

CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

**Climate Action Team Report to
Governor Schwarzenegger and the Legislature**



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1 INTRODUCTION

California has a long history of environmental leadership. Motivated by the stunning natural beauty of our coastline, inland valleys, forests and mountains, as well as by the public health and environmental challenges brought on by increasing levels of pollution, California's citizens have repeatedly called for and supported measures to protect California's environmental heritage. Our political leadership and governmental institutions have responded with a variety of initiatives that restore, protect, and enhance the environment to ensure public health, environmental quality, and economic vitality. Often these California initiatives have provided a benchmark and template for further action both nationally and internationally.

This tradition of environmental leadership continues to this day. In 2005, recognizing that global warming will impose compelling and extraordinary impacts on California, the Governor signed Executive Order S-3-05 which established climate change emission reduction targets for the state and set in motion a process to ensure the targets are met. This Executive Order also recognized the importance of preparedness in that it directed the Secretary of the California Environmental Protection Agency (Cal/EPA) to lead an effort to evaluate the impacts of climate change on California and to examine adaptation measures that would best prepare the state to respond to the adverse consequences of climate change.

1.1 Organization of the Report

The report begins (Section 2) with an overview of the scientific evidence regarding climate change and its potential effects in California. Section 3 outlines the long history of previous actions that California has taken to understand and address the threat of climate change. Section 4 provides an overview of the scenario analysis that was done to evaluate the impacts of climate change on California, potential adaptation measures that can be taken to best respond to those impacts, and an economic assessment of the impacts. Section 5 presents the Climate Action Team recommendations regarding strategies the state should pursue to reduce climate change emissions.

Section 6 outlines market-based options for the state and includes a discussion of design choices that need to be further evaluated prior to adoption of a market-based program for the state. Section 7 discusses all possible emission reduction implementation options that were considered by the Climate Action Team, including market-based options. Section 8 covers a broad assessment of the economic implications of state actions to reduce climate change emissions. Section 9 looks specifically at potential impacts on minority and low-income communities. Section 10 contains the Climate Action Team's recommendations to the Governor and the Legislature.

2 CLIMATE CHANGE OVERVIEW

The Earth's climate has always evolved—the extremes of the 100,000-year ice-age cycles in both climate and climate change emissions over the last half million years are well documented. The period of the last 10,000 years has been warm and stable, and the last millennium, over which current societies have developed, has been one of the most stable climates observed. Yet, during the 20th century, we have observed a rapid change in the climate and climate change pollutants that is attributable to human activities.

These recent changes in climate change pollutants far exceed the extremes of the ice ages, and the global mean temperature is warming at a rate that cannot be explained by natural causes alone. Human activities are directly altering the chemical composition of the atmosphere through the buildup of climate change pollutants.

It is true that levels of natural climate change pollutants have fluctuated in the past. However, there are several reasons for attributing the rise in climate change pollutants to anthropogenic, rather than natural emissions. The first indicator comes from comparing the current increase with changes that have occurred in the past.

At the end of the last ice age, the concentration of CO₂ increased by around 100 ppm (parts per million) over about 8,000 years, or approximately 1.25 ppm per century. Since the start of the industrial revolution, the rate of increase has accelerated markedly. The rate of CO₂ accumulation currently stands at around 150 ppm/century—more than 200 times faster than the background rate for the past 15,000 years.

The heat-trapping property of climate change pollutants is undisputed. Although there is uncertainty about exactly how and when the Earth's climate will respond to increasing concentrations of climate change pollutants, combining observations with climate models indicates that detectable changes are underway. There most likely are and will continue to be changes beyond global mean warming, such as changes in regional temperature extremes, precipitation, soil moisture, and sea level, all of which could have significant adverse effects on many ecological systems, as well as on human health and the economy.

This section first presents the causes and projections for climate change, then discusses climate change pollutants. It includes a definition of global warming potentials and climate change pollutants. The section concludes with a brief discussion of abrupt climate change.

2.1 Climate Change Causes and Projections

Climate change is a shift in the "average weather" that a given region experiences. This is measured by changes in the features that we associate with weather, such as temperature, wind patterns, precipitation, and storms. Global climate change means change in the climate of the Earth as a whole. The Earth's natural climate has always been, and still is, constantly changing. The

climate change we are seeing today, however, differs from previous climate change in both its rate and its magnitude.

The temperature on Earth is regulated by a system commonly known as the "greenhouse effect." Naturally occurring climate change pollutants, primarily water vapor, CO₂, CH₄, and N₂O, absorb heat radiated from the Earth's surface. As the atmosphere warms, it in turn radiates heat back to the surface to create the greenhouse effect. The Earth's surface temperature would be about 34°C (61°F) colder than it is now if it were not for the natural heat trapping effect of climate change pollutants like CO₂, CH₄, N₂O, and water vapor.

Human activities are exerting a major and growing influence on some of the key factors that govern climate by changing the composition of the atmosphere and by modifying the land surface. The concentration of CO₂ in the atmosphere has risen about 30 percent since the late 1800s (National Assessment Synthesis Team [NAST], 2001). This increase has resulted from the burning of coal, oil, and natural gas, and the destruction of forests around the world to provide space for agriculture and other human activities.

Global projections of population growth and assumptions about energy use indicate that the CO₂ concentration will continue to rise, likely reaching between two and three times its late-19th-century level by 2100. Figure 2-1 shows the atmospheric CO₂ concentration from year 1000 to year 2000 from ice core data and from direct atmospheric measurements during the past few decades. Projections of CO₂ concentrations for the period 2000 to 2100 are based on model predictions.

Figure 2-1: Past and future CO₂ atmospheric concentrations. (Source: IPCC 2001 Synthesis report)

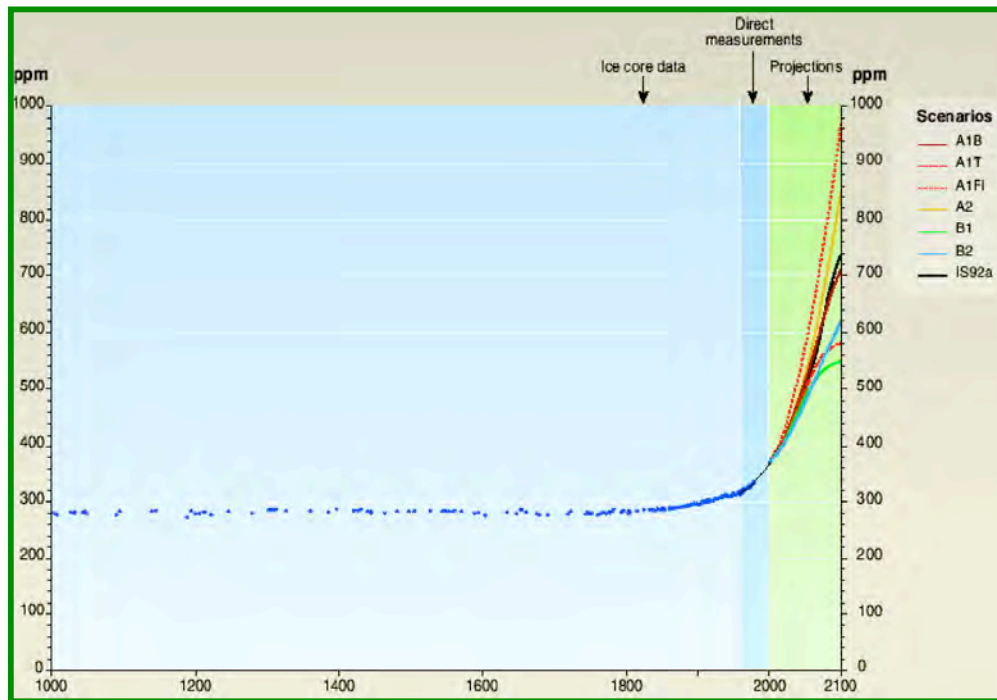
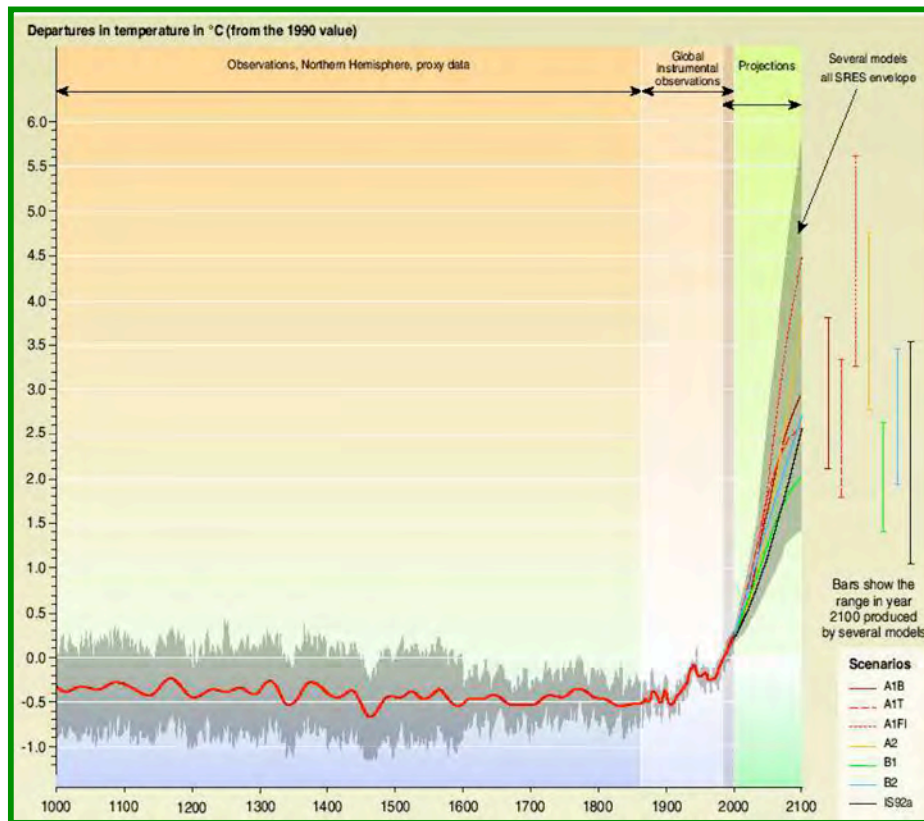


Figure 2-2 shows variations of the Earth's surface temperature for years 1000 to 2100. From year 1000 to year 1860 variations in average surface temperature of the Northern Hemisphere are reconstructed from proxy data (tree rings, corals, ice cores, and historical records). The line shows the 50-year average; the gray region, the 95 percent confidence limit in the annual data.

For the period 1860 to 2000, the figure shows variations in observations of globally and annually averaged surface temperature from the instrumental record; the line shows the decadal average. For 2000 to 2100, projections of globally averaged surface temperature are shown for several model scenarios using a global climate model.

