comprised of representatives from the agencies included on the Climate Action Team.

This report fulfills the commitment in the March 2006 Climate Action Team Report to Governor Schwarzenegger and the Legislature to update its macroeconomic impact analysis to reflect refined data and methods. The Subgroup reviewed and relied on a wide range of materials, and in particular input from all the State agencies included on the Climate Action Team. Additionally, two independent modeling frameworks were used to examine the range of macroeconomic impacts associated with achieving the emission cap in 2020. The insights and improved methods and data developed for this report will contribute to continuing improvements in the ability to assess costs and benefits of climate strategies of all types.

We particularly acknowledge the modelers who provided their modeling frameworks and performed the analyses of the climate strategies, often under tight deadlines. These include: Dr. David Roland-Holst, U.C. Berkeley; Dr. David Kennedy, ARB; and Dr. William Dean, ARB. We also acknowledge Dr. Paul Bernstein, CRA International and Dr. Larry Williams, EPRI for their assistance in specifying the analysis. The expertise, insights, and hard work of these professionals made the completion of the analysis possible.

The Economics Subgroup included the following members: Andrew Altevogt, Cal/EPA; Richard Corey, ARB; William Dean, ARB; Pierre duVair, CEC; Fereidun Feizollahi, ARB; Judith Friedman, CIWMB; Ray Hoagland, DWR; Thom Kelly, CEC; David Kennedy, ARB; Reza Navai, DOT; Vahid Nowshiravan, DOT; Tim Olson, CEC; Kristin Ralff Douglas, CPUC; Eileen Tutt, Cal/EPA; and Michael Gibbs, Cal/EPA, the Subgroup Chair.

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1. Introduction

1.1 Purpose of this Report

This report provides an update to the macroeconomic analysis of the climate strategies presented in the March 2006 Climate Action Team Report to Governor Schwarzenegger and the Legislature (2006 CAT Report). As described in the 2006 CAT Report, the macroeconomic impact assessment available at that time was preliminary, and would benefit from updated cost and savings estimates for the strategies as well as a refined analysis. Consequently, the report committed to providing an updated analysis.

This report fulfills the commitment made in the 2006 CAT Report by presenting the following:

- updated estimates of costs, savings, and emission reductions for the climate strategies presented in the 2006 CAT Report;
- refined methodologies for characterizing the climate strategies for use in the macroeconomic impact analysis; and
- revised macroeconomic impact analysis.

Additionally, this report presents net cost estimates for each of the climate strategies in terms of the dollars per ton of emissions avoided in 2020. As described below, these estimates incorporate the value of reducing criteria air pollutant emissions, a factor that was not included in the March 2006 analysis.

The estimates presented in this report reflect both updated data and refined methods. The macroeconomic impact analysis is conducted with two separate modeling frameworks that were presented at the November 29, 2006 Conference on Economic Impact Modeling of Greenhouse Gas Emission Reduction Market and Non-Market Based Strategies. Through the use of two modeling frameworks we are able to examine the implications of alternative modeling assumptions and methods on the impact estimates. Additionally, the models have the capability of examining the impacts of using market based compliance mechanisms to achieve the State's 2020 emissions limit. This capability was not available for the analysis presented in the 2006 CAT Report. The modeling frameworks are:

- Environmental Dynamic Revenue Analysis Model (E-DRAM) – provided by the Air Resources Board (ARB); and
- Berkeley Energy and Resources (BEAR) Model – provided by U.C. Berkeley.

The modeling framework developed by CRA International was also made available by the Electric Power Research Institute (EPRI). Unfortunately, the model was unable to incorporate the cost-saving characteristics of several important parts of the State's strategy to fight global warming within the timeframe for producing this report. As the cost savings have been proven in some cases, such as the California building energy efficiency standards, appliance standards, and energy efficiency programs, the analysis was not realistic, and consequently is not included in this report.

While significant progress has been made, we recognize that additional data collection and methodological refinements are ongoing. The climate strategies continue to be updated, and new climate strategies have been identified. For example, at its June 2007 hearing the Air Resources Board (ARB) adopted 37 early actions of which three were believed to meet the legislative definition of discrete early action. The ARB staff is currently evaluating stakeholder suggestions for additional early actions. As such these new and developing strategies are not represented in this analysis. The newly proposed low carbon fuel standard (LCFS) illustrates this point. Specifically, the LCFS will replace the biodiesel and ethanol strategies included in this analysis, but the information necessary to characterize the model inputs for the LCFS were not sufficiently developed to include in this analysis. Additionally, as the ARB develops the Scoping Plan as required under the Global Warming Solutions Act of 2006 (AB 32), it is updating the existing climate strategies and examining additional strategies beyond those considered here. Therefore, we will continue to build on the new data and methods incorporated in this report to develop improved analyses in the future.

1.2 Organization of this Report

This report is organized as follows:

- Section 2 presents the updated methods and data used to characterize the climate strategies.
- Section 3 introduces the modeling frameworks used to assess macroeconomic impacts, and describes the scenarios that were evaluated.
- Section 4 presents the results of the analysis, including the estimates of macroeconomic impacts. This section concludes with a discussion of further improvements to the methods and data that are warranted based on the work reflected in this report.

This report includes four attachments to provide additional detail regarding the characterization of the climate strategies and the modeling results.

- Attachment A briefly summarizes the updates performed to each of the climate strategies included in the March 2006 Climate Action Team Report.
- Attachment B describes each of the strategies for which data or methods were updated.
- Attachments C and D present more detailed results from E-DRAM and BEAR.

2. Updates to the Climate Strategies

This section presents the data and methodological refinements that were conducted to update the climate strategies presented in the March 2006 Climate Action Team Report to Governor Schwarzenegger and the Legislature (2006 CAT Report).

- Section 2.1 summarizes the updated data developed to characterize the strategies.
- Section 2.2 presents the updated assumptions and methods that were applied across all the strategies to ensure consistency and prevent double counting.
- Section 2.3 provides a summary table of the updated emission reductions, costs, and savings associated with each strategy.

Additional information on the updated strategies is provided in Attachments A and B. Attachment A presents a brief summary of the changes that were made to each strategy and shows the emission reductions, costs, and savings from the 2006 CAT Report as well as this report. Attachment B describes each strategy that was updated, including the data used to estimate emission reductions, costs, and savings.

2.1 Updates to the Climate Strategies

The 2006 CAT Report presented data on more than 40 climate strategies, representing actions that could be taken by nine State agencies to reduce global warming pollution emissions and achieve the State's emission goals in 2010 and 2020. Following completion of the 2006 CAT Report it was recognized that additional data were needed to improve the characterization of the strategies across several dimensions, including: the steps required to implement the strategy; the expected emission reduction; costs; and savings.

Following discussions among the CAT agencies, the responsible agencies collected additional information to support improved characterizations of the strategies as summarized in Exhibit 1. As shown in the exhibit, the updated information is structured to provide a complete overview of the strategy, including how it may be implemented, the entities that may be affected, the manner in which progress may be measured, and the co-benefits derived from the strategy. These data were assembled by the responsible agencies through the spring of 2007.

Efforts were focused on those strategies that would benefit most from having refined data. Exhibit 2 lists all the strategies included in the 2006 CAT Report and identifies which were updated through this process. A summary of the updates performed to each strategy is presented in Attachment A. Highlights of the updates include the following.

Air Resources Board. The ARB had 12 strategies in the 2006 CAT Report. Five of the strategies were updated to include refined emissions estimates, cost estimates, and/or savings estimates. One of the strategies was divided into two parts, creating two separate updated strategies (see Exhibit 2). Several of the strategies, including Vehicle Climate Change Standards and Diesel Anti-Idling were not updated because the strategies have already been adopted. Updates were not prepared for the fuel strategies, Biodiesel Blends and Ethanol, because a significant interagency process was ongoing to develop a comprehensive alternative fuels strategy for the State under AB 1007. This work was not completed in time to be incorporated into this analysis, and consequently the original fuels strategies were retained in this analysis. Of note is that the more recently announced Low Carbon Fuels Standard (LCFS) was also not included in this analysis. The data needed to characterize the LCFS were not available in time to be used for this analysis. Because the fuels strategies were not updated, and the LCFS was not incorporated into the analysis, the emissions reductions available from fuel-related activities are underrepresented in this analysis.

Integrated Waste Management Board. The IWMB updated two of its three strategies, incorporating refined estimates of the costs, savings, and emissions reductions for the strategies. Particular attention was paid to using California-specific data on technologies, costs, and landfill characteristics. One strategy was not updated because its goals were already achieved.

Forestry. All five Forestry strategies have been updated, in some cases significantly. The previous estimates of carbon sequestration were reviewed and were found, in some cases, to include estimates of cumulative amounts of carbon sequestered through 2020. The revised strategies report annual carbon sequestration values, including the expected carbon that can be sequestered each year through 2020. As a result, the estimates for the year 2020 are significantly reduced for some strategies as compared to the figures in the 2006 CAT Report. Additionally, the anticipated production of energy from forest biomass was restated in energy units (such as GWh) so that emissions factors could be applied consistently across all the strategies in the analysis.

Department of Water Resources. DWR updated its water use efficiency strategy to reflect information on water efficiency impacts of specific best management practices. The costs and savings estimates were refined. The energy impacts of reduced water use are also now reported in energy units (GWh) so that emissions factors could be applied consistently across all the strategies in the analysis.

Energy Commission. The CEC provided refined estimates for its most significant strategies. The four individual strategies addressing emissions from municipal utilities were combined into a single comprehensive strategy. Among other improvements to this strategy, the energy efficiency component was revised to be consistent with the manner in which energy efficiency impacts are estimated for the CPUC strategy (see below). Efforts are continuing to refine the municipal utility strategy, so that the overall costs, savings, and emissions impacts are expected to be updated in the future.

Exhibit 1: Data Assembled to Update the Climate Strategies

1. Strategy Name
2. Responsible Agency
3. Strategy Description, including: Overview Affected Entities Related Objectives (whether the strategy achieves objectives other than the reduction of greenhouse gas emissions) Strategy Metrics (how to measure progress) Strategy Goals and Implementation Approach
4. Technology (description of the technology that will be used to reduce emissions)
5. Statutory Status
6. Implementation Steps and Timeline
7. Greenhouse Gas Emission Reductions
8. Costs and Savings
9. Other Benefits (additional benefits expected, including non-monetized or un-quantified benefits)

Exhibit 2: List of Strategies that were Updated for this Analysis

2006 CAT Report Strategy	Updated Strategy in This Report	Agency	Update Status
Vehicle Climate Change Standards	Vehicle Climate Change Standards	ARB	Not updated
Diesel Anti-Idling	Diesel Anti-Idling	ARB	Not updated
Other New Light Duty Vehicle Technology Improvements	Other New Light Duty Vehicle Technology Improvements	ARB	Not updated
HFC Reduction Strategies	HFC Reduction Strategies	ARB	Updated
Transport Refrigeration Units, Off-road Electrification, Port Electrification	Transport Refrigeration Units (on and off road)	ARB	Updated as two separate strategies
	Shore Electrification	ARB	
Manure Management	Manure Management	ARB	Not updated
Semi Conductor Industry Targets (PFC Emissions)	PFC Emission Reduction for Semiconductor Manufacturers	ARB	Updated
Alternative Fuels: Biodiesel Blends	Alternative Fuels: Biodiesel Blends	ARB	Not updated
Alternative Fuels: Ethanol	Alternative Fuels: Ethanol	ARB	Not updated
Heavy-Duty Vehicle Emission Reduction Measures	Heavy-Duty Vehicle Emission Reduction Measures	ARB	Updated
Reduced Venting and Leaks in Oil and Gas Systems	Reduced Venting and Leaks in Oil and Gas Systems	ARB	Updated
Hydrogen Highway*	Hydrogen Highway*	ARB	Not updated
Achieve 50% Statewide Recycling Goal	Achieve 50% Statewide Recycling Goal	IWMB	Not updated
Landfill Methane Capture	Landfill Methane Capture	IWMB	Updated
Zero Waste—High Recycling	Zero Waste—High Recycling	IWMB	Updated
Conservation Forest Management	Conservation Forest Management	Forestry	Updated
Forest Conservation	Forest Conservation	Forestry	Updated
Fuels Management/Biomass	Fuels Management/Biomass	Forestry	Updated
Urban Forestry	Urban Forestry	Forestry	Updated
Afforestation/Reforestation	Afforestation/Reforestation	Forestry	Updated
Water Use Efficiency	Water Use Efficiency	DWR	Updated
Building Energy Efficiency Standards in Place	Building Energy Efficiency Standards in Place	CEC	Updated
Appliance Efficiency Standards in Place	Appliance Efficiency Standards in Place	CEC	Updated