The Third Assessment Report of the International Panel on Climate Change (IPCC, Synthesis Report, 2001) and the National Research Council of the National Academies (NRC, 2001) conclude that the global climate is changing at a rate unmatched in the past 1,000 years. The IPCC assessment cites new and stronger evidence that most of the global warming observed over the last 50 years is attributable to human activities and that anthropogenic climate change will persist for many centuries.

Figure 2-2. Variations of the Earth's surface temperature: years 1000 to 2100
 (Source: IPCC 2001 Synthesis report)



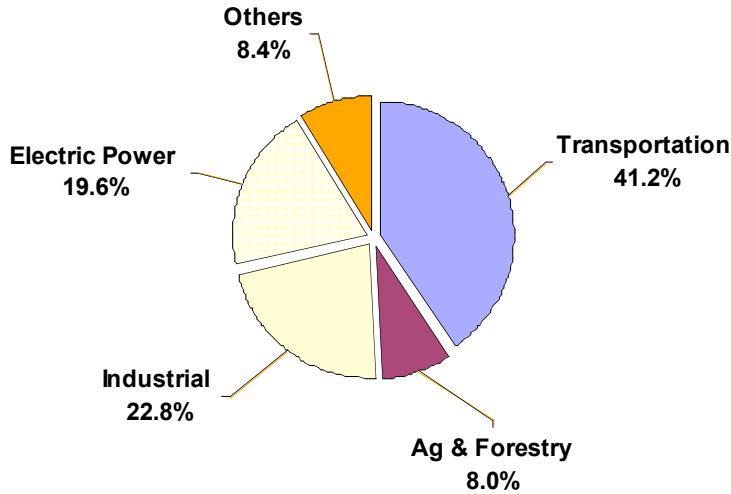
Many sources of data indicate that the Earth is warming faster than at any time in the previous 1,000 years. The global mean surface temperature has increased by 1.1°F since the 19th century (IPCC Synthesis report, 2001). The 10 warmest years of the last century all occurred within the last 15 years.

For example, 2002 and 2003 are tied as the second warmest years on record, according to a year-end review of climate data by the National Oceanic and Atmospheric Administration. Both the IPCC (2001) and the NAST (2001) reports project that warming in the 21st century will be significantly larger than in the 20th century. Scenarios examined in these assessments indicate that temperatures in the U.S. will rise by about 5° to 9°F (3° to 5°C) on average in the next 100 years.

2.2 Climate Change Emission Sources and Pollutants

As shown in Figure 2-3, fossil fuel consumption in the transportation sector was the single largest source of California's climate change emissions in 2002, with the industrial sector as the second-largest source. Electricity production, from both in-state and out-of-state sources, was the third-largest source. Agriculture, forestry, commercial, and residential activities comprised the balance of California's climate change emissions (CEC, 2005).

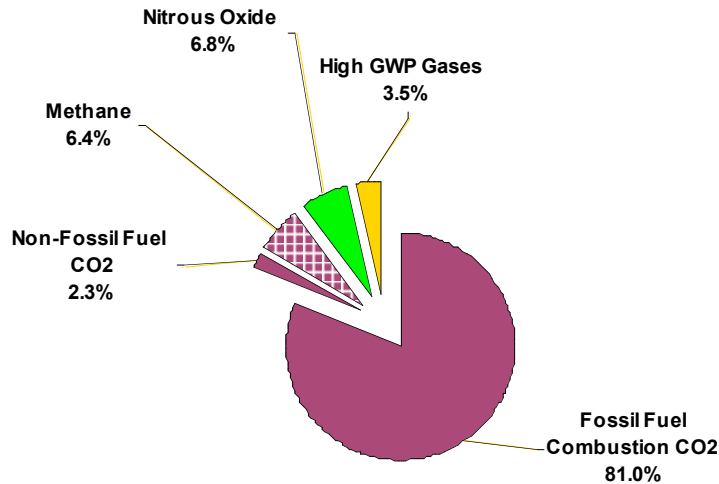
Figure 2-3: Sources of California's Climate Change Emissions, 2002 Expressed in Terms of CO₂ Equivalence (adapted from CEC, 2005).



As previously indicated, human activities are altering the chemical composition of the Earth's atmosphere through the release and build-up of climate change emissions. However, climate change pollutants such as water vapor, CO₂, CH₄, N₂O, and O₃ can also be associated with natural sources. Conversely, several classes of halogenated substances that contain fluorine, chlorine, or bromine are also climate change emissions, but they are, for the most part, solely a product of industrial activities.

Figure 2-4 provides a distribution of California anthropogenic climate change pollutants by gas in 2002, expressed in terms of CO₂ equivalence. In addition, there are a number of other pollutants such as carbon monoxide, nitrogen oxides, and aerosols that have direct or indirect effects on terrestrial or solar radiation absorption. Individual climate change species are briefly discussed in the following section.

Figure 2-4: California Composition of Gross Climate Change Pollutants, 2002 Expressed in Terms of CO₂ Equivalence (adapted from CEC, 2005).



Carbon Dioxide (CO₂)

In the atmosphere, carbon generally exists in its oxidized form, as CO₂. Increased CO₂ concentrations in the atmosphere have been primarily linked to increased combustion of fossil fuels. Fossil fuel combustion accounted for 98 percent of gross California CO₂ emissions. California's total CO₂ emissions from fossil fuel combustion in 2002 were 360 million metric tons CO₂, which accounts for approximately 7 percent of the U.S. emissions from this source. The transportation sector accounted for the largest portion of CO₂ emissions with gasoline consumption accounting for the greatest portion of emissions.

Methane (CH₄)

Methane accounted for approximately 6 percent of gross 2002 climate change emissions in California (CO₂ equivalent). Methane is produced during anaerobic decomposition of organic matter in biological systems. Decomposition occurring in landfills accounts for the majority of anthropogenic CH₄ emissions in California and in the United States as a whole. Agricultural processes such as enteric fermentation, manure management, and rice cultivation are also significant sources of CH₄ in California.

Nitrous Oxide (N₂O)

Nitrous oxide emissions accounted for nearly 7 percent of climate change emissions (CO₂ equivalent) in California in 2002. The primary sources of anthropogenic N₂O emissions in California are agricultural soil management and fossil fuel combustion in mobile sources.

Nitrous oxide is a product of the reaction that occurs between nitrogen and oxygen during fuel combustion. Both mobile and stationary combustion emit N_2O , and the quantity emitted varies according to the type of fuel, technology, and pollution control device used, as well as maintenance and operating practices. U.S.EPA estimates from 2003 suggest that in 2001, N_2O emissions from mobile combustion were 13 percent of U.S. N_2O emissions, while stationary combustion accounted for 3 percent.

Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), and Sulfur Hexafluoride (SF_6)

HFCs, PFCs and SF_6 accounted for about 3.5 percent of gross 2002 climate change emissions in California (CO_2 equivalent). HFCs are primarily used as substitutes for ozone-depleting substances (ODS) regulated under the Montreal Protocol. PFCs and SF_6 are generally emitted from various industrial processes including aluminum smelting, semiconductor manufacturing, electric power transmission and distribution, and magnesium casting. There is no aluminum or magnesium production in California; however, the rapid growth in the semiconductor industry leads to greater use of PFCs.

Other Radiatively Important Gases

In addition, there are a number of man-made pollutants, emitted primarily as by-products of combustion (both of fossil fuels and of biomass), that have indirect effects on terrestrial or solar radiation absorption by influencing the formation or destruction of other climate change emissions. These include carbon monoxide (CO), nitrogen oxides (NO_x), nonmethane volatile organic compounds (NMVOCs), and sulfur dioxide (SO_2).

These compounds, regulated in the U.S. and California pursuant to the Clean Air Act, are often referred to as "criteria pollutants." The criteria pollutants are reactive compounds, and they tend to remain in the atmosphere for a much shorter time (typically hours to months) than the previously discussed gases. As shown in Table 2-1, CO_2 , N_2O , CH_4 , and HFC-134a have atmospheric lifetimes ranging from a century to 10 years.

The sequence of reactions that removes CO, NO_x , and NMVOCs from the atmosphere, however, tends to promote the formation of tropospheric O_3 which is also a potent climate change emission. At present, there is large scientific uncertainty in estimating the radiative forcing effects of criteria pollutants.

Aerosols

Aerosols are extremely small particles or liquid droplets found in the atmosphere. Various categories of aerosols include naturally produced aerosols (e.g., soil dust, sea salt, biogenic aerosols, and volcanic aerosols), and anthropogenic aerosols (e.g., sulfates, ammonium nitrate, industrial dust, and carbonaceous aerosols including black carbon and organic carbon). Anthropogenic aerosols are derived directly or indirectly from transportation, coal combustion, cement manufacturing, waste incineration, and biomass burning.

Aerosols affect radiative forcing in both direct and indirect ways: directly by scattering and absorbing solar and thermal infrared radiation; and indirectly by altering the cloud properties and atmospheric heating rates that in turn modify the formation, precipitation efficiency, and radiative properties of clouds. The effect of aerosols on regional and global climate is complex: in general, sulfate aerosols enhance the reflection of sunlight and cool the Earth, while black carbon aerosols enhance the absorption of sunlight and warm the Earth.

Understanding the role of aerosols in climate change requires inclusion of realistic representations of aerosols and their radiative forcings in climate models. However, uncertainty in aerosol radiative forcing arises because neither emissions, atmospheric abundance, optical properties, nor indirect effects are well characterized. The IPCC (2001) and the NACIP (2002) have identified the total (direct and indirect) radiative forcing due to aerosols, and in particular light absorbing aerosols, as one of the most uncertain components of climate change models.

Water Vapor

It should be noted that just because water vapor is the most important contributor to the natural greenhouse effect does not mean that human-made climate change emissions are unimportant. However, human activities do not seem to be appreciably changing the atmospheric concentration of water vapor in any direct way on the global average.

A simple comparison of the relative greenhouse efficiencies of water vapor and CO₂ quickly becomes problematic because water vapor enters the climate system mostly as a "feedback" gas. Further, water stays in the atmosphere for a few days, while other climate change emissions linger for decades or centuries. The overall impact of water vapor with respect to global climate change is not well understood as it can lead to both warming (absorption of long-wave radiation from Earth) and cooling (cloud formation/reflection of solar radiation).

2.3 Global Warming Potentials

Radiative forcing is often defined as a net imbalance in energy flux in the atmosphere, and is expressed in watts per square meter (W/m²), i.e. heat per area of the Earth's surface. Radiative forcing of the surface-troposphere system, resulting, for example, from a change in climate change pollutant concentrations, is the change in the balance between radiation coming into the atmosphere and radiation going out. A positive radiative forcing tends, on average, to warm the surface of the Earth, and negative forcing tends, on average, to cool the surface.