2006 CAT Report Strategy	Updated Strategy in This Report	Agency	Update Status
Fuel-Efficient Tires & Inflation Programs	Fuel-Efficient Tires & Inflation Programs	CEC	Updated
Building Energy Efficiency Standards in Progress*	Building Energy Efficiency Standards in Progress*	CEC	Not updated
Appliance Energy Efficiency Standards in Progress*	Appliance Energy Efficiency Standards in Progress*	CEC	Not updated
Cement Manufacturing	Cement Manufacturing	CEC	Not updated
Municipal Utility Energy Efficiency Programs/ Demand Response	Comprehensive Municipal Utility Program	CEC	Updated as a comprehensive municipal utility program
Municipal Utility Renewable Portfolio Standard			
Municipal Utility Combined Heat and Power			
Municipal Utility Electricity Sector Carbon Policy			
Alternative Fuels: Non-Petroleum Fuels*	Alternative Fuels: Non-Petroleum Fuels*	CEC	Not updated
Measures to Improve Transportation Energy Efficiency	Measures to Improve Transportation Energy Efficiency and Smart Land Use and Intelligent Transportation	BTH	Updated as a combined strategy write up
Smart Land Use and Intelligent Transportation			
Conservation tillage/cover crops*	Conservation tillage/cover crops*	Food/Ag	Not updated
Enteric Fermentation	Enteric Fermentation	Food/Ag	Not updated
Green Buildings Initiative	Green Buildings Initiative	SCSA	Updated
Transportation Policy Implementation*	Transportation Policy Implementation*	SCSA	Not updated
Accelerated RPS to 33% by 2020	Accelerated RPS to 33% by 2020	CPUC	Updated
California Solar Initiative	California Solar Initiative	CPUC	Updated
IOU Energy Efficiency Programs	IOU Energy Efficiency Programs	CPUC	Updated
IOU Additional Energy Efficiency Programs	IOU Additional Energy Efficiency Programs	CPUC	Updated
IOU Combined Heat and Power Initiative	IOU CHP (Self Generation Incentive Program)	CPUC	Updated
IOU Electricity Sector Carbon Policy	IOU Electricity Sector Carbon Policy (including SB 1368 Implementation for IOUs)	CPUC	Updated
* The 2006 CAT Report did not include emission reduction estimates, costs, or savings for the strategies marked with an asterisk.			

The CEC's building and appliance energy efficiency standard strategies were also updated. The updates reflect refined methods for estimating costs and savings over time that have been applied to all the strategies. These refinements are discussed further below. The updates also reflect revised values for the energy saved (i.e., $/MWh and $/Therm), which are applied to all the strategies.

The CEC has not provided estimates for future building and appliance energy efficiency standards, which were also not provided in the 2006 CAT Report. It is premature to provide such estimates, as the regulatory processes for these standards are not complete. Similarly, no estimates are provided for the non-petroleum fuels strategy. As discussed above for the ARB fuels strategies, the work under AB 1007 was not completed in time to be incorporated into this analysis, and consequently no estimates are included.

Business, Transportation, and Housing Agency. BTH updated its two groups of strategies, which for purposes of presentation in this report are combined into a single write up. Many of these strategies have multiple benefits, including GHG emission reduction. The 2006 CAT Report data were scrutinized and refinements in the estimated emissions impacts of the activities were performed. Estimates of costs and savings were provided (which were not available in the previous report). The updates do not capture all the benefits generated by the transportation strategies. Consequently, the savings are underestimated, and the net cost estimates (cost minus savings) do not reflect the full set of benefits. Efforts are continuing to refine these strategies, including more detailed analysis of the cost and benefits.

Department of Food and Agriculture. The Food and Agriculture strategies were not updated. Efforts are currently under way to develop improved data for these strategies, and to develop additional strategies from the agriculture and food processing sectors.

State Consumer Services Agency. The Green Buildings strategy was refined to reflect updated estimates of the impacts of the State's green building efforts. The impacts of the strategy were restated in energy units (e.g., GWh) so that emissions factors could be applied consistently across all the strategies in the analysis. The transportation policy strategy was not updated, so that no emission reduction estimates are available for this strategy.

Public Utilities Commission. The CPUC developed substantial refinements to their strategies. For the energy efficiency strategies, data from the investor-owned utilities (IOU) were analyzed to estimate the persistence of energy efficiency measures included in the IOU energy efficiency program portfolios. These persistence estimates, summarized in Exhibit 3, were used to estimate energy savings over time from energy efficiency investments. The percentages shown in the exhibit are the portion of the first-year energy savings that remains throughout the full 20 year lifetime of the energy efficiency measures. The energy efficiency programs install energy efficiency measures each year that save energy in the first year in which they are installed. Some of these measures have lifetimes of a few years, such as certain high efficiency light bulbs in commercial applications. Other measures, such as high efficiency air conditioners, have long lifetimes of many years. The figures in Exhibit 3 reflect how the savings over time are affected by the lifetimes of the full mix of measures installed. For example, by the fifth year following installation, the electric savings are about 84% of the savings in the first year. By year 10, the electric energy savings are estimated at about 67% of the first-year savings. With this approach, the savings associated with a given year's installations decline over time in a manner that reflects the lifetime of the mix of energy-saving equipment that was installed. Because these estimates are based on the full portfolio of energy efficiency programs being implemented by the IOUs, this approach enabled the energy impacts (in GWh and Therms) of the energy efficiency investments to be better reflected through 2020.

The CPUC also provided significant updates to the solar energy strategy. The revised figures incorporate estimates from the IOUs of their anticipated solar program installations and incentives by year. The persistence of solar power generation from the installations was also considered explicitly so that the anticipated amount of solar generation developed through the program is reflected over time.[1] Also of importance is that the impacts of all of CPUC's strategies were restated in energy units (GWh and Therms) so that emissions factors could be applied consistently across all the strategies in the analysis. As mentioned above for the CEC strategies, the updates also reflect revised values for the energy saved (i.e., $/MWh and $/Therm), which are applied to all the strategies.

Exhibit 3: Estimated Persistence of Energy Efficiency Measures (Based on Analysis of the IOU Program Portfolios)

Year Following Installation	Remaining Energy Efficiency Impact	
	Electric Measures	Gas Measures
1	99.69%	100.00%
2	95.97%	99.46%
3	89.59%	98.51%
4	85.14%	97.84%
5	84.02%	97.11%
6	78.32%	89.75%
7	78.24%	89.75%
8	78.22%	89.75%
9	74.58%	89.70%
10	66.73%	87.45%
11	51.71%	73.71%
12	34.56%	72.45%
13	33.13%	70.45%
14	32.88%	69.27%
15	32.51%	67.90%
16	17.12%	42.47%
17	4.56%	42.47%
18	4.56%	42.47%
19	4.03%	40.40%
20	3.89%	38.64%

Percentages reflect the portion of the first-year energy savings that remains throughout the full 20 year lifetime of the energy efficiency measures.

Estimated from the Investor Owned Utilities' energy efficiency portfolio plans for 2006-2008.

[1] Solar power generation was estimated to decline by 1% per year following its initial installation.

As reflected in these highlights of the updates to the strategies, efforts remain ongoing to refine many of the strategies. New strategies have also been developed and are undergoing development. For example, at its June hearing the ARB approved staff recommendations to develop 37 early actions strategies. Per the Board's direction, staff are evaluating stakeholder suggestions for consideration as early actions, with additional stakeholder recommendations anticipated. The Board is also considering additional strategies for achieving emission reductions as part of its Scoping Plan that it is developing. Consequently, the macroeconomic analysis presented in this report is based on a snapshot of the climate strategies and their characteristics as of the spring of 2007. The strategy descriptions are included as Attachment B.

2.2 Assumptions and Methods Applied Consistently to All Strategies

An important objective of this analysis is to improve the transparency and consistency of the emissions, costs, and savings estimates for the strategies. The 2006 CAT Report assembled the best data available at that time to characterize the strategies. By necessity, these data came from multiple sources that relied on a variety of assumptions and methods. In some cases, it was not possible to deconstruct the available data to harmonize fully key aspects of the emissions, costs, and savings estimates. Consequently, although considerable effort went into using the available data as effectively as possible, it was not possible to ensure that all the strategies used the same underlying methods and data to characterize their impacts in the 2006 CAT Report.

This analysis refines the previous work by harmonizing the most important elements of the emissions, costs, and savings estimates. Fundamental to accomplishing this objective is the requirement that the <u>energy impacts of each of the strategies be reported in energy units</u>. Most of the climate strategies have an impact on energy in some manner, for example by:

- reducing energy consumption, such as through improved energy efficiency;
- producing energy from a low-carbon fuel, such as producing electricity from forest biomass or landfill gas; or
- shifting from one energy source to another, such as ships in port shifting from diesel electric generation to grid-supplied electricity.

To ensure that we could develop consistent emissions, costs, and savings estimates across all the strategies, all the energy impacts were expressed as follows:

- electric energy in MWh;
- natural gas in millions of Btus (MMBtu) or Therms;
- gasoline and diesel fuel in gallons.

Using these values, we applied a consistent set of emissions factors and energy prices for purposes of estimating emissions, costs, and savings impacts. Additionally, we paid particular attention to potential double counting of emissions reductions that could result due to interactions among the strategies. Finally, we applied a consistent method for counting costs and savings to all the strategies. These methods are described in the following subsections.

2.2.1 Emissions Factors

The direct emissions rate of global warming pollution from the combustion of fossil fuels has been well established to be primarily a function of the carbon content of the fuel. Exhibit 4 presents the emissions factors used in this analysis for natural gas, gasoline, and diesel fuel combustion. The emissions factors shown in the exhibit reflect the combustion emissions only from these fuels, and do not include emissions due to fuel extraction, processing, and transportation. Consequently, the estimates of emission reductions realized by reducing the use of these fuels are underestimated in this analysis by an amount equal to the non-combustion related lifecycle emissions of each fuel.

Exhibit 4: Fossil Fuel Emissions Factors

Fossil Fuel	Energy Units	CO_2e Emissions Factor
Natural Gas	MMBtu	53.06 kg CO_2e per MMBtu
California Reformulated Gasoline	Gallons	8.55 kg CO_2e per gallon
Diesel Fuel	Gallons	10.05 kg CO_2e per gallon

Developing an appropriate emissions factor for electricity is a more complex matter. The estimate needs to consider the mix of electric generating technologies that would be affected by each strategy, and the emission rate for each technology. This mix changes over time for a variety of reasons, including improvements in technology and implementation of policies (such as the renewable portfolio standard). Additionally, the mix of generating technologies used varies throughout the day and throughout the year, reflecting varying base load and peak load requirements.

To assess the emissions impacts of strategies that affect electricity demand, or that displace fossil electricity generation, a detailed analysis of the electric sector is required that considers impacts on the future construction of generation capacity as well as the use of the available capacity in each year. The modeling frameworks used in this analysis do not have a detailed electric sector model capable of considering the full set of the factors affecting emissions from the electric sector. The CPUC has recently initiated development of additional modeling tools that will assist in assessing the emissions impacts of alternative electric sector policies. While these tools will improve future assessments, they were not available for this analysis.

Therefore, simplifying assumptions were used to characterize the emissions impacts of strategies that affect electricity demand and supply. These assumptions focus on developing standardized emissions factors that are appropriate to use for estimating impacts in 2020. The emissions factors are used for two purposes in this analysis. First, they are used to calculate the emissions impacts of the strategies in 2020. Second, they are used to calculate the net cost of the strategies in terms of dollars per ton of emissions reduced.

As mentioned above, the changes in electricity demand and supply resulting from the strategies will affect the construction of new generation capacity. Because we are focusing on impacts in 2020, this approach emphasizes the mix of new generation capacity that will be avoided in 2020. We use the following assumptions to characterize this mix of avoided new generation capacity:

- Avoided Fossil Generation: The avoided fossil generation power plant is defined as a gas fired combined cycle unit, with a heat rate of 7,000 Btus per kWh. This level of performance is anticipated, and is a reasonable representation of a new power plant that may be avoided due to reduced demand or displacement by renewable energy sources. The emissions from this representative plant are estimated at 370 kg per MWh (815 pounds per MWh).
- Avoided Renewable Generation: By 2020, renewable generation is expected to be at least 20% of electric supply. The IOUs are committed to achieving this level of renewables by 2010, and the municipal utilities are expected to achieve this level prior to 2020. Therefore,

reductions in electricity demand in 2020 will reduce generation from the entire mix of generating assets, including renewable generation. While some renewable electric supply has zero direct GHG emissions (e.g., wind), data provided by the CPUC indicate that geothermal sources may have emissions on the order of 22.7 kg per MWh (50 pounds per MWh). Based on recent CEC staff scenario analysis showing that geothermal sources may account for about one-third of renewable energy production,[2] we estimate emissions from the renewable portion of electric power generation to be 7.6 kg per MWh.

- Transmission Losses: Transmission losses need to be considered. Because these losses are a function of actual power flows, we again are required to make simplifying assumptions to produce usable estimates. Based on CPUC data, we estimate that losses from in-state generation are about 4.5% and losses from out-of-state generation are about 7.5%. Further, we assume that 80% of the new generation would come from in-state sources, with the remainder coming from out-of-state sources (similar to the current supply ratio).

Using these assumptions and data, we estimate the emissions factors shown in Exhibit 5. The emission factor for reduced electricity demand reflects the fact that the avoided electricity generation comes from both fossil and renewable sources in 2020.[3] The fossil-renewable mix of 80% and 20% respectively is used (in anticipation of the 20% RPS being achieved by both investor owned utilities and municipal utilities). The emission factor for increased renewable electricity production reflects that the renewable generation would displace fossil generation, and likely be used to achieve the required renewable energy goal for electricity generation. Consequently, the emission factor for increased renewable energy production is calculated to displace fossil fuel only. We recognize that interactions among the strategies will affect the emission impacts. Below we discuss how these interactions were addressed.

The details of the calculations used to develop the standardized emission factors for electricity are shown in Exhibit 6. The top part of the exhibit shows the parameters used in the calculation. The bottom part of the exhibit shows the intermediate calculations, and the final estimates at the bottom.

Exhibit 5: Standardized Emission Factors for Electricity

Climate Strategy Impact	Emissions Factor (CO_2e)	Comment
Reduced electricity demand, for example due to improve efficiency	313 kg per MWh of electricity avoided	Reduced demand avoids the use of both fossil and renewable electric energy in 2020. The emission factor uses a mix of 80% fossil and 20%renewable.
Increased renewable energy production, for example from forest biomass or landfill gas	390 kg per MWh of fossil electric generation displaced	Increased renewable energy production will displace the fossil portion of the electric generation mix.

[2] *Scenario Analysis of California's Electricity System: Preliminary Results for the 2007 Integrated Energy Policy Report* may be downloaded from www.energy.ca.gov/2007publications/CEC-200-2007-010/CEC-200-2007-010-SD.PDF.

[3] The solar strategy is treated as a reduction in electric demand at the customer meter, and consequently the emission factor for reduced demand is used to evaluate the solar strategy.

Exhibit 6: Calculation Details for the Standardized Electricity Emissions Factor

Estimating Parameters		Source
815	pounds of CO_2/MWh for gas combined cycle generating unit	CEC estimate
80%	portion of additional capacity that will be generated from fossil sources	20% RPS requirement
20%	portion of additional capacity that will be generated from renewable resources	20% RPS requirement
33%	portion of renewable resources that comes from geothermal electric generation	CEC estimate
50	pounds of CO_2/MWh for geothermal electric generation	CEC estimate
0	pounds of CO_2/MWh for non-geothermal renewable electric generation	CEC estimate
20%	portion of additional capacity expected to be from out-of-state generation	CEC estimate
80%	portion of additional capacity expected to be from in-state generation	CEC estimate
7.5%	transmission losses associated with out-of-state generation	CEC estimate
4.5%	transmission losses associated with in-state generation	CEC estimate
Calculations		
881	pounds of CO2/MWh for out-of-state fossil generation, considering transmission losses (815 / (1-0.075))	
17.8	pounds of CO2/MWh for out-of-state renewable generation, considering transmission losses (0.33 x 50) / (1-0.075)	
708	pounds of CO2/MWh on average for out-of-state generation considering fossil/renewable mix and transmission losses (881 x 0.8 +17.8 x 0.2)	
853	pounds of CO2/MWh for in-state fossil generation, considering transmission losses (815 / (1-0.045))	
17.3	pounds of CO2/MWh for in-state renewable generation, considering transmission losses (0.33 x 50) / (1-0.075)	
686	pounds of CO2/MWh on average for in-state generation considering fossil/renewable mix and transmission losses (853 x 0.8 +17.8 x 0.2)	
690	**pounds of CO_2/MWh on average for generation considering fossil/renewable mix, transmission losses, and in/out of state mix (708 x 0.2 + 686 x 0.8)**	
313	**kg of CO_2/MWh on average for generation considering fossil/renewable mix, transmission losses, and in/out of state mix (690 / 2.2046)**	
390	**kg of CO_2/MWh on average for generation considering fossil generation only (no renewables), transmission losses, and in/out of state mix (881 x 0.2 + 853 x 0.8) / 2.2046**	

In addition to the GHG emissions from the use of fossil fuels, we also estimate the emissions of three criteria pollutants from fossil fuel combustion: reactive organic gases (ROGs); nitrogen oxides (NOx), and particulate matter (PM10). Recognizing that the emission rates for these pollutants vary depending on the specific technologies used, we adopted the representative emission factors shown in Exhibit 7 as indicative of the magnitude of emissions avoided due to reduced energy consumption.

Strategy-specific emissions estimates were developed as needed. For example, the ARB strategies that focus on high GWP gases estimate emissions using data specific to the processes being addressed. Similarly, methane emissions from landfills were estimated using methods and data specific to California landfill conditions. Criteria air pollutant emissions impacts were also estimated for strategy-specific conditions. For example, the avoided criteria air pollutant emissions due to reductions in wildfires were estimated for the forestry strategy that focuses on hazardous fuel removal from forest lands. The strategy descriptions in Attachment B describe the manner in which the strategy-specific emissions were estimated.

Exhibit 7: Criteria Pollutant Emission Factors

Fuel	Emission Factors		
	ROGs	**NOx**	**PM10**
Electricity	(not estimated)	0.018 kg/MWh	0.018 kg/MWh
Gasoline: up stream emissions avoided by reduced fuel use	0.33 kg/1,000 gallons	0.022 kg/1,000 gallons	0.066 kg/1,000 gallons
Gasoline: combustion emissions avoided by reduced vehicle use	4.4 kg/1,000 gallons	9.3 kg/1,000 gallons	0.9 kg/1,000 gallons
Diesel Fuel: combustion emissions avoided by reduced fuel use	11.0 kg/1,000 gallons	140 kg/1,000 gallons	0.25 kg/1,000 gallons
Emissions from electricity production estimated for a natural gas fired turbine meeting BACT limits with a heat recovery steam generator. Gasoline and diesel fuel emissions factors based on estimates for vehicles and heavy duty vehicles respectively. The up stream emissions factors for gasoline are used to estimate avoided emissions associated with the Vehicle Climate Change Standards. The combustion emissions avoided for gasoline are used to estimate avoided emissions associated with reduced vehicle use (reduced vehicle miles traveled). The emissions factors for diesel fuel are used primarily to estimate avoided emissions associated with the Diesel Anti-Idling and Heavy Duty Vehicle Emission Reduction strategies.			

2.2.2 Energy Prices

Energy prices are an important component of the climate strategy and macroeconomic impact analyses. Energy prices are used to estimate savings: for example, the value of gasoline saved. In some cases, energy consumption is shifted from one fuel to another, such as shifting from diesel electric generation to grid-supplied electricity. The energy prices are used to assess the costs and savings associated with such switches in supply.

To apply a consistent set of energy prices, including energy prices that are consistent with the GHG emissions baseline used in the 2006 CAT Report, we adopted the energy price forecasts that were used in the 2005 Integrated Energy Policy Report (IEPR). Exhibit 8 shows these price forecasts for oil, gasoline, diesel fuel, and natural gas through 2020. These figures are expressed in real 2006 dollars.

When viewed in the current energy price environment, the forecast for crude oil, gasoline, and diesel fuel prices appears to be substantially lower than what is now expected. However, we retained these 2005 IEPR price forecasts to be consistent with the baseline economic and emissions forecast used in the previous macroeconomic analysis. The implications of higher future prices than the forecasts used here include:

- higher future fossil fuel prices may tend to reduce the growth in future GHG emissions from fossil fuels, so that fewer emission reductions are required to achieve the State's 2020 emissions target; and

- higher future fossil fuel prices will increase the value of the savings from energy efficiency and improve the competitiveness of alternative energy sources, tending to make it less costly to reduce emissions.

Consequently, the energy price forecasts used in this analysis are conservative, in that the costs associated with achieving the emissions target are likely overstated.

To be consistent with these forecast fuel prices, we prepared an electricity price forecast that is derived from the natural gas price forecast. As discussed above, the fossil electricity generation that we expect to avoid through the implementation of energy efficiency strategies and increased renewable power production will be produced from a gas-fired combined cycle facility. Therefore, we calculated the avoided cost of electricity production using the gas price forecast and cost factors for such a facility.

To ensure consistency across the strategies, and in particular, to ensure that the cost of electricity used in this analysis is consistent with the cost of electricity used by the CPUC and the CEC in their regulatory programs, we relied on an avoided cost model used by the CPUC.[4] The avoided cost model estimates a long run marginal cost for power generation, plus externalities costs (criteria pollutant and GHG emissions), transmission and distribution costs, and reliability costs. Calculations were performed for each of the three IOUs (PG&E, Southern California Edison, and San Diego Gas and Electric), taking into consideration utility-specific factors. The model produces hourly prices through 2030, so that 8,760 prices are calculated for each year for each utility.

Exhibit 8: Energy Price Forecast

Year	Crude Oil ($/barrel)	Gasoline ($/gallon)	Diesel Fuel ($/Gallon)	Gas Price ($/MMBtu)
2007	$35.32	$2.20	$2.14	$8.17
2008	$35.32	$2.20	$2.14	$6.55
2009	$35.32	$2.20	$2.14	$6.45
2010	$35.32	$2.20	$2.14	$5.25
2011	$35.37	$2.20	$2.14	$6.56
2012	$35.42	$2.20	$2.14	$6.09
2013	$35.48	$2.20	$2.14	$7.15
2014	$35.53	$2.20	$2.14	$6.42
2015	$35.58	$2.20	$2.14	$7.20
2016	$36.10	$2.22	$2.16	$7.13
2017	$36.61	$2.23	$2.17	$7.03
2018	$37.14	$2.24	$2.18	$7.36
2019	$37.66	$2.27	$2.20	$7.69
2020	$38.17	$2.28	$2.21	$7.69
All prices in 2006 dollars.				

[4] The avoided cost model used in the energy efficiency proceeding, and related documentation, is available at: http://www.ethree.com/cpuc_avoidedcosts.html.

For this analysis, the avoided cost model was used with the following assumptions:

- natural gas combined cycle generating unit with a heat rate of 7,000 Btu/kWh;
- natural gas price forecast from the 2005 IEPR (Exhibit 8);
- no inflation (all analysis done in real, 2006 dollars); and
- no externality costs (which we consider separately in this analysis).