The impact of a climate change pollutant upon the atmosphere is related not only to radiative properties of the gas and its initial abundance, but also to the length of time the climate change pollutants remain in the atmosphere. Radiative properties control the absorption of radiation per kilogram of gas present at any instant, but the lifetime of the gas controls how long an emitted kilogram remains

in the atmosphere and hence its cumulative impact on the atmosphere's thermal budget.

Gases in the atmosphere can contribute to the greenhouse effect both directly and indirectly. Direct effects occur when the gas itself is a climate change pollutant. Indirect radiative forcing occurs when chemical transformations of the original gas produce other climate change pollutants, when a gas influences the atmospheric lifetimes of other gases, and/or when a gas affects atmospheric processes that alter the radiative balance of the Earth (e.g., cloud formation).

The concept of a Global Warming Potential (GWP) has been developed in parallel to the concept of ozone depletion potential developed under the Montreal Protocol to compare the ability of each climate change pollutant to trap heat in the atmosphere relative to another gas.

Carbon dioxide, as the primary anthropogenic climate change pollutant, has been chosen as the reference gas. GWP is defined as the ratio of the time-integrated radiative forcing from the release of 1 kilogram of a trace substance relative to that of 1 kg of CO₂ (IPCC 2001). While any length of integration can be selected, the 100-year GWPs are recommended by the IPCC and will be employed for policy-making and reporting purposes.

GWP values allow a comparison of the impacts of emission changes (reductions or increases) of different gases. According to the IPCC (2001), GWPs typically have an uncertainty of ± 35 percent. In addition to communicating climate change pollutants in units of mass, we have also chosen to use GWPs to reflect their inventories in CO₂-equivalent terms because it effectively places all of the climate change pollutants on the same comparative scale.

Table 2-1 lists GWPs for CO₂, CH₄, N₂O, and HFC-134a for the 20-, 100-, and 500-year time horizons. It should be noted that when the lifetime of the species in question differs substantially from the response time of CO₂ (nominally about 150 years), then the GWP becomes very sensitive to the choice of time horizon. The GWP concept is only relevant for compounds that have sufficiently long lifetimes to become globally well-mixed. Therefore, short-lived gases and aerosols with varying atmospheric distributions and lifetimes pose a problem in the simple GWP framework.

Table 2-1. Numerical Estimates of Global Warming Potentials Compared with CO₂ (Kilograms of Gas Per Kilogram of CO₂ adapted from IPCC 2001).

Climate Change Pollutants	Lifetime (years)	Global Warming Potential		
		20 years	100 years	500 years
CO ₂	~150	1	1	1
CH ₄	12	62	23	7
N ₂ O	114	275	296	156
HFC-134a	14	3,300	1,300	400

2.4 Abrupt Climate Change

When most people think about climate change, they imagine gradual increases in temperature and only marginal changes in other climatic conditions, continuing indefinitely or even leveling off at some time in the future. It is assumed that human societies can adapt to gradual climate change. However, recent climate change research has uncovered a disturbing feature of the Earth's climate system: it is capable of sudden, violent shifts. This is a critically important realization.

Climate change will not necessarily be gradual, as assumed in most climate change projections, but may instead involve relatively sudden jumps between very different states. A mounting body of evidence suggests that continued increasing climate change emissions may push the oceans past a critical threshold and into a drastically different future.

Abrupt climate change is the subject of reports commissioned by the National Academy of Science (NRC 2002) and the U.S. Department of Defense (Schwartz and Randall, 2003). Thus, in addition to the gradual (albeit accelerated) climate changes projected by current climate models, Californians need to be aware of the possibility of much more sudden climate shifts.

2.5 Summary

There is little doubt that climate change is happening today, that human-caused increases in the atmospheric abundance of climate change pollutants are a large cause of that change, and the 21st century climate change will be greater than that we have experienced in the 20th century. Much of that projected climate change is as yet unrealized warming from the climate change pollutants in the atmosphere today. Nevertheless, actions taken to reduce climate change emissions today can reduce the magnitude and rate of climate change this century.

There is no scientific uncertainty about the fact that human activities have increased the atmospheric abundance of climate change pollutants. The uncertainties center on predicting exactly what the climate changes will be in various local areas of the Earth and what the effects of clouds will be in determining the rate at which the mean temperature will increase.

There are also uncertainties associated with characterizing the timing and magnitude of other consequences of a warmer planet: sea level rise, spread of certain diseases out of their usual geographic range, the effect on agricultural production, water supply, sustainability of ecosystems, increased strength and frequency of storms, extreme heat events, air pollution episodes, and the impact of these effects on human health and the economy.

3 CALIFORNIA ACTIONS TO ADDRESS CLIMATE CHANGE

The State of California has traditionally been a pioneer in efforts to reduce air pollution, dating back to 1963 when the California New Motor Vehicle Pollution Control Board adopted the nation's first motor vehicle emission standards. California likewise has a long history of actions undertaken in response to the threat posed by climate change.

Beginning in 1988, legislation was enacted that directed the California Energy Commission, in consultation with the Air Resources Board and other agencies, to study the implications of global warming on California's environment, economy, and water supply.

This effort continued with Governor Schwarzenegger's June 2005 Executive Order creating climate change emission reduction targets for the state. The Order requested a report that specifically addresses the impacts of climate change on the state and includes adaptation measures the state can implement to best respond. California state government has consistently recognized the necessity for state action on climate change to protect California's interests.

3.1 Summary of California Activities Underway

California has a long history of environmental leadership and has continued that leadership in the efforts to reduce climate change emissions. Table 3-1 indicates those strategies that are underway in California.

Section 2.1 asserted that the transportation sector is the largest source of emissions in California. The motor vehicle standards of the Air Resources Board (ARB) provide significant emission reductions in this sector in the 2020 time frame. Two other key strategies in the state are the Renewable Portfolio Standard and the Energy Efficiency Programs. These strategies have been instrumental in California's efforts to provide energy security for the state and have also provided significant climate change emission reductions. The state's Energy Efficiency Programs have resulted in a stable per-capita energy use in the state even while California's economy has soared.

It is important to note that these strategies, though underway, will require continuing efforts by the responsible agencies as well as strong leadership to ensure they remain in place. Governor Schwarzenegger has pledged his support of the ARB's motor vehicle regulations and the acceleration of the Renewable Portfolio Standard. The Governor's support and the continuing support of the Legislature will be essential as the state implements these strategies successfully.

Table 3-1 Emission Reduction Strategies Underway in California

Agency Responsible	Climate Change Emission Reductions (Million Tons CO ₂ Equivalent)	
	2010	2020
Strategies		
Air Resources Board		
Vehicle Climate Change Standards	1	30
Diesel Anti-idling	1	1.2
Public Utilities Commission		
Accelerated Renewable Portfolio Std to 33% by 2020 (including load-serving entities [LSE])	5	11
California Solar Initiative	0.4	3
Investor Owned Utility Energy Efficiency Programs(including LSEs)	4	8.8
Integrated Waste Management Board		
Achieve 50% Statewide Recycling Goal	3	3
Energy Commission		
Building Energy Efficiency Standards	1	2
Appliance Energy Efficiency Standards	3	5
Fuel-efficient Replacement Tires & Inflation Programs	1.5	1.5
State and Consumer Services and Cal/EPA		
Green Buildings Initiative	0.5	1.8
Air Resources Board and Cal/EPA		
Hydrogen Highway	Included*	
Total Potential Emission Reductions	22	68

* The benefits of the Hydrogen Highway have been captured in other programs such as the motor vehicle regulations and green buildings initiative.

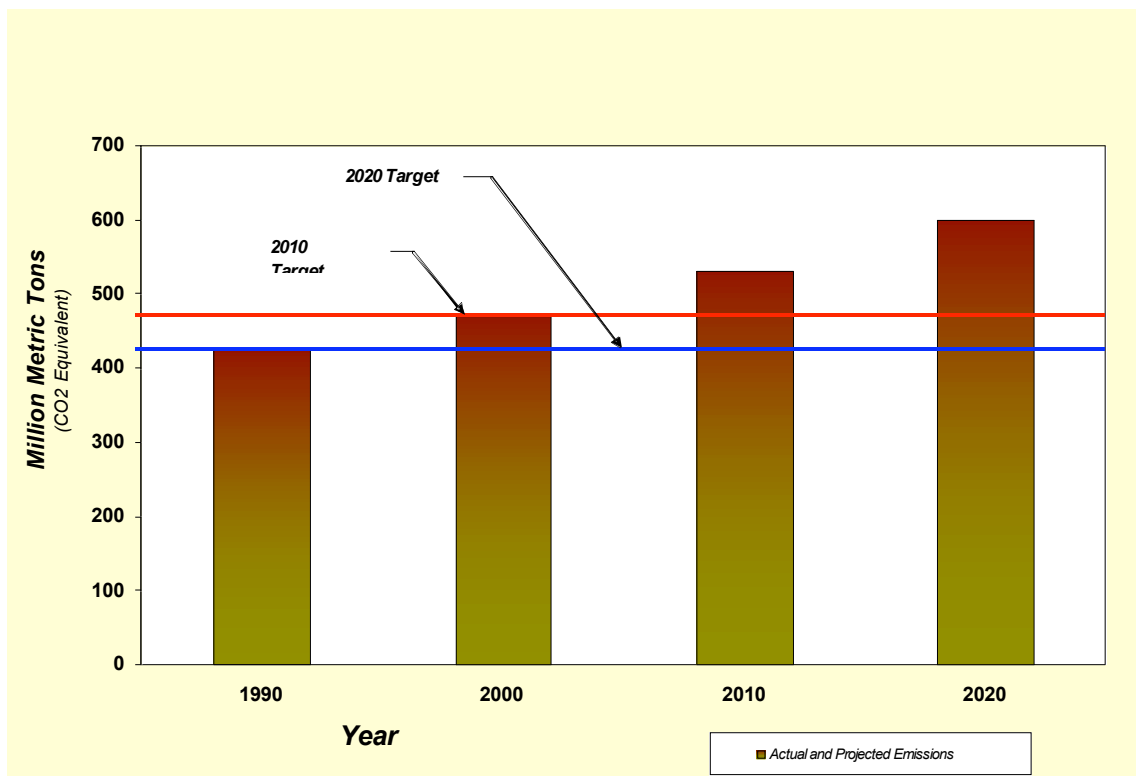
3.2 Executive Order S-3-05

On June 1, 2005, Governor Schwarzenegger signed Executive Order S-3-05 (EO) during the United Nations World Environment Day event in San Francisco. The EO established climate change emission reduction targets for California and was heralded in the nation and around the world as a landmark event signaling that California is taking a leadership role in the United States in addressing the issue of climate change. The Governor said in his remarks preceding the signing of the EO, "...the debate is over. We know the science. We see the threat. And we know the time for action is now."