The individual results for each of the three IOUs were produced. The costs were estimated with and without transmission and distribution costs, so that the avoided costs for power generation alone could be estimated separately. The individual IOU results were weighted by sales volume for each of the 8,760 hours to produce three standardized sets of statewide prices:

- Prices Applied to Energy Efficiency Savings: The energy efficiency programs implemented by the IOUs and municipal utilities are expected to reduce electricity use primarily during the day on week days. This time period is most relevant because the largest components of the efficiency savings are for commercial lighting and commercial/residential air conditioning. Consequently, the standardized electricity price was calculated using the time-of-use periods defined by the utilities that encompass 9:00 AM through 9:00 PM on weekdays year round. Each hour is weighted equally, even though more electricity is likely conserved during the summer months when electric prices are higher. Consequently, the electricity price estimate may be conservative (i.e., low) when applied to the energy efficiency strategies.
- Prices Applied to Solar Power Generation: The solar energy strategy results in solar electric generation at customer sites. Using hourly photovoltaic energy generation for an average of six California cities,[5] a standardized price was calculated using the relative amount of electricity generated each hour of the year. Using this approach, the electric price reflects the pattern of solar power generation across the day and across the year.
- Prices Applied to Renewable Power Generation: The renewable power generation in several of the strategies is best characterized as base load generation, with high utilization rates. The standardized price for the electricity displaced by this new generation was computed using the average of all 8,760 hours. The transmission and distribution (T&D) costs were excluded from these prices, so that only the avoided generation costs are included in this price estimate. The T&D capital costs were excluded because such costs would not be avoided when centralized renewable generation displaces centralized fossil generation.

The three electricity price estimates resulting from these methods are presented in Exhibit 9. The prices represent the marginal cost of avoided electricity.[6] As shown in the table, the prices applied to energy efficiency savings are highest due to the hours that are used to estimate the standardized price. The prices applied to solar power generation are lower because solar generation includes weekend days, which are excluded from the prices for Energy Efficiency. The prices applied to renewable power generation are the lowest of the three, due to the use of all 8,760 hours to calculate the standardized price, and the exclusion of T&D capital costs.

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[5] The hourly pattern of solar generation was computed using from PVWATTS: Hourly PV Performance Data for six CA cities: San Diego; Los Angeles; Bakersfield; Fresno; San Francisco; and Sacramento. The data were developed using the tools at: http://rredc.nrel.gov/solar/codes_algs/PVWATTS/version1/version1_index.html#map.

[6] The marginal cost of avoided electricity differs from the average cost. In particular, the average cost includes costs that cannot be avoided by marginal changes in future demand and supply.

Exhibit 9: Forecast of Annual Standardized Prices of Electricity Avoided Using the 2005 IEPR Natural Gas Price Forecast

Year	Price of Electricity Avoided ($/MWh)			Gas Price ($/MMBtu)
	Applied to Energy Efficiency Savings	Applied to Solar Power Generation	Applied to Renewable Power Generation	
2007	$110.88	$108.92	$77.12	$8.17
2008	$99.85	$97.99	$68.42	$6.55
2009	$98.90	$97.10	$67.63	$6.45
2010	$87.14	$86.04	$58.19	$5.25
2011	$100.07	$98.24	$68.50	$6.56
2012	$95.49	$93.95	$64.76	$6.09
2013	$106.10	$103.98	$73.18	$7.15
2014	$99.01	$97.32	$67.44	$6.42
2015	$106.69	$104.59	$73.52	$7.20
2016	$106.12	$104.08	$73.00	$7.13
2017	$105.25	$103.28	$72.25	$7.03
2018	$108.55	$106.41	$74.85	$7.36
2019	$111.85	$109.54	$77.46	$7.69
2020	$111.82	$109.53	$77.39	$7.69

To examine the sensitivity of the results to the natural gas and electricity price forecasts, we used an alternative natural gas price forecast from the CPUC known as the Market Price Referent. The methods described above were used to calculate electricity prices, and the results are presented in Exhibit 10. Comparing the results from the two forecasts, the CPUC natural gas prices are higher in the early years, and then lower in the later years. As a result, the electric price in 2020 is calculated to be lower when based on the Market Price Referent forecast.

Although the electricity prices presented above incorporate many of the primary factors affecting future electricity prices, this approach remains simplified. Similar to the discussion above of emissions from the electric sector, a more complete analysis of the electric sector is needed to capture all the potential price effects from the strategies.

2.2.3 Strategy Interactions and Potential Double Counting

To estimate properly the costs, savings, and emissions impacts of the climate strategies as a group, we must consider the interactions among the strategies and identify conditions under which emission reductions may be inadvertently double counted. Based on our review of the strategies currently included in the analysis, we have identified two types of interactions for attention:

- 33% RPS: The CPUC includes a strategy that would expand the Renewable Portfolio Standard (RPS) to require 33% renewables in the electricity supply by 2020. As described above, the emission factor for electricity generation avoided is based on a 20% penetration of renewable power in 2020. Consequently, if the RPS is increased to 33%, the strategies that reduce the demand for electricity (such as the energy efficiency strategies) will be avoiding electricity generation in the future that is cleaner than originally expected. Consequently, the overall emission reductions from the combined set of strategies will be less than the sum of the emission reductions calculated for the strategies independently.

- Renewable Power Production: Several strategies propose to increase electricity production from renewable energy sources, such as forest biomass, municipal solid waste, and landfill gas. Insofar as these renewable energy supplies are used by the utilities to achieve their required RPS levels of renewable power production, the emissions impacts of the renewable power from the forest, waste, and landfill strategies are already reflected in the 20% RPS baseline or the 33% RPS strategy. Consequently, it may be inappropriate to count the emission reduction from displacing fossil-fuel-based electricity generation with renewable energy as part of the individual strategies because the emissions impacts may already counted in the RPS data.

Exhibit 10: Forecast of Annual Average Prices of Electricity Avoided Using the Market Price Referent Natural Gas Price Forecast

Year	Average Price of Electricity Avoided ($/MWh)			Gas Price ($/MMBtu)
	Applied to Energy Efficiency Savings	Applied to Solar Power Generation	Applied to Renewable Power Generation	
2007	$110.88	$108.92	$77.12	$8.45
2008	$116.43	$113.61	$81.68	$8.23
2009	$111.15	$108.65	$77.42	$7.69
2010	$106.16	$103.96	$73.40	$7.18
2011	$101.76	$99.83	$69.85	$6.73
2012	$99.09	$97.34	$67.64	$6.45
2013	$96.41	$94.85	$65.43	$6.17
2014	$93.93	$92.54	$63.38	$5.91
2015	$91.44	$90.22	$61.32	$5.65
2016	$92.41	$91.16	$62.03	$5.74
2017	$94.25	$92.92	$63.45	$5.92
2018	$95.88	$94.47	$64.72	$6.08
2019	$98.00	$96.48	$66.37	$6.29
2020	$99.72	$98.12	$67.72	$6.46

To take into account the potential double counting from these strategy interactions, the potential double-counted emission reduction impacts were calculated explicitly and subtracted from the totals. The potentially double-counted emissions associated with the 33% RPS strategy are reported below as part of that strategy. The potentially double-counted emission reductions associated with renewable power production from forest biomass, municipal solid waste, and landfill gas are reported individually for those strategies.[7]

[7] Situations may arise in which the power produced from landfill gas, municipal waste, or forest biomass is not counted toward achieving the RPS. In such situations, more emission reductions would be

For two strategies, grid-supplied electricity consumption is expected to increase. In these cases, the additional emissions associated with the electric supply are considered within the individual strategies as indicated by the MWh of electric consumption anticipated. Additionally, the California Solar Initiative includes an energy efficiency component for new construction. The energy efficiency associated with this component of the solar program is not counted in this analysis, thereby avoiding potential double counting with the energy efficiency strategies.

Additional interactions may become important among the climate strategies in future analyses. For example, the Low Carbon Fuel Standard (LCFS) will interact with other strategies that reduce emissions from transportation, such as the vehicle emissions standards and the fuel efficient tires strategy. However, because the LCFS is not included in this analysis, these interactions are not considered at this time.

2.2.4 Cost and Savings Estimates

To improve the transparency and consistency of the costs and savings estimates for the strategies, this analysis adopted a standardized approach for reporting costs and savings for each strategy.

- Capital Costs: Capital costs include investments in equipment or facilities with lifetimes of multiple years. All capital costs are included, regardless of the entity that incurs the cost. All capital costs were reported in the years in which they would be incurred.[8]
- Operating and Maintenance Costs: All operating and maintenance costs were reported in the years in which they would be incurred. All costs are included, regardless of the entity that incurs the cost.
- Energy Costs and Savings: All energy impacts were reported in energy units in the years in which they would be incurred. A consistent set of energy prices (presented above) were applied to the changes (increases and reductions) in energy consumption.
- Other Costs and Savings: All other costs and savings were reported in the years in which they would be realized, along with an explanation of the basis for the estimates.
- Real 2006 Dollars: All costs and savings were reported in real 2006 dollars (unless otherwise noted).

The updated climate strategy data reported in Attachment B reflect this overall approach to reporting costs.

Having the cost and savings data at this specified level of detail enabled this analysis to apply a consistent method for summarizing the costs and savings of each strategy, and for representing the costs and savings in the macroeconomic analysis. Recognizing that facilities and equipment purchased with capital expenditures typically create a stream of emissions impacts over time, the capital costs were "levelized" across the lifetime of the relevant equipment and facilities to maintain a constant relationship to the emission reduction achieved in each year. This approach requires that an appropriate portion of the capital cost be "paid for" in each year

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achieved than the amounts reported here because there would be no need to subtract potential double-counted emissions.

[8] For example, the incremental capital costs of energy efficiency measures were included as part of the capital cost. These capital costs are incurred by customers installing the measures, and are offset (partially) by utility-provided rebates. The rebates represent a fund transfer (funds collected from all ratepayers are used to provide rebates to those customers that participate in the energy efficiency program). However, the rebate does not reduce the capital costs themselves, which are counted in their entirety as a cost within the analysis.

in which emission reductions are realized. A real 5% discount rate was used to levelize the capital costs.

For example, assume a capital cost of $100 is expended to purchase equipment that reduces emissions each year by two metric tons over its 10-year useful life. The $100 capital cost is spread over the 10 year period using a 5% discount rate, so that it is represented as 10 equal costs of $13 each year for 10 years. The present value of this stream of costs is $100, when evaluated using a 5% discount rate. In this manner, the capital cost is spread over the 10 years, so that each year the capital cost of $13 can be divided by two tons, producing an estimate of $6.5 per ton of emission reduction for the capital cost of the equipment.

Using this approach, the costs and savings associated with a strategy in any given year are equal to the sum of: the levelized capital cost for that year; the operating and maintenance cost in that year; the value of the energy savings or costs in that year; and any other strategy-specific savings or costs identified for that year. These data are used to estimate the cost effectiveness of each strategy in terms of dollars per ton of emissions avoided. Additionally, the estimated costs and savings are used in E-DRAM and BEAR as input to the macroeconomic analyses.

2.3 Climate Strategy Results

The resulting emissions, costs, and savings estimates are presented in Exhibit 11 for each of the strategies included in this analysis, including:

- name of the strategy;
- lead agency for the strategy;
- whether the strategy was updated for this analysis;
- emission reduction estimated for the strategy in 2020;
- potential double-counted emission reduction for the strategy in 2020, as discussed above in section 2.2.3;
- cost estimated for the strategy in 2020; and
- savings estimated for the strategy in 2020.

Exhibit 12 presents the energy impacts estimated for each of the strategies. In addition to the fuel and electricity impacts, the estimated emission reduction associated with the fuel and electricity impacts is reported for each strategy. The data in Exhibit 12 show the portion of the emission reduction estimated for each strategy that is due to changes in fossil energy consumption (or production).

The total emission reduction estimated for 2020 across the strategies included in this analysis is about 138 million metric tons of CO_2 equivalent ($MMTCO_2e$). Of this amount, about 6 $MMTCO_2e$ may be double counted due to interactions among the strategies. The net emission reduction is therefore about 132 $MMTCO_2e$ in 2020.

Exhibit 11 also shows the total costs and savings estimated for 2020. The total savings exceed the total costs, primarily due to the vehicle climate change standards and the energy efficiency programs and standards. These strategies were estimated to have savings that exceed costs by substantial amounts. The cost and savings estimates for each of the strategies were used as input to the macroeconomic analysis conducted using E-DRAM and BEAR.

The total emission reduction of about 132 $MMTCO_2e$ is a substantial reduction compared to the 193 $MMTCO_2e$ estimated in the 2006 CAT Report. Attachment A presents the previous

2006 estimates and the revised estimates for each strategy. The primary factors leading to the reduced estimates of emission reductions are the following:

- Electricity emissions factor: The emission factor for avoided electricity generation in 2020 used in this analysis is 40% less than the emissions factor that was used in the 2006 CAT Report. This revised assumption reduces the emissions impact by more than 14 $MMTCO_2e$. As discussed above, more detailed modeling capabilities for the electric sector that are under development will help improve the estimates of emissions impacts due to changes in electricity supply and demand.
- Revised forestry strategies: Several of the forestry strategies were revised substantially to report annual carbon sequestration in 2020 rather than cumulative sequestration through 2020. As a result, the forestry strategy impacts are reduced by approximately 25 $MMTCO_2e$ in 2020. These strategies are among those undergoing additional refinement, so that the emission impact estimates will continue to evolve.
- Strategies undergoing significant revision: Several strategies undergoing significant revision are not estimated for this analysis. Examples of these strategies are the CPUC Electric Sector Carbon Policy strategy and the Combined Heat and Power (now Self Generation Incentive Program) strategy. The 2006 CAT Report included about 7 $MMTCO_2e$ of emission reductions from these strategies.

Various strategy-specific revisions also resulted in other changes in the emissions estimates. As discussed above, multiple newly developed strategies that were not included in the 2006 CAT Report are not included in this analysis and are not shown in Exhibit 11 and Exhibit 12. The newly developed strategies will add additional emission reductions to the totals presented, possibly by significant amounts. Descriptions of the updated strategies are presented in Attachment B.

Using the estimates in Exhibit 11, the net cost of each strategy can be calculated in terms of dollars per ton of emissions avoided in 2020 as follows:

Net Cost ($/ton) = (Costs – Savings) / Emission Reduction.

However, many of the strategies have multiple benefits that are not captured in the savings estimates reported in Exhibit 11. For many strategies, the non-climate benefits are substantial, in particular because the 2006 CAT Report focused on identifying strategies with multiple significant benefits. Consequently, the net cost estimate is biased for many of the strategies.

To address a portion of this bias, we can calculate the value of the avoided criteria pollutant emissions using the criteria pollutant emission factors discussed above (see Exhibit 7) and values for avoiding these emissions. Based on analyses of the cost of reducing criteria pollutant emissions in the State, ARB proposes values for this net cost calculation of: $12,500/ton for reactive organic gases (ROGs); $20,800/ton for nitrogen oxides (NOx); and $20,000/ton for particulate matter (PM10). The revised net cost calculation is:

Net Cost ($/ton) = (Costs – Savings – Value of Avoided Criteria Pollutant Emissions) / Emission Reduction.

The results of these calculations are shown in Exhibit 13. The net cost of the strategies covers a broad range. The negative net cost values indicate that savings exceed costs. Strategies with high positive values have costs that exceed the savings. Exhibit 14 presents the data graphically. As shown in the graph, the net cost is along the horizontal axis and the emission reduction is along the vertical axis. The strategies with the largest emission reductions are identified. The graph shows that most of the strategies have negative net costs.

Although the net cost calculation includes the value of the avoided criteria pollutant emissions, multiple other benefits are not captured by the estimates. For example, the Urban Forestry strategy produces storm water runoff benefits, improves aesthetics, and can increase property values. These benefits are not captured. Similarly, the California Solar Initiative strategy has significant benefits related to distributed generation and diversity of energy supply that are not reflected. The full health benefits of reducing PM10 emissions in heavily impacted areas near port facilities are not captured for the Shore Electrification strategy. Consequently, the figures remain an incomplete evaluation of the full benefits of some of the strategies. The non-quantified benefits of the strategies are identified in the updated strategy descriptions in Attachment B.

Exhibit 11: Updated Estimates for 2020 for the Climate Strategies Included in the 2006 CAT Report

Updated Strategy in This Report	Agency	Updated?	Emission Reductions ($MMTCO_2e$)	Potential Double-Counted Emission Reductions ($MMTCO_2e$)	Costs (millions 2006$)	Savings (millions 2006$)
Vehicle Climate Change Standards	ARB	No	30		$1,331	$6,643
Diesel Anti-Idling	ARB	No	1.46		$58	$322
Other New Light Duty Vehicle Technology Improvements	ARB	No	5.4		$1,569	$1,355
HFC Reduction Strategies	ARB	Yes	8.7		$276	$201
Transport Refrigeration Units (on and off road)	ARB	Yes	0.02		$21	$13
Shore Electrification	ARB	Yes	0.55		$150	$119
Manure Management	ARB	No	1		$45	$9
PFC Emission Reduction for Semiconductor Manufacturers	ARB	Yes	0.53		$27	$0
Alternative Fuels: Biodiesel Blends	ARB	No	0.8		$0	$0
Alternative Fuels: Ethanol	ARB	No	2.38		$3,102	$2,233
Heavy-Duty Vehicle Emission Reduction Measures	ARB	Yes	3.15		$136	$698
Reduced Venting and Leaks in Oil and Gas Systems	ARB	Yes	1		$10	$9
Hydrogen Highway*	ARB	No	--		--	--
Achieve 50% Statewide Recycling Goal	IWMB	No	3		$82	$0
Landfill Methane Capture	IWMB	Yes	2.66	0.86	$61	$171
Zero Waste—High Recycling	IWMB	Yes	3	0.00	$180	$111
Conservation Forest Management	Forestry	Yes	2.35		$4	$0
Forest Conservation	Forestry	Yes	0.4		$15	$0
Fuels Management/Biomass	Forestry	Yes	3.0	1.80	$1,305	$1,559
Urban Forestry	Forestry	Yes	0.88	0.69	$287	$155
Afforestation/Reforestation	Forestry	Yes	1.98		$21	$0
Water Use Efficiency	DWR	Yes	0.51		$90	$358

Updated Strategy in This Report	Agency	Updated?	Emission Reductions ($MMTCO_2e$)	Potential Double-Counted Emission Reductions ($MMTCO_2e$)	Costs (millions 2006$)	Savings (millions 2006$)
Building Energy Efficiency Standards in Place	CEC	Yes	2.14		$255	$658
Appliance Efficiency Standards in Place	CEC	Yes	4.48		$509	$1,489
Fuel-Efficient Tires & Inflation Programs	CEC	Yes	0.12		$1	$32
Cement Manufacturing	CEC	No	1		$3	$8
Comprehensive Municipal Utility Program	CEC	Yes	18.0		$1,848	$2,147
Alternative Fuels: Non-Petroleum Fuels*	CEC	No	0			
Measures to Improve Transportation Energy Efficiency and Smart Land Use and Intelligent Transportation[1]	BTH	Yes	18.67		$2,190	$2,190
Conservation tillage/cover crops*	Food/Ag	No	--		--	--
Enteric Fermentation	Food/Ag	No	1		$3	$0
Green Buildings Initiative	SCSA	Yes	1.8		$559	$559
Transportation Policy Implementation*	SCSA	No	--		--	--
Accelerated RPS to 33% by 2020	CPUC	Yes	8.2	2.66	$100	$0
California Solar Initiative	CPUC	Yes	0.92		$890	$322
IOU Energy Efficiency Programs	CPUC	Yes	3.66		$987	$1,186
IOU Additional Energy Efficiency Programs	CPUC	Yes	5.60		$1,690	$1,790
IOU CHP (Self Generation Incentive Program)	CPUC	Yes	TBD		TBD	TBD
IOU Electricity Sector Carbon Policy (including SB 1368 Implementation for IOUs)	CPUC	Yes	TBD		TBD	TBD
Total			**138.3**	**6.00**	**$17,805**	**$24,337**

* The 2006 CAT Report did not include emission reduction estimates, costs, or savings for the strategies marked with an asterisk.

1. The full benefits of the transportation measures have not been estimated. See text.

TBD = Updated estimates remain To Be Determined.

Multiple newly developed strategies that were not in the 2006 CAT Report are not included in this analysis. Examples include the Low Carbon Fuel Standard and other strategies being considered for early action and for the Scoping Plan. Many of the strategies are continuing to be refined.

Exhibit 12: Energy Impacts for 2020 for the Updated Climate Strategies Included in the 2006 CAT Report

Updated Strategy in This Report	Agency	Avoided Gasoline (Million gallons)	Avoided Diesel (Million gallons)	Avoided Natural Gas (MMBtu)	Renewable Electric Supply (MWh)	Avoided Electric Demand (MWh)	Emission Reduction ($MMTCO_2e$)
Vehicle Climate Change Standards	ARB	3,033					**25.9**
Diesel Anti-Idling	ARB		146				**1.5**
Other New Light Duty Vehicle Technology Improvements	ARB	595					**5.1**
HFC Reduction Strategies	ARB					1,796,000	**0.56**
Transport Refrigeration Units (on and off road)	ARB		6			-116,258[d]	**0.02**
Shore Electrification	ARB		86			-1,000,000	**0.55**
Manure Management	ARB						**(a)**
PFC Emission Reduction for Semiconductor Manufacturers	ARB						**0**
Alternative Fuels: Biodiesel Blends	ARB						**(a)**
Alternative Fuels: Ethanol	ARB						**(a)**
Heavy-Duty Vehicle Emission Reduction Measures	ARB	11	304				**3.15**
Reduced Venting and Leaks in Oil and Gas Systems	ARB						**0**
Hydrogen Highway*	ARB						**(b)**
Achieve 50% Statewide Recycling Goal	IWMB						**0**
Landfill Methane Capture	IWMB				2,210,000		**0.86**
Zero Waste—High Recycling	IWMB				601,155		**0.23**
Conservation Forest Management	Forestry						**0**
Forest Conservation	Forestry						**0**
Fuels Management/Biomass	Forestry	125[e]			4,609,000		**2.86**
Urban Forestry	Forestry				1,764,000	163,000	**0.74**
Afforestation/Reforestation	Forestry						**0**
Water Use Efficiency	DWR					1,626,000	**0.51**
Building Energy Efficiency Standards in Place	CEC			9,603,440		5,219,688	**2.14**
Appliance Efficiency Standards in Place	CEC			9,926,840		12,635,358	**4.48**
Fuel-Efficient Tires & Inflation Programs	CEC	14					**0.12**
Cement Manufacturing	CEC						**(a)**

Updated Strategy in This Report	Agency	Avoided Gasoline (Million gallons)	Avoided Diesel (Million gallons)	Avoided Natural Gas (MMBtu)	Renewable Electric Supply (MWh)	Avoided Electric Demand (MWh)	Emission Reduction ($MMTCO_2e$)
Comprehensive Municipal Utility Program	CEC					19,200,000	**6.01**
Alternative Fuels: Non-Petroleum Fuels*	CEC						**(b)**
Measures to Improve Transportation Energy Efficiency and Smart Land Use and Intelligent Transportation	BTH	1,000					**8.55**
Conservation tillage/cover crops*	Food/Ag						**0**
Enteric Fermentation	Food/Ag						**0**
Green Buildings Initiative	SCSA			7,504,225		4,479,887	**1.80**
Transportation Policy Implementation*	SCSA						**(b)**
Accelerated RPS to 33% by 2020	CPUC						**(a)**
California Solar Initiative	CPUC					2,939,007	**0.92**
IOU Energy Efficiency Programs	CPUC			10,650,219		9,874,985	**3.66**
IOU Additional Energy Efficiency Programs	CPUC			18,817,921		14,714,654	**5.60**
IOU CHP (Self Generation Incentive Program)	CPUC						**(c)**
IOU Electricity Sector Carbon Policy (including SB 1368 Implementation for IOUs)	CPUC						**(c)**
Total		**4,779**	**541**	**56,502,645**	**9,184,155**	**71,532,321**	**75.3**

a. Energy impact calculation not broken out separately.
b. Emissions and energy impacts not calculated for this strategy.
c. Energy impact estimates remain to be determined.
d. Negative numbers indicate increased energy consumption.
e. Equivalent gasoline produced from renewable resources (forest biomass).
* The 2006 CAT Report did not include emission reduction estimates, costs, or savings for the strategies marked with an asterisk.
Multiple newly developed strategies that were not in the 2006 CAT Report are not included in this analysis. Examples include the Low Carbon Fuel Standard and other strategies being considered for early action and for the Scoping Plan. Many of the strategies are continuing to be refined.