This quote appeared in the media throughout the world. Internationally the developed nations agree that the issue of climate change must be addressed. It is no exaggeration to say that the world had been waiting for a strong signal that the state which has led a nation on so many public health and environmental issues would continue that leadership in addressing climate change.

The targets established by the EO are shown in Figure 3-1. The 2010 and 2020 targets are based on an ambitious estimate of how much the state can reduce emissions with strong top-down leadership and a coordinated effort amongst various state agencies. Cal/EPA worked with the ARB, CEC and Tellus, a technical contractor, to develop the targets in the 2010 and 2020 timeframes. The 2050 target is based on emission reductions the science indicates will be necessary from all developed nations to ensure protection of the planet in the 100-year time frame.

Figure 3-1. California's Climate Change Emissions and Targets



In addition to setting targets for the state, the EO placed Cal/EPA in the lead to coordinate efforts to meet these targets among the following agencies: Business, Transportation and Housing Agency (BT&H), Department of Food and Agriculture (CDFA), Energy Commission (CEC), Resources Agency, and Public Utilities Commission (PUC). A coordinated effort is essential to success in climate change emission reduction strategies. Programmatic, incentive-based, or market-based strategies will require the efforts of agencies whose purview stretches across all sectors of the economy, from transportation to energy to agriculture to waste management.

Finally, the EO directed Cal/EPA to lead an evaluation of the impacts of climate change in California, mitigation strategies to reduce emissions, and adaptation measures that can be taken by the state to best respond to the adverse impacts of climate change. This effort is built upon the work of the CEC under the Public Interest Energy Research plan.

The CEC is currently about half way through a five-year plan that responds to many of the same directives included in the EO. Cal/EPA worked with CEC and other agencies to incorporate a broader scope and provide the Governor and Legislature with a mid-point estimate of what California can expect as a result of climate change and how the state can best respond to the adverse consequences.

3.3 Climate Action Team

In response to the EO, the Secretary of Cal/EPA created the Climate Action Team (CAT). The CAT includes knowledgeable representatives from Air Resources Board; Business, Transportation, & Housing; Department of Food and Agriculture; Energy Commission; California Integrated Waste Management Board (CIWMB), Resources Agency, and Public Utilities Commission (PUC). The CAT has prepared a recommended list of strategies for the state to pursue to reduce climate change emissions in the state. This list is described in detail in Section 0. The CAT has also contributed to and reviewed the scenario analysis described in Section 4.

There are two subgroups of the CAT, the market-based options subgroup and the scenario analysis subgroup. Both subgroups are made up of representatives appointed by the CAT and experts as appropriate. The market-based options subgroup was created by the Secretary of Cal/EPA because of the cross-cutting nature of a market-based program for the state. The scenario analysis subgroup addressed the directive in the EO to evaluate the impacts of climate change on the state and adaptation measures that can be taken by the state to best prepare for the adverse consequences of climate change.

4 SCENARIO ANALYSIS

In California and throughout western North America, signs of a changing climate are evident. Over the last 50 years, observations reveal trends toward warmer

winter and spring temperatures, a smaller fraction of precipitation falling as snow instead of rain, a decrease in the amount of spring snow accumulation in lower and middle elevation mountain zones, an advance in snowmelt of 5 to 30 days earlier in the spring, and a similar shift in the timing of spring flower blooms.

These changes are consistent with much broader scale global measures. From 1900 through 1970, the average global temperature rose by about 0.1°F (0.06 °C) per decade, but since then the rate of warming has increased markedly, to about 0.5°F (0.3°C) per decade. During the last 1,000 years, available observations suggest that the 10 warmest years all occurred after 1990. Much of the warming during the last four decades is attributable to the increasing atmospheric concentrations of climate change emissions due to human activities.¹

It is now evident that even if actions could be taken to immediately curtail climate change emissions, the potency of emissions that have already built up, their long atmospheric lifetimes, and the inertia of the Earth's climate system could produce as much as 1.1°F (0.6°C) of additional warming.² As a result, some impacts from climate change are now unavoidable.

For example, studies show that some unique ecosystems, such as coral reefs, and those in arctic and alpine regions, have been or will be severely damaged or lost as a result of climate changes already underway.³ However, depending on the amount of climate change emissions emitted over the next few decades, an opportunity remains to avoid the most severe impacts that are expected with greater rises in temperature.

The scientific community is striving to determine how vulnerable human society and the earth systems on which it depends are to future climate changes. Although no consensus has been reached as to what constitutes "dangerous" climate change, there has been increasing warning about the impacts of global average temperatures rising over 3.6°F (2°C). These include a rapid increase in global hunger, health risks, and water shortages¹. Temperature rises above

¹ Hare, W.: 2003, 'Assessment of Knowledge on Impacts of Climate Change – Contribution to the Specification of Art. 2 of the UNFCCC'. Potsdam, Berlin, WBGU - German Advisory Council on Global Change.
http://www.wbgu.de/wbgu_sn2003_ex01.pdf

3.6°F (2°C) also increase the risk of abrupt climatic changes such as rapid sea level rise from continental ice including the disintegration of the West Antarctic Ice Sheet.⁴

Linking specific temperature changes—such as the proposed 3.6°F (2°C) dangerous threshold—with particular levels of global warming emissions in the atmosphere, is complicated. Although all climate models project increased temperatures to result from higher concentrations of climate change pollutants, these models vary in their sensitivity of the global and regional temperatures and other climate measures to changes in climate change pollutant concentrations.

For example, temperature rises between 2.7°–8.1°F (1.5°–4.5°C) have been projected for a doubling of the atmospheric CO₂ concentration above pre-industrial levels. This wide range of temperature rise projections is the result of differences in the way the models represent key processes within the climate system, particularly in characterizing clouds which can lead to either damping or reinforcing of global warming.

Society can neither control nor precisely determine the sensitivity of the earth's climate system to rising climate change emission concentrations. As a result, it is critical to carefully consider implications of a range of climate sensitivities when evaluating the risks of climate change and devising policies to manage the one factor we can control: our own climate change emissions.

For example, the United Kingdom (UK) adopted a target to limit the maximum atmospheric CO₂ concentration to 550 parts per million (ppm) and determined that reaching this target would require the industrialized world to decrease emissions by approximately 60 percent by the year 2050.

However, because of the uncertainty in climate model sensitivity, it is unclear if this 550 ppm target will keep global temperatures below a 3.6°F (2°C) dangerous threshold. Although the Intergovernmental Panel on Climate Change (IPCC) suggests that the UK concentration target is consistent with several recent climate model simulations, the 3.6°F upper warming limit under the 550 ppm threshold holds up under the lower- but is exceeded under the higher-climate

sensitivity models. This suggests that a lower concentration target, and therefore greater emission reductions, could be needed.

This chapter summarizes findings of recent analyses that explore the implications of various climate change scenarios for California. The studies focus on comparing the implications of different scenarios of climate change emissions given a range of climate sensitivities. The projections reported are driven by three climate change emission scenarios—a lower emissions, medium-high emissions, and higher emissions scenario.

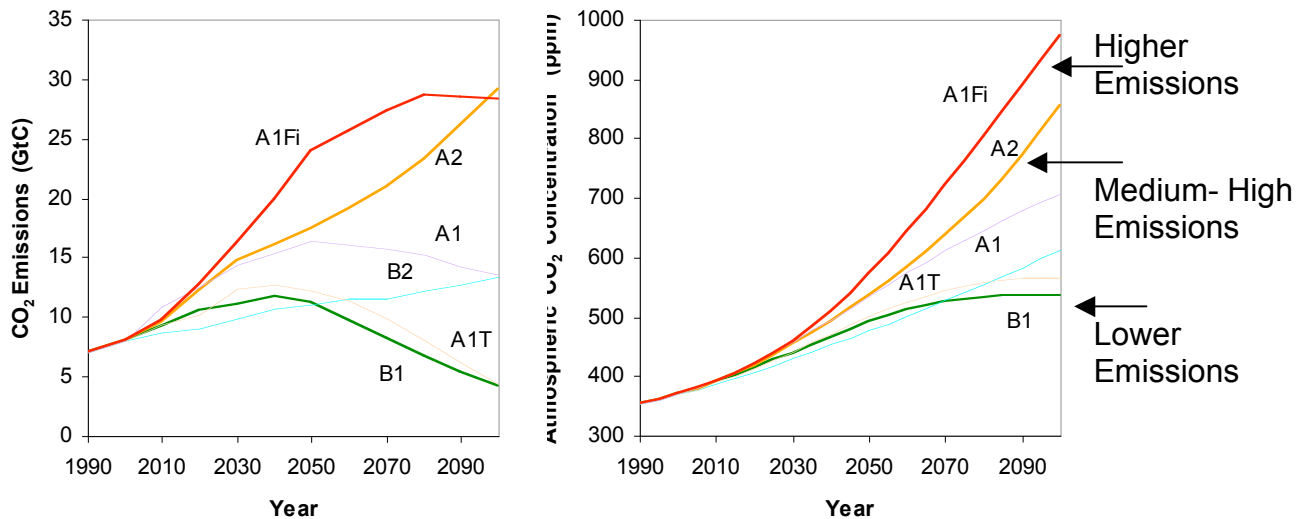
The sensitivity of the climate system to increasing atmospheric concentrations of climate change pollutants is explored by comparing the projected temperature rise from three different global climate models, each containing somewhat different representations of some crucial physical processes that result in levels of climate sensitivity.

The following section describes the global warming emission scenarios and climate projections reported in this chapter. Other sections report on the projected impacts of the specific climate projections across six sectors—coasts, water resources, agriculture, forests/fire, public health, and electricity. The chapter concludes with a discussion of the implications of these projections for mitigation and adaptation.

4.1 Climate Change Scenarios ⁵

The Intergovernmental Panel on Climate Change Special Report on Emissions Scenarios (SRES) developed a set of possible future emissions scenarios based on different assumptions about global development paths (Figure 4-1). This section relies upon the results from recent analysis for California of three SRES emission scenarios—a higher emissions scenario (A1Fi), a medium-high emission scenario (A2), and lower emission scenarios (B1).

Figure 4-1. Special Report on Emissions Scenarios



The higher emissions scenario (A1fi) represents a world of rapid fossil-fuel-intensive economic growth, global population that peaks mid-century then declines, and the introduction of new and more efficient technologies toward the end of the century. Global warming emissions grow rapidly, reaching about 25 gigatonnes per year (Gt/yr), more than 3 times the present rate of emissions, by 2050.

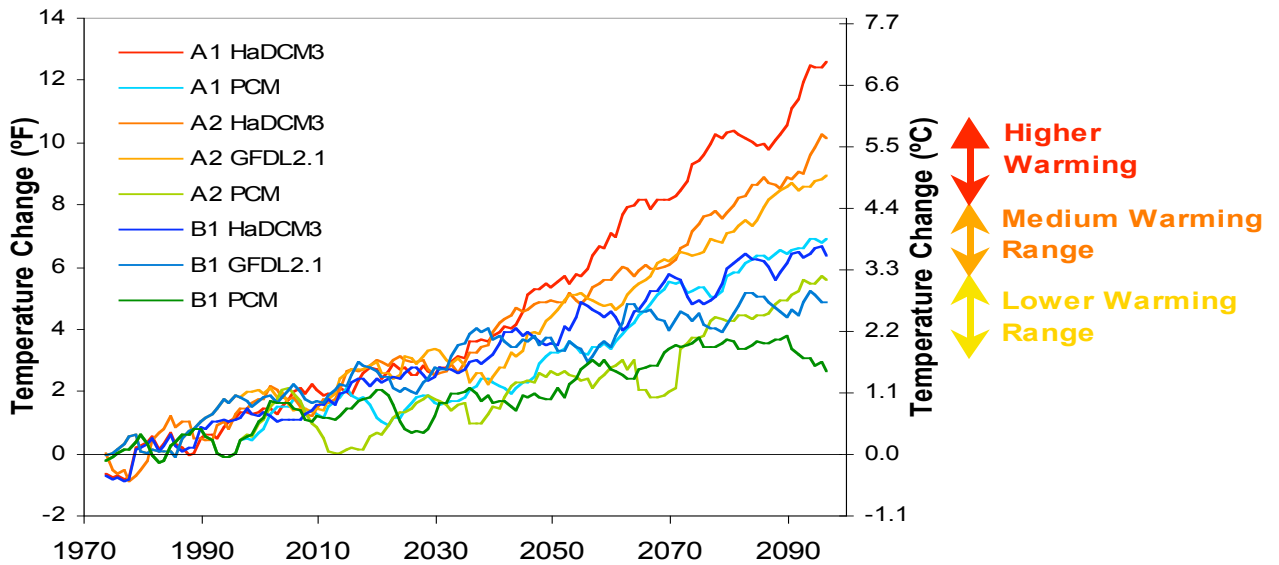
The medium-high emissions scenario (A2) projects continuous population growth with slower economic growth and technological change than in the other scenarios. In contrast, the lower emissions scenario (B1) characterizes a world with population growth similar to the highest emissions scenarios, but with rapid changes towards a service and information economy and with the introduction of clean and resource-efficient technologies. The B1 scenario has CO₂ emissions peaking just below 10 Gt/yr in mid-century before dropping below the current-day level of 7 Gt/yr by 2100. Under the B1 scenario, the CO₂ concentration would double, relative to its pre-industrial level, by the end of this century.⁶ For the range of climate sensitivities reported on here, the B1 scenario leads to global temperature rises between 1.8-3.1 °C, capturing yet mostly rising above the "dangerous" threshold of 2°C described above. Importantly, in the B1 scenario simulations, while the upward trend of temperature tends to level off or slow down during the last few decades of the 21st Century, in the A2 and A1fi simulations the rising trend in temperature continues at a high rate, indicating that more warming would occur under these higher scenarios before an equilibrium is reached.

To capture a range of uncertainty among climate models, this chapter reports on projections from three state-of-the-art global climate models (GCMs)—a low-sensitivity model, the Parallel Climate Model (PCM1)⁷ from the National Center for Atmospheric Research (NCAR) and the Department of Energy (DOE) groups; a medium-sensitivity model, the Geophysical Fluids Dynamic Laboratory (GFDL) CM2.1 (NOAA Geophysical Dynamics Laboratory, Princeton NJ)⁸ model; and the slightly higher-sensitivity U.K. Met Office Hadley Centre Climate Model, version 3 (HadCM3)⁹.

Temperatures are projected to rise significantly over the 21st century. The magnitude of projected warming varies between models and the emission scenarios. The temperature rise (2000 to 2100) projections are from approximately 1.7°C to 3.0°C (3.0°F-5.4°F) in the lower range of projected warming, 3.1°C-4.3°C (5.5°F-7.8°F) in the medium range, and 4.4°C to 5.8°C (8.0°F-10.4°F) in the higher range. To comprehend the magnitude of these projected temperature changes, over the next century, the lower range of projected temperature rise is slightly larger than the difference in annual mean temperature between Monterey and Salinas, and the upper range of project warming is greater than the temperature difference between San Francisco and San Jose, respectively (Figure 4-2). There is no clear trend in precipitation

projections for California over the next century. However the consensus of the recent IPCC model projections, including several models that were not selected for the present study, is for relatively little change in total precipitation, with a tendency toward a slightly greater winter and lower spring precipitation.

Figure 4-2. Change in California Annual Average Daily Mean Temperature Relative to 1961-1990



Change in California annual mean temperature (°F and °C) by year from 1961 to 2100 relative to 1961–1990 average—7-year running mean.

HadCM3 = Hadley Climate Model version 3

PCM = Parallel Climate Model

GFDL2.1 = Geophysical Fluid Dynamics Laboratory model 2.1

A1, A2, and B1 refer to global emission scenarios explained in Section 4. They are higher (A1), medium-high (A2), and lower (B1) emission scenarios.

4.2 Public Health Impacts¹⁰

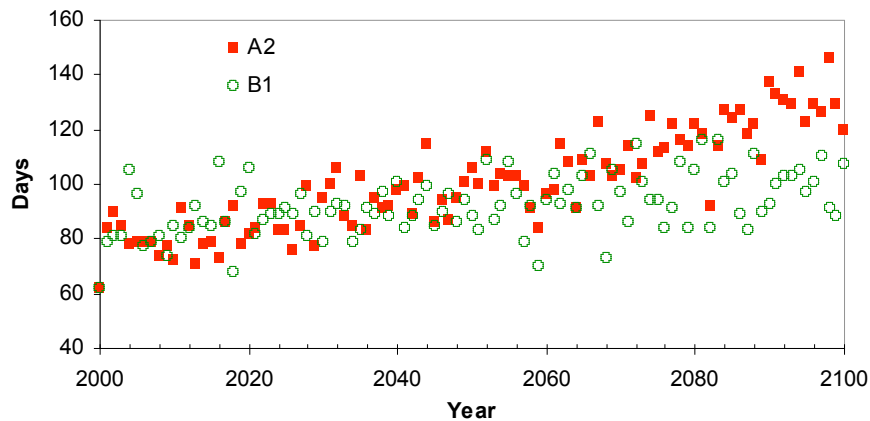
Climate change will affect the health of Californians due to increases in the frequency, duration, and intensity of conditions conducive to air pollution formation, oppressive heat, and wildfires. The primary concern is not the change in average climate, but rather the projected increase in extreme conditions that are responsible for the most serious health consequences.

Californians experience the worst air quality in the nation, with annual health and economic impacts estimated at 9,000 deaths and \$60 billion per year. Ozone and particulate matter (PM) are the pollutants of greatest concern, and the current control programs for motor vehicles and industrial sources cost about \$10 billion per year.

Maximum ozone levels are about double the current air quality standards. Climate change will slow progress toward attainment and increase control costs by boosting emissions, accelerating chemical processes, and raising inversion temperatures during summertime stagnation episodes. Results from statistical analyses indicate that the number of days meteorologically conducive to pollution formation may rise by 75 to 85 percent in the high ozone areas of Los Angeles (Riverside) and the San Joaquin Valley (Visalia) by the end of the century if

temperatures rise to the higher projected warming range, and by 25 to 35 percent if temperature increases stay within the lower warming range.

Figure 4-3. Projected Days at Riverside Meteorologically Conducive to Exceedances of the 1-Hour California Ambient Air Quality Standard for Ozone of 0.09 Parts Per Million (ppm)



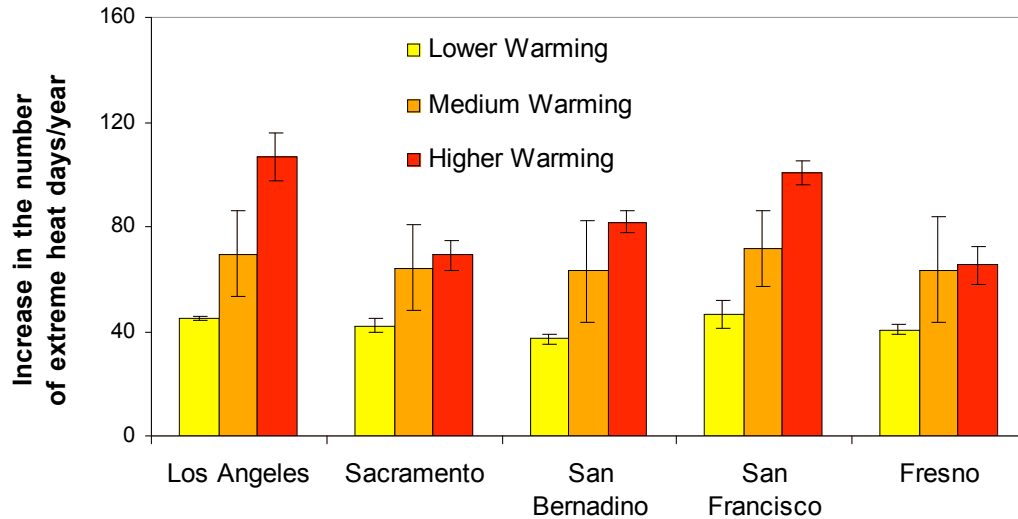
Geophysical Fluid Dynamics Laboratory (GFDL). Source: Kleeman and Cayan, 2006

In addition, global background ozone (primarily formed from methane and nitrogen oxides from fuel combustion) is projected to increase by 4 to 10 percent (lower emissions scenario) to 25 percent (higher emissions scenario) by 2100. If background ozone increases by the amount projected for the higher scenario, the ozone targets would be impossible to attain in much of California, even with near-zero local emissions.

The future trend for PM is not as clear, as increasing temperatures reduce some particle types while others show no change or increase slightly. In general, increased temperatures tend to reduce atmospheric nitrate, an important contributor to levels of PM_{2.5} (particles less than 2.5 microns) in California. However, a preliminary study by Kleeman and Cayan (2006) suggests that if global background ozone levels double, there would be an increase in PM_{2.5} levels despite the corresponding increase in temperature. Rainy days, wildfires, global dust storms, humidity, and other factors also affect PM and are the subject of ongoing study.

Analyses of various climate change scenarios project that the future will have a greater number of extremely hot days and fewer extremely cold days, with large increases in heat-related deaths predicted for the five cities studied.

Figure 4-4. Projected increase in extreme heat days relative to 1961–1990. “Extreme heat” defined as by the average temperature which is exceeded less than 10% of the days during the historical period (1961-1990), or approximately 36 days a year.



Source: Drechsler et al., 2006

For the higher warming range, the number of days with temperatures above 90°F in Los Angeles and higher than 95°F in Sacramento will increase to about 100 days by the end of the century, almost twice the increase projected if the temperatures stay within the lower warming range. Individuals likely to be the most affected include the elderly, already ill, and poor. On peak demand summer days in 2100, California would need at least 10 percent more electricity, compared to total generation capacity today, for air conditioning alone. Ongoing studies are investigating the relative contribution of air pollution to heat-related death, and refining the air conditioning demand estimates.