Exhibit 13: Net Cost Estimates for 2020 for the Updated Climate Strategies Included in the 2006 CAT Report

Updated Strategy in This Report	Agency	Net Cost ($/ton of CO_2e)	
		Without Criteria Air Pollutant Values	With Criteria Air Pollutant Values
Vehicle Climate Change Standards	ARB	-$177.05	-$177.71
Diesel Anti-Idling	ARB	-$180.82	-$486.27
Other New Light Duty Vehicle Technology Improvements	ARB	$39.64	$38.92
HFC Reduction Strategies	ARB	$8.61	$8.44
Transport Refrigeration Units (on and off road)	ARB	$400.00	-$510.26
Shore Electrification	ARB	$56.36	-$407.61
Manure Management	ARB	$36.00	$36.00
PFC Emission Reduction for Semiconductor Manufacturers	ARB	$50.94	$50.94
Alternative Fuels: Biodiesel Blends	ARB	(c)	(c)
Alternative Fuels: Ethanol	ARB	$365.13	$365.13
Heavy-Duty Vehicle Emission Reduction Measures	ARB	-$178.41	-$473.58
Reduced Venting and Leaks in Oil and Gas Systems	ARB	$0.30	$0.30
Hydrogen Highway*	ARB	(a)	(a)
Achieve 50% Statewide Recycling Goal	IWMB	$27.33	$27.33
Landfill Methane Capture	IWMB	-$41.35	-$41.35
Zero Waste—High Recycling	IWMB	$23.00	$23.00
Conservation Forest Management	Forestry	$1.70	$1.70
Forest Conservation	Forestry	$37.50	$37.50
Fuels Management/Biomass	Forestry	-$86.10	-$86.38
Urban Forestry	Forestry	$150.00	$149.85
Afforestation/Reforestation	Forestry	$10.61	$10.61
Water Use Efficiency	DWR	-$525.49	-$528.09
Building Energy Efficiency Standards in Place	CEC	-$188.32	-$190.31
Appliance Efficiency Standards in Place	CEC	-$218.75	-$221.05
Fuel-Efficient Tires & Inflation Programs	CEC	-$258.33	-$259.09
Cement Manufacturing	CEC	-$5.00	-$5.00
Comprehensive Municipal Utility Program	CEC	-$16.60	-$17.47
Alternative Fuels: Non-Petroleum Fuels*	CEC	(a)	(a)

Updated Strategy in This Report	Agency	Net Cost ($/ton of CO_2e)	
		Without Criteria Air Pollutant Values	With Criteria Air Pollutant Values
Measures to Improve Transportation Energy Efficiency and Smart Land Use and Intelligent Transportation	BTH	$0.00	-$16.06
Conservation tillage/cover crops*	Food/Ag	(a)	(a)
Enteric Fermentation	Food/Ag	$3.00	$3.00
Green Buildings Initiative	SCSA	$0.00	-$2.03
Transportation Policy Implementation*	SCSA	(a)	(a)
Accelerated RPS to 33% by 2020	CPUC	$12.20	$12.20
California Solar Initiative	CPUC	$617.39	$614.78
IOU Energy Efficiency Programs	CPUC	-$54.37	-$56.57
IOU Additional Energy Efficiency Programs	CPUC	-$17.86	-$20.00
IOU CHP (Self Generation Incentive Program)	CPUC	(b)	(b)
IOU Electricity Sector Carbon Policy (including SB 1368 Implementation for IOUs)	CPUC	(b)	(b)
Total		**-$47.22**	**-$59.75**

a. Net cost not calculated because emission impacts are not estimated.

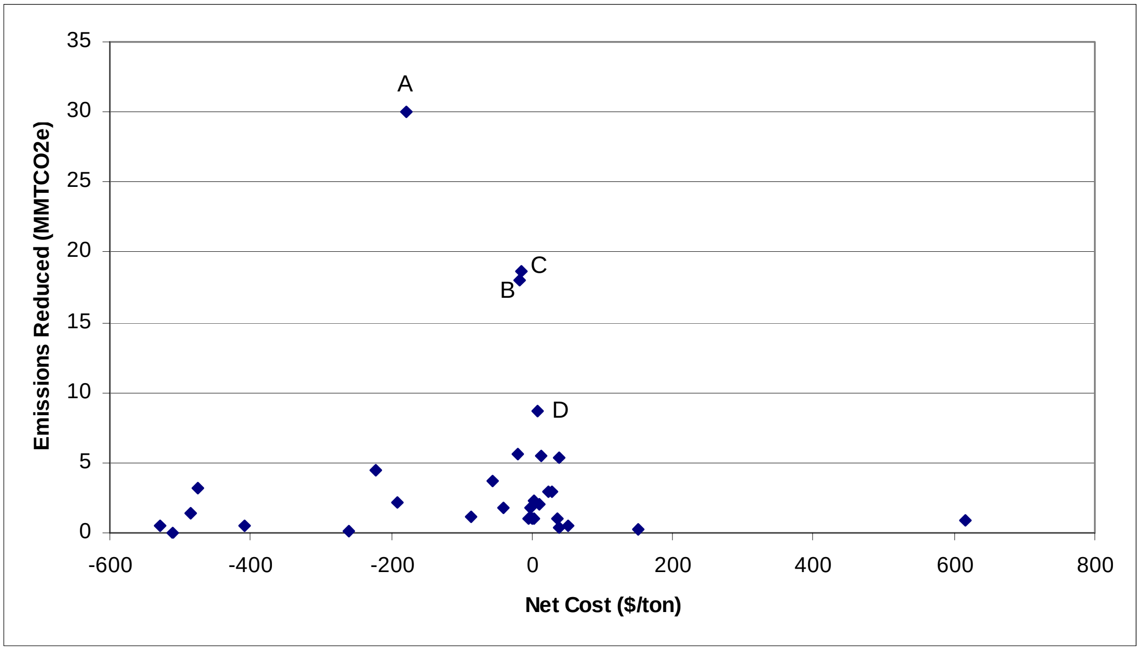
b. Costs, savings, and emission impacts remain to be determined.

c. Net cost not calculated because costs and benefits are not estimated.

* The 2006 CAT Report did not include emission reduction estimates, costs, or savings for the strategies marked with an asterisk.

Multiple newly developed strategies that were not in the 2006 CAT Report are not included in this analysis. Examples include the Low Carbon Fuel Standard and other strategies being considered for early action and for the Scoping Plan. Many of the strategies are continuing to be refined.

Exhibit 14: Graph of Net Cost Estimates for 2020 for the Updated Climate Strategies Included in the 2006 CAT Report



A. Vehicle Climate Change Standard

B. Comprehensive Municipal Utility Program

C. Measures to Improve Transportation Energy Efficiency and Smart Land Use and Intelligent Transportation

D. HFC Reduction Strategies

Negative values for net cost indicate that savings exceed costs.

Multiple newly developed strategies that were not in the 2006 CAT Report are not included in this analysis. Examples include the Low Carbon Fuel Standard and other strategies being considered for early action and for the Scoping Plan. Many of the strategies are continuing to be refined.

3. Modeling Frameworks and Scenarios Evaluated

3.1 Introduction

This section presents the modeling frameworks used to update to the macroeconomic analysis, and defines the scenarios analyzed. This analysis expands on the macroeconomic analysis in the 2006 CAT Report in three main respects. First, the 2006 CAT Report relied on a single modeling framework to evaluate impacts. This analysis uses two independent models with diverse designs and capabilities:

- Environmental Dynamic Revenue Analysis Model (E-DRAM) – provided by the Air Resources Board (ARB); and
- Berkeley Energy and Resources (BEAR) Model – provided by U.C. Berkeley.

The models have varying strengths and weaknesses, with differing levels of detail for individual sectors. Through the use of multiple models we provide a more robust assessment of potential impacts.

Second, the 2006 CAT Report analyzed a single scenario of climate strategies that would be implemented to achieve the State's 2020 emissions target. This updated analysis evaluates and compares multiple scenarios to reflect a range of potential policies and program implementation strategies that may be considered. By analyzing multiple scenarios, the updated analysis helps inform assessments of alternative approaches for achieving the State's 2020 emissions target.

Third, the macroeconomic analysis in the 2006 CAT Report excluded consideration of market-based compliance mechanisms, such as a cap and trade program. This updated analysis includes the consideration of a cap and trade program – reflecting two potential designs identified by the Market Advisory Committee.[a]

While these enhancements to the analysis fulfill the commitment in the 2006 CAT Report, continued improvement is needed in the ability to assess the costs and benefits of alternative policies for addressing global warming. Additional modeling tools are under development by the CPUC and the ARB to improve the ability to understand potential responses by and impacts among the electric sector and other major sectors of the California economy and the economy in the western United States. These tools, when used in combination with one or more of the modeling frameworks employed in this updated analysis, will help further refine our ability to understand the full economic benefits and costs of reducing GHG emissions.

The remainder of this section is organized as follows:

- Section 3.2 presents an overview of the modeling frameworks;
- Section 3.3 presents how the models were harmonized to enable comparisons; and
- Section 3.4 summarizes the scenarios that were analyzed.

[a] *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. Available at: http://www.climatechange.ca.gov/documents/index.html.

3.2 Overview of the Modeling Frameworks

The models used in this analysis are of a similar class: referred to as Computable General Equilibrium (CGE) Models.[a] CGE models are widely used to analyze the aggregate welfare and distributional impacts of policies whose effects may be transmitted through multiple markets.

The conceptual starting point for a CGE model is a circular flow of commodities in a closed economy, represented in Exhibit 15. As shown in the exhibit, the main actors are households and firms. Households own the factors of production (i.e., labor and capital) and are the final consumers of goods and services. Household decisions are based on maximizing utility (i.e., well being) subject to a budget constraint.

Firms rent the factors of production from the households for the purpose of producing goods and services that the households then consume. Firm decisions are based on maximizing profits subject to a production function. The production function represents a given level of technology that transforms factors of production (labor, capital, raw materials) into output. Government's role in the model is passive: to collect taxes and disburse these revenues to firms and households as subsidies and lump-sum transfers, subject to rules of budgetary balance that are specified by the modeler. The models solve for the prices of goods and services and factors of production that make the quantity demanded and supplied equal (i.e., an equilibrium is reached).

When a regulation or a policy is adopted that could affect the costs of production in one part or sector of the economy, the rest of the economy will adjust to the perturbation through price or employment changes. The CGE tracks the changes and estimates how each sector responds to the policy. The main economic indicators presented in this analysis are changes in gross state product, employment, and personal income. We also compute GHG emissions and the estimated price of an emission allowance under the cap and trade program. These indicators are particularly informative for characterizing the impact of potential policies on California's economy.

Although the models have this same underlying design and capability, the models differ in the additional detail they add to specific sectors that may be the subject of particular analyses. For example, E-DRAM is a CGE that was developed to assess the revenue impacts of tax and other State policies. While it was not specifically designed to model climate policy, it can perform this function, and can be used in combination with sector-specific models that provide detail on the responses of specific sectors to emission reduction policies. The BEAR model includes a detailed treatment of several important sectors, providing the ability to model responses from multiple sectors in some detail. The following is a brief overview of the two modeling frameworks.

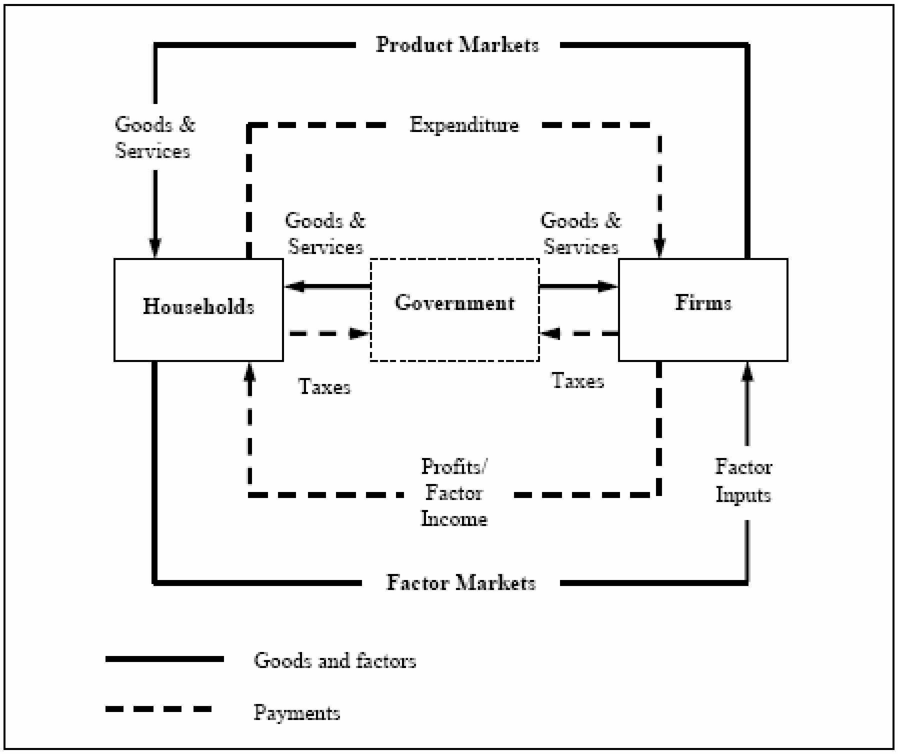
E-DRAM: The Environmental Dynamic Revenue Analysis Model (E-DRAM) is a computable general equilibrium (CGE) model of the California economy developed by Professor Peter Berck of the University of California, Berkeley.[b] E-DRAM was originally developed to assess the revenue impacts of tax and other State policies for the Department of Finance. E-DRAM has subsequently been used by the California Energy Commission and the ARB to assess impacts of reducing petroleum dependency (AB2076), and by the ARB for the Vehicle Climate Change

[a] For a more complete discussion, see Wing, Ian Sue. 2004. "Computable General Equilibrium Models and Their Use in Economy-Wide Policy Analysis: Everything You Ever Wanted to Know (But Were Afraid to Ask)." Available at http://web.mit.edu/globalchange/www/MITJPSPGC_TechNote6.pdf.

[b] See Berck, P., E. Golan and B. Smith. 1996. "Dynamic Revenue Analysis for California." Available at http://www.arb.ca.gov/cc/112906conf/e-dram.pdf

Standards, the State Implementation Plan analysis, and the previous Climate Action Team analysis.

Exhibit 15: Circular Flow of Goods and Services in the Economy



BEAR: The Berkeley Energy and Resources (BEAR) is a dynamic CGE model developed by Professor David Roland-Holst of the University of California, Berkeley. The BEAR model consists of four components that make it suitable for modeling multi-sector policies: a CGE model; a technology module; an emissions policy analysis module; and a transportation services/demand model. The model is designed to support a broad spectrum of policy analysis, including energy policy and policy responses to climate change such as trading and offset mechanisms. The model explicitly tracks the path of development of the economy over time as policies are implemented. The BEAR model has previously been used to assess the economic impacts of California greenhouse gas control policies.[a]

3.3 Model Harmonization

While the two models incorporate differing methods and approaches for modeling the impacts of policies to reduce GHG emissions, the models were harmonized around several key baseline assumptions, including economic activity, emissions, and fuel prices in order to compare model

[a] See Roland-Holst, D. 2006. "Economic Growth and Greenhouse Gas Mitigation in California." Available at http://calclimate.berkeley.edu/Growth_Strategies_Full_Report.pdf and Roland-Holst, D. 2007. "Cap and Trade and Structural Transition in the California Economy." Department of Agricultural and Resource Economics, UC Berkeley.

results. Exhibit 16 presents baseline estimates for several measures of economic activity. As shown in the exhibit, the models project similar future levels of economic activity relative to their base year of 2003. In particular, both models project similar growth in real state output.

The BEAR model was also harmonized around the baseline greenhouse gas emissions forecast used in the 2006 CAT Report. That baseline showed emissions growing from about 426 $MMTCO_2e$ in 1990 to about 600 $MMTCO_2e$ in 2020.[a] With this emissions forecast, a reduction of 174 $MMTCO_2e$ is required to return emissions to 1990 levels in 2020.[b] E-DRAM does not compute emissions internally, but rather takes the emissions reductions as given and shows the resulting economic impacts, and consequently further harmonization was not required in this respect.

Finally, the models used the fuel prices and electricity prices above in Section 2.2.2, and presented in Exhibit 8 and Exhibit 9. As discussed below, the alternative forecast of natural gas prices was used as a sensitivity case.

All other aspects of the modeling frameworks remained unmodified from their typical configurations used in previous analyses. There are significant differences between the models, including the parameters used to characterize technologies and opportunities to reduce GHG emissions in response to price changes. Consequently, varying estimates of impacts may be anticipated for similar specifications of policies that reduce GHG emissions.

Exhibit 16: Baseline Growth Assumptions

Economic Activity and GHG Emissions	**% Change to 2010[1]**		**% Change to 2020[1]**	
	E-DRAM	**BEAR**	**E-DRAM**	**BEAR**
Real State Output	24%	22%	61%	63%
Personal Income	24%	23%	61%	41%
Employment	11%	12%	20%	34%
Emissions	NA[2]	9%	NA	22%

1. Change measured relative to 2003.
2. E-DRAM does not calculate emissions internally.

3.4 Scenarios Analyzed

The modeling frameworks were used to analyze nine scenarios that reflect a range of policies and programs for achieving the State's 2020 emissions target. The scenarios were defined in terms of the following:

- ***Emissions Target:*** All nine scenarios incorporate the same emissions target of reducing GHG emissions in 2020 to 1990 levels. Using the baseline emissions forecast from the 2006 CAT Report, an emission reduction of 174 $MMTCO_2e$ is required in 2020.
- ***Climate Strategies:*** Both of the modeling frameworks use the climate strategies presented above in Section 2.3 to characterize the emission reductions achieved through the State's

[a] See California Energy Commission. 2006. *Inventory of California Greenhouse Gas Emissions and Sinks: 1990 To 2004*, Table F-1 -- California Greenhouse Gas Emissions.

[b] Significant refinements to the 1990 emissions estimate are underway. The ARB plans to bring the 1990 emissions baseline estimate to the Board for consideration by the end of 2007. The emissions forecast from the 2006 CAT Report was retained in this analysis to maintain consistency with the previous work.

actions. Exhibit 17 shows that all the climate strategies with emissions and cost estimates were represented in each modeling framework.

To assess the impact of failing to obtain emission reductions from the climate strategies, we defined a sensitivity case in which the emission reductions, costs, and savings of the strategies are reduced by 50% across the board. The estimates for this sensitivity case provide an indication of how the economy may be affected if these (or other) strategies are not implemented in a manner that can deliver the emission reductions as anticipated.

- ***Cap and Trade Program:*** Recognizing that no decisions have been made regarding whether a cap-and-trade program will be used in California, the updated analysis incorporates a cap and trade program as a market-based compliance mechanism for achieving the emission cap. The Market Advisory Committee's Report (MAC Report) discusses the design elements of a cap-and-trade system.[a] Typically, a cap is specified as a mandatory limit on the total emissions that can be released in a given period from sources included under the cap. Sources covered by the program can buy and sell allowances from each other. The ARB has yet to analyze fully the MAC Report recommendations.

  For purposes of this analysis, two representations are used to illustrate the range of potential program designs. **Program A** sets the cap across the entire California economy, putting all emissions sources under the cap. This program is similar in its impact to the MAC Report Program 4 -- upstream coverage of carbon in fossil fuels and downstream coverage of large sources of non-CO_2 gases and some suppliers of high GWP gases. **Program B** sets the cap on a narrower subset of sources in the California economy, focusing on the energy intensive industries, including the electric sector (including imported power), the cement sector, and the refining sector. Program B is similar to the MAC Program 1 – coverage of medium and large point sources of emissions, and some suppliers of high GWP gases. These two specifications, Program A and Program B cover the full breadth of the options discussed in the MAC Report.

  In all scenarios examined, the cap starts in 2012 and declines linearly to the 2020 emission target. Under Program A, all sources in the state can contribute to the emission reductions. Under Program B, only sources in the energy intensive sectors can contribute to emission reductions, so that the energy intensive sectors bear a disproportionate emission reduction burden. No cost minimizing methods, such as emission allowance banking or borrowing, are included in the analysis. However, several specifications for offsets are examined, as described next.

- ***Offsets:*** An offset is a credit for an emission reduction that is achieved by an entity outside of the sectors covered by the cap-and-trade program. If offsets are included in a cap-and-trade program, entities under the program can meet their emission reduction obligations by purchasing offsets. The extent to which offsets may be used is one of the design decisions required for a cap-and-trade program. Both the European Union Emissions Trading Scheme (EU ETS) and the Regional Greenhouse Gas Initiative (RGGI) allow offsets to be used to some extent.

  As mentioned above, no decisions have been made regarding whether a cap-and-trade program will be used in California. Similarly, recognizing that no decision has been made regarding whether offsets may be part of such a program were it adopted, the updated analysis examines a range of assumptions regarding the use of offsets to achieve emission

[a] See Market Advisory Committee. 2007. "Recommendations of the Market Advisory Committee to the California Air Resources Board." Available at http://www.climatechange.ca.gov/documents/2007-06-29_MAC_FINAL_REPORT.PDF

reductions under the cap. The analysis includes a scenario with no offsets at all. Separate scenarios are also specified in which offsets are can account for up to 10% of the emission reduction required to be achieved. In 2020, the offsets may be used to account for 10% of the 174 $MMTCO_2e$ of emission reductions required, or 17.4 $MMTCO_2e$. The cost of the offsets cannot be known at this time because the cost will depend on the types and locations of emission reductions that may be eligible for offsets. This analysis explores a range of offset prices, including $10/ton, $30/ton and $50/ton. The low-cost offset scenario may be reflective of a program that allows the purchase of offsets from anywhere outside of California. The higher-cost offset scenarios may be reflective of a program that limits offsets to specific types of emission reductions or to reductions only within certain geographic areas.

- ***Energy Prices:*** The analysis adopts the energy prices described in Section 2.2.2. A scenario is analyzed to assess the sensitivity of the results to the alternative natural gas price forecast presented in that section.

Exhibit 18 lists the combinations of the variables that comprise the nine scenarios analyzed. As shown in the exhibit, the scenarios can be grouped as follows:

- ***Reference Case:*** Scenario 1 is the reference scenario against which the other scenarios can be compared.
- ***Offsets:*** Scenarios 2-4 examine the potential impact of including offsets.
- ***Scope:*** Scenarios 5-6 examine the implications of adopting a cap and trade program with a narrow scope focused on selected sectors, i.e., Program B.
- ***Climate Strategies:*** Scenarios 7-8 present the sensitivity cases regarding the climate strategy emission reductions.
- ***Energy Prices:*** Scenario 3* examines the energy price sensitivity case, using the CPUC natural gas price forecast with the other assumptions in Scenario 3.

Although these nine scenarios reflect a range of possible programs and policies, many additional scenarios are of interest and warrant analysis. For example, analyses of alternative cost containment mechanisms are of interest, as are assessments of alternative methods for allocating emission allowances under a cap and trade program. These and many other program design questions remain to be examined.