Climate change could affect asthma prevalence and attacks, but this is difficult to predict for several reasons. The most common asthma triggers are dust mites and molds, both of which are higher indoors than outdoors and require a relatively humid environment for survival. Consequently, if the climate becomes drier, these triggers will become less important, but they respond to higher humidity with increased growth. Many asthmatics are allergic to various plant pollens. Plants and trees typically have pollination seasons that last a few weeks per year. To the extent that pollen seasons lengthen or become more intense in response to climate change, increased asthma exacerbation could result.

Climate change has the potential to influence the incidence of infectious disease spread by mosquitoes, ticks, fleas, rodents, and food. More study is needed as research to date has focused on short-term changes in weather patterns (primarily in ambient temperature and rainfall), rather than long-term trends.

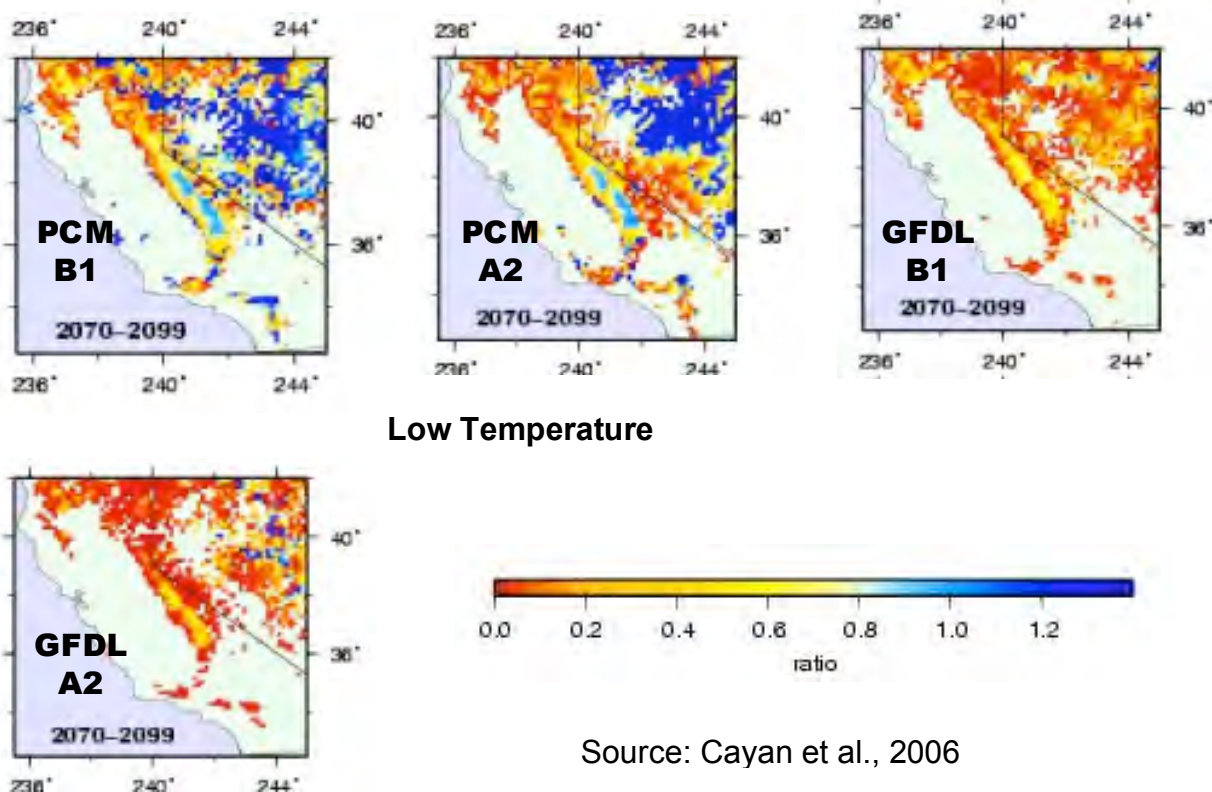
4.3 Water Resources Impacts¹¹

Although precipitation is projected to change only modestly over this century, rising temperatures are expected to diminish snow accumulation in the Sierra Nevada and other mountain catchments in California. Higher temperatures will result in more precipitation as rain instead of snow and earlier melt of the snow that does fall. Reductions in snow accumulation and earlier snowmelt will have cascading effects on water supplies, natural ecosystems, and winter recreation.

Snowpack

The projected losses in snowpack increase with temperature. Each of the simulations shows losses of spring snow accumulation, largely over the Sierra Nevada, to become progressively larger during the 21st century. By the 2035–2064 period, snowpack in the Sierra Nevada could decrease 10 to 40 percent depending on the amount of warming and precipitation patterns. By the end of century, snowpack could decrease by as much as 90 percent if temperatures rise to the higher warming range, almost double the loss is expected if temperature rises stay within the lower warming range.

Figure 4-5. April 1 Snow water equivalent 2070-2099 fraction of 1961–1990



Source: Cayan et al., 2006

Medium Temperature

Water Supply

Declining snowpack will aggravate the already overstretched water resources in California. The snowpack in the Sierra Nevada provides natural water storage

equal to about half the storage capacity in California's major man-made reservoirs. The snowpack holds the winter precipitation in the form of snow and, historically, has released it in the spring and early summer as the snow melts. This loss in storage could mean more water shortages in the future. However, the full effect of this storage loss will depend in part on whether reservoirs can be managed to capture the earlier snowmelt while losing flood control capacity.

Under most scenarios stream flows are projected to decrease slightly by mid-century with more dramatic changes by the end of the century. Flows into the major Sierra Nevada reservoirs could decline between 25 to 30 percent if temperatures rise to the medium warming range and precipitation decreases by approximately 20%. This is almost double the decrease projected if temperatures are confined to within the lower warming range. However, in one model run, projections suggest a slight increase in precipitation and a corresponding rise in projected stream flows.

After mid-century, the change in the volume and timing of runoff reduces the ability of the major projects to deliver water to agricultural users south of the Delta. The projected changes in water supply may be further exacerbated by increasing demand. By the end of century, increasing temperatures are expected to increase the crop demand for water between 2 and 13 percent in the lower and medium warming ranges, respectively.

Winter Recreation

Declines in Sierra snowpack will also have widespread implications for winter tourism. Toward the end of the century, in lower temperature scenarios the ski season could shorten by as much as a month while projected climatic changes under the higher temperature scenario suggest that the minimum snow conditions for ski resort operation might be eliminated entirely. Many resorts would be forced to rely on snowmaking or move their operations.

4.4 Agriculture Impacts¹²

Agriculture, along with forestry, is the sector of the California economy that is most likely to be affected by a change in climate. California agriculture is a \$68 billion industry.¹³ California is the largest agricultural producer in the nation and accounts for 13 percent of all U.S. agricultural sales, including half of the nation's total fruits and vegetables.

Regional analyses of climate trends in agricultural regions of California suggest that climate change is already in motion. During the period 1951 to 2000, the growing season has lengthened by about a day per decade, and warming temperatures have resulted in an increase of 30 to 70 growing degree days per decade, with much of the increase occurring in the spring. Climate change affects agriculture directly through increasing temperatures and rising CO₂ concentrations and indirectly through changes in water availability and pests.

The agriculture sector is likely to bear a disproportionate share of any water scarcity due to any reduced water availability from climate change. A preliminary

analysis suggests that a drier climate would impose significant costs on agricultural production in the Central Valley.

Temperature

Temperature influences crop growth through its impact on photosynthesis and respiration, as well as growing season length and water use. Temperature also serves as a controlling factor for developmental processes, such as flowering and fruit maturation, which may be threatened if lengthening of the growing season introduces asynchrony between the timing of flowering and the life cycle of important insect pollinators.

In general, a warming from a low to a higher temperature raises yield at first but then becomes harmful. Possible effects of excessively high temperature include decreased fruit size and quality for stone fruits, premature ripening and possible quality reduction for grapes, reduced fruit yield for tomatoes, increased incidence of tip burn for lettuce, and similar forms of burn for other crops.

As temperatures rise toward the medium warming range, by the end of this century, the local winter climate is expected to approach critical chill-hour thresholds for many species of fruit trees. (Chill hour is the number of hours below a critical temperature.)

Carbon Dioxide (CO₂)

From a variety of studies in the literature, photosynthesis increases when a plant is exposed to a doubling of CO₂. However, whether this translates into increased yield of economically valuable plant product is uncertain and highly variable. Also, elevated CO₂ levels are associated with decreased concentrations of mineral nutrients in plant tissues, especially a decrease in plant nitrogen, which plays a central role in plant metabolism.

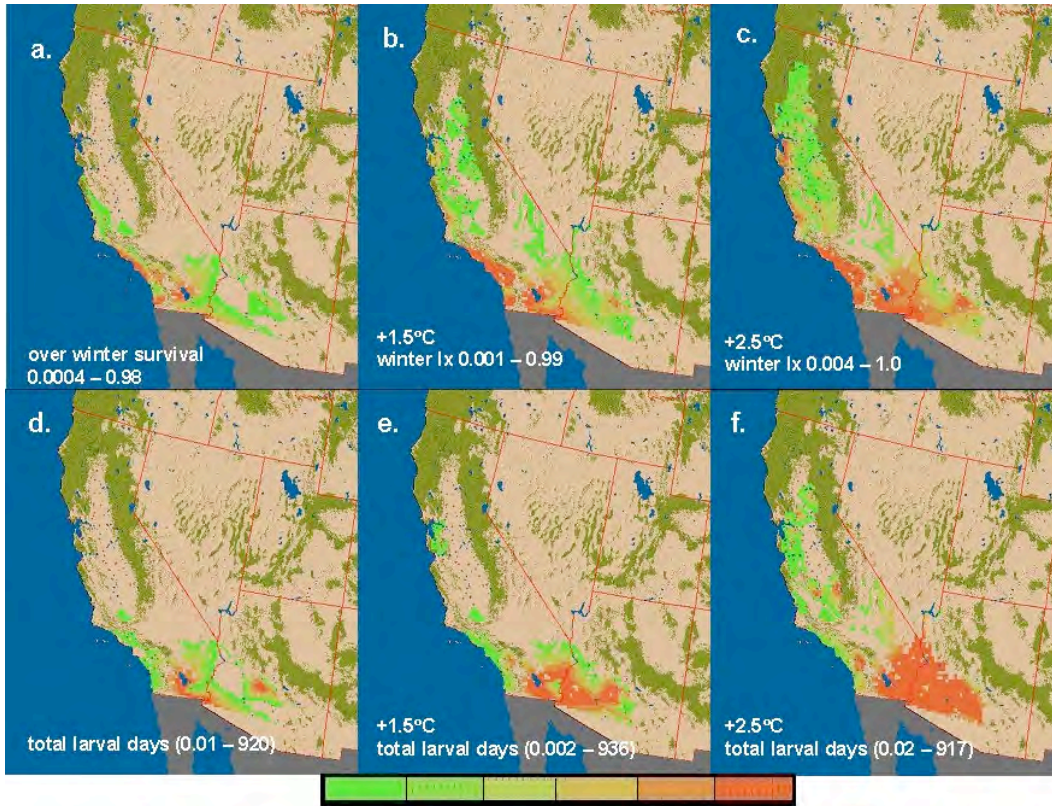
Some crops may benefit in quality from an increase in CO₂; for example, the fruit flavor of strawberries improves. Some crops are harmed by an increase in CO₂; for example grain protein in crops decreases and, in the case of wheat, bread-making quality decreases.