Exhibit 17: Climate Strategies Represented in the Modeling Frameworks

Strategy	Agency	E-DRAM	BEAR
Vehicle Climate Change Standards	ARB	X	X
Diesel Anti-Idling	ARB	X	X
Other New Light Duty Vehicle Technology Improvements	ARB	X	X
HFC Reduction Strategies	ARB	X	X
Transport Refrigeration Units (on and off road)	ARB	X	X
Shore Electrification	ARB	X	X
Manure Management	ARB	X	X
PFC Emission Reduction for Semiconductor Manufacturers	ARB	X	X

Strategy	Agency	E-DRAM	BEAR
Alternative Fuels: Biodiesel Blends	ARB	X	X
Alternative Fuels: Ethanol	ARB	X	X
Heavy-Duty Vehicle Emission Reduction Measures	ARB	X	X
Reduced Venting and Leaks in Oil and Gas Systems	ARB	X	X
Hydrogen Highway*	ARB		
Achieve 50% Statewide Recycling Goal	IWMB	X	X
Landfill Methane Capture	IWMB	X	X
Zero Waste - High Recycling	IWMB	X	X
Conservation Forest Management	Forestry	X	X
Forest Conservation	Forestry	X	X
Fuels Management/Biomass	Forestry	X	X
Urban Forestry	Forestry	X	X
Afforestation/Reforestation	Forestry	X	X
Water Use Efficiency	DWR	X	X
Building Energy Efficiency Standards in Place	CEC	X	X
Appliance Efficiency Standards in Place	CEC	X	X
Fuel-Efficient Tires & Inflation Programs	CEC	X	X
Cement Manufacturing	CEC	X	X
Comprehensive Municipal Utility Program	CEC	X	X
Alternative Fuels: Non-Petroleum Fuels*	CEC		
Measures to Improve Transportation Energy Efficiency and Smart Land Use and Intelligent Transportation	BTH	X	X
Conservation tillage/cover crops*	Food/Ag		
Enteric Fermentation	Food/Ag	X	X
Green Buildings Initiative	SCSA	X	X
Transportation Policy Implementation*	SCSA		
Accelerated RPS to 33% by 2020	CPUC	X	X
California Solar Initiative	CPUC	X	X
IOU Energy Efficiency Programs	CPUC	X	X
IOU Additional Energy Efficiency Programs	CPUC	X	X
IOU CHP (Self Generation Incentive Program)	CPUC	X	X
SB 1368 Implementation for IOUs	CPUC		
IOU Electricity Sector Carbon Policy (including SB 1368 Implementation for IOUs)	CPUC		

* The 2006 CAT Report did not include emission reduction estimates, costs, or savings for the strategies marked with an asterisk.

Multiple newly developed strategies that were not in the 2006 CAT Report are not included in this analysis. Examples include the Low Carbon Fuel Standard and other strategies being considered for early action and for the Scoping Plan. Many of the strategies are continuing to be refined.

Exhibit 18: Scenarios Analyzed

Analysis Cases	**Climate Strategies**[1]	**Cap-and-Trade Program**[2]	**Offsets**[3]	**Energy Prices**[4]
Baseline	None	None	None	IEPR Forecast
Scenario 1	Reference Case	Program A: All Sectors	None	IEPR Forecast
Scenarios 2-4: The Impact of Allowing Offsets				
Scenario 2	Reference Case	Program A: All Sectors	$10/ton	IEPR Forecast
Scenario 3	Reference Case	Program A: All Sectors	$30/ton	IEPR Forecast
Scenario 4	Reference Case	Program A: All Sectors	$50/ton	IEPR Forecast
Scenarios 5-6: The Impact of Narrowing the Scope of the Cap and Trade Program				
Scenario 5	Reference Case	Program B: Major Sectors Only	None	IEPR Forecast
Scenario 6	Reference Case	Program B: Major Sectors Only	$30/ton	IEPR Forecast
Scenarios 7-8: Sensitivity Case Examining What if the Climate Strategies Produce only 50% of Their Expected Reductions				
Scenario 7	Sensitivity Case: 50% Effective	Program A: All Sectors	$30/ton	IEPR Forecast
Scenario 8	Sensitivity Case: 50% Effective	Program B: Major Sectors Only	$30/ton	IEPR Forecast
Scenario 3*: Energy Price Sensitivity Case				
Baseline	None	None	None	CPUC MPR Forecast
Scenario 3*	Reference Case	Program A: All Sectors	$30/ton	CPUC MPR Forecast

1. Reference Case climate strategies listed in Exhibit 11. The sensitivity case uses 50% of the emission reductions, costs, and savings.
2. Program A sets the cap across the entire California economy. Program B sets the cap across the energy intensive sectors, including the electric sector (including electricity imports), the cement sector, and the refining sector.
3. Offsets can account for up to 10% of the required emission reduction. In 2020, offsets can account for up to 10% of the 174 $MMTCO_2e$ emission reduction required, or 17.4 $MMTCO_2e$.
4. The energy prices are based on the 2005 Integrated Energy Policy Report (IEPR) forecast. The Sensitivity Case is based on the CPUC Market Price Referent (MPR) natural gas price forecast (see Section 2.2.2).

4. Macroeconomic Impacts

This section presents the results of the macroeconomic analysis. As this analysis has identified several important issues regarding how emission reduction policies should be analyzed, this section concludes with a discussion of the improvements that may be warranted based on the work reflected in this report. Additionally, this analysis focuses exclusively on California and does not address the impacts that may occur with a multi-state or Federal emissions policy.

The reported measures of economic impact include: real state output, personal income, and employment. Also reported are the volume of emission reductions and the associated emission allowance price from the cap-and-trade program. Economic and emission impacts are reported as the percent change from the Baseline forecast of economic and emissions growth. As discussed in Section 3, the analysis includes nine scenarios run on each of model. As described below, it was not possible to analyze all of the strategies in both models.

4.1 Modeling Results

The modeling results are presented in Exhibit 19 through Exhibit 22. Presented in the exhibits are the impacts on: real state output; personal income; and employment. These impacts are expressed as changes from the baseline values. A positive value indicates an increase from the baseline value, for example an increase in real state output. A negative value indicates a decrease. Also reported are the estimated emission allowance prices, in units of dollars per ton of CO_2e.

Across the two models, the economic impacts range from slightly positive to slightly negative. As shown in Exhibit 19, real state output in 2020 may be affected by about plus 0.7% to minus 0.3%, depending on the scenario. To put these changes into context, real state output is expected to grow by about 60% from 2003 to 2020. These impacts, positive and negative, represent a very small portion of this anticipated growth.

The E-DRAM results are consistently positive, while the BEAR results primarily show negative impacts for the assumptions used in these scenarios. Observations regarding the results include the following:

- ***Offsets*:** The impact of allowing offsets is reflected by comparing Scenarios 2 through 4 with Scenario 1. Whereas Scenario 1 includes no offsets, Scenarios 2 through 4 include offsets at increasing prices. With offsets available at $10/ton, E-DRAM indicates that impacts on state output are reduced compared to Scenario 1. BEAR indicates larger impact on state output. As offsets become more expensive, they have less influence on the results. For example, at prices of $30/ton and $50/ton, both E-DRAM and BEAR estimate that no offsets would be purchased because the estimated allowance prices are less than the offset prices.
- ***Scope*:** The comparison of Scenario 5 to Scenario 1 indicates the impact of narrowing the scope of the cap-and-trade program to the energy intensive sectors.[16] BEAR shows larger impacts for Scenario 5 (E-DRAM was not able to analyze Scenarios 5 and 6). Allowance prices are estimated to increase substantially (from $22/ton in Scenario 1 to $80/ton in Scenario 5). This increase is due to the fact that the sectors included in the narrower scope of the cap-and-trade program are being asked to carry a larger emission reduction burden.

[16] The definition of energy intensive sectors differs in the MRN-NEEM and the BEAR models, but both include at a minimum, the electricity, oil refining and cement sectors.

Note is that the allowance price is sensitive to the availability of emission offsets, as shown by the results for Scenario 6 compared to Scenario 5. The estimated allowance price under Scenario 6 (with offsets available) is substantially lower than the estimate for Scenario 5 (that excluded offsets).

- ***Climate Strategies:*** Scenarios 7 and 8 examine the implications of obtaining only half of the anticipated emission reductions from the climate strategies. Both the E-DRAM and BEAR results show increased impacts under this assumption. E-DRAM shows employment losses under Scenario 7, the only scenario under which E-DRAM shows employment losses. Estimated allowance prices in Scenario 7 are substantially higher than the prices in Scenarios 1 through 6, particularly for the BEAR analysis. This result for BEAR may be interpreted as indicating that the model incorporates a relatively modest set of low cost abatement opportunities, so that higher cost options must be used when the climate strategies are much less effective than anticipated.

  Scenario 8 combines the narrower scope with reduced effectiveness of the climate strategies. In comparison to Scenario 7, the BEAR impacts increase as the burden of emission reductions is placed on a smaller number of sectors. Allowance prices in this scenario increase substantially (E-DRAM was not able to analyze Scenario 8).

- ***Energy Prices:*** Scenario 3* is a sensitivity case that uses an alternative forecast for natural gas prices, and is best compared to Scenario 3. Both E-DRAM and BEAR indicate an increase in impacts. The differences are not substantial, however.

Overall, the results across the modeling frameworks and scenarios indicate that the State's emission target for 2020 can be achieved with small positive or small negative economic impacts through 2020. The results highlight the importance of achieving substantial emission reductions from the climate strategies. Also, the results are consistent with the expectation that there is value in implementing policies that promote emission reductions as broadly as possible throughout the economy.

Exhibit 19: Impacts on Real State Output (% Change from Baseline)

Scenarios	**E-DRAM**	**BEAR**
Scenario 1	0.5%	-0.1%
Offset Scenarios:		
Scenario 2	0.4%	-0.2%
Scenario 3	0.5%	-0.1%
Scenario 4	0.5%	-0.1%
Scope Scenarios:		
Scenario 5	NA	-0.2%
Scenario 6	NA	-0.1%
Climate Strategy Scenarios:		
Scenario 7	0.7%	-0.2%
Scenario 8	NA	-0.3%
Energy Price Sensitivity Scenario:		
Scenario 3*	0.4%	-0.2%
NA: E-DRAM was not able to analyze these scenarios.		

Exhibit 20: Impacts on Personal Income (% Change from Baseline)

Scenarios	E-DRAM	BEAR
Scenario 1	0.9%	-0.6%
Offset Scenarios:		
Scenario 2	0.9%	-0.7%
Scenario 3	0.9%	-0.6%
Scenario 4	0.9%	-0.6%
Scope Scenarios:		
Scenario 5	NA	-0.6%
Scenario 6	NA	-0.6%
Climate Strategy Scenarios:		
Scenario 7	0.5%	-0.7%
Scenario 8	NA	-0.9%
Energy Price Sensitivity Scenario:		
Scenario 3*	0.8%	-0.8%
NA: E-DRAM was not able to analyze these scenarios.		

Exhibit 21: Impacts on Employment (% Change from Baseline)

Scenarios	E-DRAM	BEAR
Scenario 1	0.3%	0.2%
Offset Scenarios:		
Scenario 2	0.4%	0.1%
Scenario 3	0.3%	0.2%
Scenario 4	0.3%	0.2%
Scope Scenarios:		
Scenario 5	NA	0.1%
Scenario 6	NA	0.2%
Climate Strategy Scenarios:		
Scenario 7	-0.3%	-0.1%
Scenario 8	NA	-0.5%
Energy Price Sensitivity Scenario:		
Scenario 3*	0.3	-0.2%
NA: E-DRAM was not able to analyze these scenarios.		

Exhibit 22: Estimated Emission Allowance Prices

Scenarios	E-DRAM	BEAR
Scenario 1	$21	$22
Offset Scenarios:		
Scenario 2	$13	$7
Scenario 3	$21	$22
Scenario 4	$21	$22
Scope Scenarios:		
Scenario 5	NA	$80
Scenario 6	NA	$17
Climate Strategy Scenarios:		
Scenario 7	$45	$206
Scenario 8	NA	$442
Energy Price Sensitivity Scenario:		
Scenario 3*	$17	$9
NA: E-DRAM was not able to analyze these scenarios.		

4.2 Further Modeling Efforts

This analysis is preliminary in many respects, and significant work remains to be performed to support ARB's Scoping Plan. As discussed above, the climate strategies continue to be refined and updated, and new climate strategies are under development (such as the Low Carbon Fuel Standard). The analysis must be revised to incorporate these updated and new strategies. Although the BEAR model includes abatement cost information for most sectors, additional detail is desired as is evidenced by the estimates of high allowance prices in Scenarios 7 and 8. The CPUC and ARB are developing improved modeling tools to address this need, which will improve the basis for future analysis.

The use of two independent modeling frameworks expanded the range of results produced and highlighted the importance of several key approaches and assumptions. Considerable additional investigation is needed to understand more fully the key factors that lead to both differences and similarities in the results.

Finally, a number of important cap-and-trade program design elements (e.g., allocation of allowances, banking, safety-valves, etc.) warrant complete and thorough investigation and analysis. The modeling tools need to be enhanced to examine many of these issues.