Pests and Weeds¹⁴

Growth rates of weeds, insect pests, and pathogens are also likely to increase with elevated temperatures, and their ranges may expand. A relatively new area of research involves the use of physiologically-based dynamic models to fully understand the effects of weather (e.g., temperature, rainfall, solar radiation, etc.) on species dynamics.

One of these models was used to estimate the potential impacts of a pest (pink bollworm, or PBW) on cotton cultivation in the state. At the present time this pest is of importance only in the southern desert valleys (e.g., Imperial and Coachella Valleys) because winter frost restricts the invasion of PBW to the million acres of cotton grown in the San Joaquin Valley. However, if winter temperatures rise by 3.6°–4.5°F (2°–2.5°C), the range of PBW of this pest would likely expand northward.

Figure 4-6. Cotton/pink bollworm (PBW): Predicting areas favored by PBW



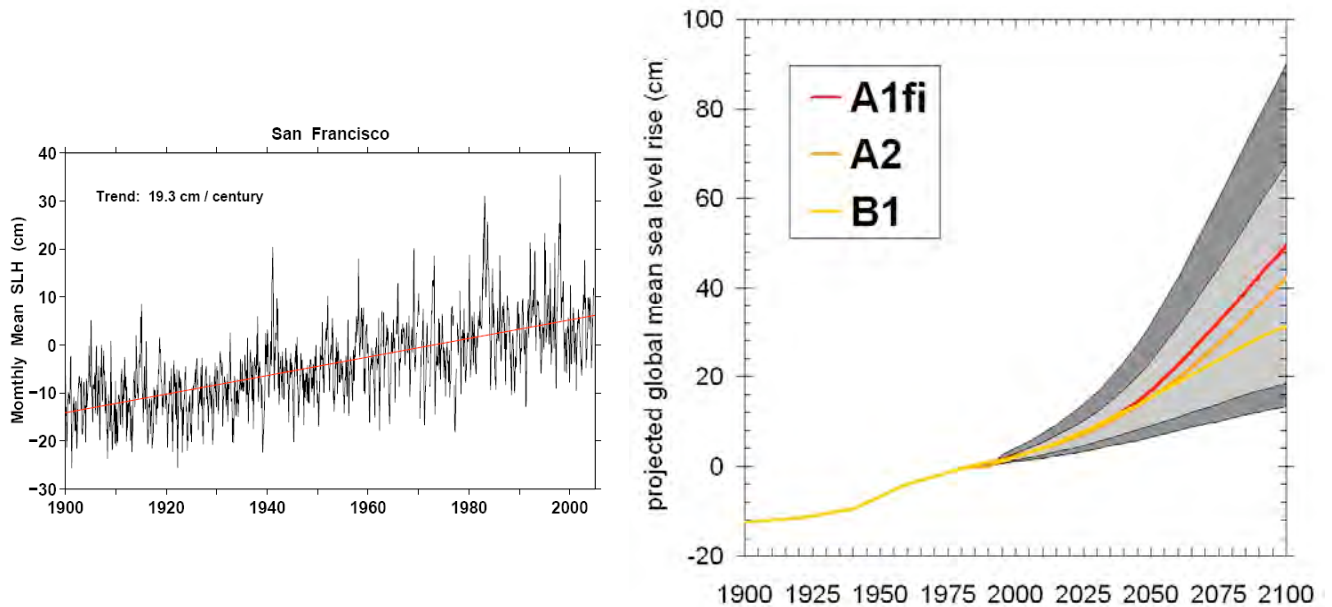
The effects on winter survival (a-c) and total seasonal pest PBW larval densities (larval days, d-e) under current weather (a,d) and with 1.5°C (b,e) and 2.5°C (c,f) increases in daily temperatures respectively (Gutierrez et al. in press).

4.5 Coastal Sea Level Impacts¹⁵

California's coastal observations and global model projections indicate that California's open coast and estuaries will experience increasing sea levels during the next century. These changes could amplify the sea level rise which has historically affected much of the coast of California, including the Southern California coast, the Central California open coast, and the San Francisco Bay and upper estuary. These trends, quantified from a small set of long-duration California tide gages, show rises of about 2 mm/year (Figure 4-6). They are very similar to trends estimated for global sea level.

In addition to long-term trends, sea levels along the California coast undergo shorter period variability above or below predicted tide levels. Highest sea levels have usually occurred when winter storms and Pacific climate disturbances such as El Niño² have coincided with high astronomical tides. So far, there is little evidence that the rate of global sea level rise has accelerated (the rate of rise at California tide gages has actually flattened during the last several years), but climate models suggest strongly that this may change.

Figure 4-7. Observed Change in Sea Level in San Francisco during the last century and Projections of Global Mean Sea Level during next century.



Source: Cayan et al., 2006

Global sea level rise is projected to range from 4 to 33 inches during the 2000 to 2100 period. This compares to a rate of approximately 7.6 inches (19 cm) per

² El Niño: A phenomenon in the equatorial Pacific Ocean characterized by a positive sea surface temperature departure from normal. Water in the eastern Pacific Ocean close to the equator gets warmer than normal, which results in changes in weather patterns. In some cases, El Niño results in significant increases in precipitation in California. For example the 1982-1983 El Niño event.)

century observed at San Francisco and San Diego during the last 100 years. Superimposed on these rising seal levels will be astronomically-driven tides, and fluctuations from weather, El Niño and other influences, so that, the occurrence of extreme events will increase as sea level rises.

The frequency that sea level exceeds a stationary threshold, as projected over future decades for locations such as the San Francisco tide gage, increases markedly as the mean sea level increases. Thus, historical coastal structure design criteria may be exceeded, the duration of events will increase, and these events will become increasingly frequent as sea level rise continues. On the open coast, impacts during these events will continue to be exacerbated by high surf from wind, waves, and, in the Sacramento/San Joaquin Delta of the San Francisco Bay estuary, by floods that may further jeopardize levees and other structures.

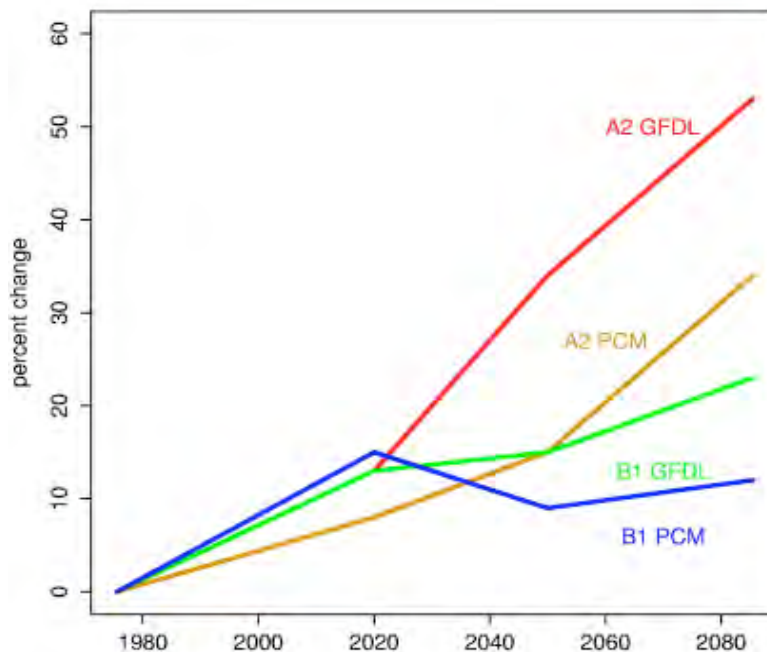
4.6 Forests and Natural Landscapes Impacts¹⁶

Climate changes and increased CO₂ concentrations are expected to alter the extent and character of forest and other ecosystems. The distribution of species is expected to shift, the risk of climate-related disturbance such as wildfires, disease, and drought is expected to rise, and forest productivity is projected to increase or decrease depending on species and region. The ecosystems most susceptible to temperature rise are the alpine and sub-alpine forest cover. In addition, changes in fire frequency are expected to lead to an increase in grasslands, largely at the expense of woodland and shrub-land ecosystems.

Wildfires¹⁷

The changing climate may modify the natural fire regimes in ways that could have social, economic and ecological consequences. The most recent analysis, which is a conservative estimate that does not include the effects of extreme fire weather, indicates that wildfire will increase, especially as warming intensifies. These projections suggest that the risk of large wildfires statewide may rise almost 35 percent by mid-century, 55 percent by the end of the century under a medium-high emissions scenario, and almost twice that expected under lower emissions scenarios.

Figure 4-8. Percent change in the expected minimum number of large fires per year in California



Source: Westerling et al., 2006

These increases in fire season severity could lead to more “bad air” days as well as increased damage costs of approximately 30 percent above current annual damage

Although society has developed a number of ways to adapt to wildfires, climate change, along with the multiplying impacts of other stresses such as population growth and land-use change, may be pushing California outside of its coping range.

However, in the short-term, California can take actions to improve its ability to live within the state’s fire-prone landscapes while maintaining the functioning and structure of the ecosystems upon which its residents depend. These include¹⁸: 1) the adoption of a risk-based framework for fire management; 2) the reintroduction of fire to fire-prone ecosystems (managing natural fires in some regions rather than suppression); 3) creation of new and flexible policies that are able to differentiate between the diverse ecosystems in California; and 4) a re-evaluation of urban planning and building in the wildland-urban interface.

Pests and Pathogens¹⁹

Historically, pests and disease have caused significant damage to California forests. The changing climate may exacerbate these effects by expanding the range and frequency of pest outbreaks. For example, the introduced pathogen, pine pitch canker (*Fusarium subglutinans* f. sp. *pini*), once limited to coastal

areas of California, has expanded to the El Dorado National Forest in the Sierra Nevada. Rising winter temperatures in the Sierra Nevada would make conditions more favorable for pitch canker and could result in increased disease severity and economic loss.

Forest Productivity²⁰

Several studies have projected increases in forest productivity under future climate change. However, recent studies indicate that it is uncertain how trees will respond to elevated CO₂ concentrations, and that there will be increased risk and susceptibility to catastrophic loss. Thus, the implications for the forest productivity and the timber industry may be less optimistic.

The most recent assessment of the impact of climate change on the California forest sector used an industry standard planning tool to forecast 30-year tree growth and timber yields for forest stands in El Dorado County under a high and medium temperature scenario.

Conifer tree growth was reduced under all climate change scenarios. If temperatures rise to the projected medium warming range, productivity in mature stands is expected to decline by 20 percent toward the end of the century. The reductions in yield were more severe (30 percent) for pine plantations. Projections further indicate that the reduced growth rates could lead to substantial decrease in tree survival rates.

4.7 Electricity Sector Impacts²¹

Changes in temperature and other meteorological variables will affect both the generation of and demand for electricity. This section discusses the potential effects of climate change on hydropower production and electricity demand in California.

Energy Supply—Hydropower

Changes in precipitation levels, should they occur, and patterns and timing of snowmelt would alter the amount of electricity that hydroelectric facilities could generate. It would also affect seasonal availability, with less water available for hydroelectric generation in the late spring and summer months when demand is the highest.

In addition, there is a high likelihood that changes in precipitation and runoff patterns would lead to changes in broader water policies and end-use priorities, such as water supply and flood control, which could impose further limitations on hydroelectric production. Currently, hydropower generation contributes about 15 percent of the in-state electricity production, with a range from 9 to 30 percent due to variations in climatic conditions.

Past studies have suggested that annual hydropower generation will increase or decrease with increasing or decreasing precipitation levels in California. The most recent study using an economic-engineering optimization model of the state water system suggests that under a medium range of temperature increase and decreased precipitation levels, annual generation by the end of this century

would decrease by about 30 percent and stream flows would decrease by 28 percent.

Another new study prepared by the Department of Water Resources (DWR) simulating the State Water and Central Valley Projects suggests reductions of approximately 7 percent in hydropower unit electricity generation for most scenarios by mid-century. However, one exception is the low temperature scenario in the less dry model, where electricity generation is projected to increase by approximately 4 percent.

It is important to emphasize that even relatively small changes in in-state hydropower generation results in substantial extra expenditures for energy generation, because losses in this “free” generation must be purchased from other sources.

For example, assuming a decrease of 10 percent from the current average in-state generation level from this renewable energy source, and assuming a price of about 10 cents per kilowatt-hour, this decrease would result in an additional \$0.35 billion per year in net expenditures to purchase sufficient electricity to replace the electricity that otherwise would be generated using hydroelectric resources.

Electricity Demand

Electricity demand is projected to rise between 3 to 20 percent by the end of this century. These results are based on correlation functions relating electricity demand with temperatures in key areas in California and future climate projections assuming current socio-economic conditions, including no change in present day population. In the next 20 years electricity demand would increase from 1 to 3 percent from the baseline, and peak electricity demand would increase at a faster rate.

Since annual expenditures of electricity demand in California represent about \$28 billion, even the relatively small increases in energy demand would result in substantial extra energy expenditures for energy services in the state. For example, assuming a linear increase in electricity expenditures from the historical period, a 3 percent increase in electricity demand by 2020 would translate to about \$1.2 billion a year in extra electricity expenditures.

Potential Coping Strategies

There are several options to reduce the negative effect of climate change on the electricity system. The use of modern probabilistic hydrological forecasts for the management of water reservoirs in the state is a promising option being studied. Some options needed to reduce climate change emissions can be seen as coping strategies. They include, for example, enhanced energy efficiency programs, increased penetration of photovoltaic systems, and the implementation of measures designed to reduce the heat island effect.

4.8 Implications for Mitigation and Adaptation²²

Continued climate change would have widespread impacts on California's economy, ecosystems, and the health of its citizens. However, analyses from the present study, summarized in Figure 17, suggest that many of the more severe impacts projected under the medium and higher warming ranges could be avoided by following the lower emissions pathway. It should be noted though, that, if the actual climate sensitivity to climate change emissions reaches the level of the more sensitive global climate models employed here, an even lower emissions path than the B1 scenario may be required to avoid the medium warming range. How much would climate change emissions have to be reduced to stay below the lower emissions pathway (B1) and insure against temperatures rising to the medium and higher warming ranges presented in this study? The Governor's Executive Order #S-3-05, calls for an 80% reduction in CLIMATE CHANGE emissions, relative to 1990 levels, by 2050. If the industrialized world were to follow California's lead and the industrializing nations transitioned to a lower emissions energy system as characterized by the B1 pathway, global emissions would remain below the lower emissions scenario (B1),³ increasing the likelihood that California and the world would be on track to avoid the more severe impacts by preventing temperatures from rising to the medium warming ranging.⁴ This estimate of the impact of an 80% reduction by the industrialized world on global emissions depends crucially on the development patterns of the Industrializing Nations. The SRES B1 scenario assumes development proceeds with a "high level of environmental and social consciousness" with a transition to "alternative energy systems" (Nakicenovic et al. 2000). Emission reductions targets such as the one set by the Governor's Executive Order could spur the innovation necessary to lead the World to a transition to alternative energy systems.

³This was calculated as follows: 1) OECD population and total emissions were based on SRES B1 IMAGINE runs (Nakicenovic et al. 2000). OECD total emission in 1990 were 2.83 GtC; 2) 80% below this value is 566MtC; 3) Total global emissions was calculated by adding the 566 MtC to the total emissions for non-OECD countries, as projected by SRES B1. This value is approximately 10GtC; 4) This 10 GtC/yr was compared to the global emission projected in the B1 scenario (approximately 11 GtC/yr).

⁴ As illustrated in figure 1, beyond 2050 global emissions will need to decrease substantially below 10 GtC/yr to stay on the B1 pathway out to the end of the century. The SRES B1 pathway assumes Global emissions decrease to 4.23 GtC/yr by 2100. However, stabilizing atmospheric concentrations will require even lower emissions as natural uptake is estimated between 0.7-2.9 GtC/yr (IPCC 2001).

Figure 4-9. Projected Impacts End of Century

Emissions Scenarios (End of century Atmospheric CO ₂ Concentration)		Statewide Temperature Rise (°C) 2070-2099
Higher Emissions A1fi (970 ppm)	<ul style="list-style-type: none"> 90% loss in Sierra snow pack 55-75 cm (22-30 inches) of Sea level rise 3-4 times as many heatwave days in major urban centers² 2.5 times the number critically dry years³ 20 % increase in electricity demand 4-10 times as many heat-related deaths projected for some urban centers⁴ Increase in Forest yields not evaluated for this scenario⁵ Increase in Fire risk not evaluated for this scenario⁵ Increase in days meteorologically conducive to ozone formation⁵ 	4.4 – 5.8 °C (8-10.4 °F)
Medium-High Emissions A2 (830 ppm)	<ul style="list-style-type: none"> 70- 80 % loss in Sierra snow pack 35-55 cm (14-22 inches) of Sea level rise 1-2 times as many heatwave days in major urban centers 2.5-5.5 times as many heat-related deaths projected for some urban centers⁴ 75-85% increase in days meteorologically conducive to ozone⁶ 2-2.5 times the number critically dry years³ 11% increase in electricity demand 30% decrease in forest yields (Pine) 55% increase in the expected risk of large fires 	3.1 -4.4 °C (5.5-7.9 °F)
Lower Emissions B1 (550 ppm)	<ul style="list-style-type: none"> 30-60 % loss in Sierra snow pack 15-35 cm (6-14 inches) of Sea level rise 2-2.5 times as many heatwave days in major urban centers 2-4 times as many heat-related deaths projected for some urban centers⁴ 25-35% increase in days meteorologically conducive to ozone formation⁶ Upto 1-1.5 times the number critically dry years³ 3- 6 % increase in electricity demand 7-14% decrease in forest yields (Pine) 10-35% increase in the risk of large fires 	1.7 -3.0 °C (3.0-5.4 °F)

1. Impacts presented relative to 1961–1990.
2. Los Angeles, San Bernardino, San Francisco, Sacramento, and Fresno.
3. Measures for the San Joaquin and Sacramento basins.
4. For Los Angeles, Riverside, and Sacramento.
5. Impacts expected to be more severe as temperatures rise. However, higher temperature scenarios were not assessed for the project.
6. Formation in Los Angeles and the San Joaquin Valley.

Climate projections show little difference between the emissions scenarios prior to 2035 due to the inertia of the climate system, indicating that even under the lower emissions path some further impacts from climate change are inevitable. Consequently, although it is not the solution to global warming, it is becoming clear that adaptation is an essential complementary strategy to manage some of the projected impacts of climate change. While there are many opportunities for California to increase its capacity to cope with the projected changes, these are often costly.

Furthermore, there are limits to adaptation, especially in addressing the threats of abrupt climate changes or in dealing with those impacts on natural, unmanaged species and ecosystems. These species may not be able to keep up with the increasingly rapid and severe climate change expected in future decades. Finally, the ability to cope and adapt is differentiated across populations, economic sectors, and regions within the state. As a result, without appropriate actions climate change will likely aggravate existing equity issues within California and the rest of the U.S.

For example, the most vulnerable populations to the health impacts of climate change are children, elderly people, and residents of minority and low-income communities—the same groups that already face the greatest health and environmental risks.

The Department of Water Resources and other State agencies have already started to include climate change considerations in their long-range plans. However, no cities in California have a heat emergency action plan; such plans are especially crucial to assist the elderly, especially those living in housing without air conditioning, who may be the most at risk from heat waves.

Thus, the Department of Health Services should develop heat emergency action plans for California (with a focus on protecting the economically disadvantaged) before the need arises. Existing air pollution control programs do not consider the effect of climate change on vulnerable populations; children and the elderly (especially those with pre-existing heart disease) are among the groups most vulnerable to air pollution episodes. Those that live closer to freeways and other emission sources (disproportionately in low-income and minority communities) are exposed to higher levels of pollution.

The Air Resources Board should work with the U.S. Environmental Protection Agency to begin to build climate change considerations into efforts to attain and maintain the health-based air quality standards over the long term.

Better monitoring of California's climate and sensitive climate related sectors will be crucial to detecting and understanding a complex chain of impacts. Finally, the State should continue to generate public discussion and build awareness of the need to manage climate change, develop enabling (or eliminating constraining) adaptation policies, and foster the political will necessary to critically assess and ultimately realize the State's significant adaptive potential.

5 RECOMMENDATIONS FOR EMISSION REDUCTION STRATEGIES

The CAT evaluated a significant number of strategies that could be implemented in California to reduce climate change emissions. The strategies listed in the section represent the recommendations of the CAT regarding activities that should be undertaken in the state agencies to ensure the Governor's targets are met. Most of these strategies can be implemented with existing authority of the state agencies represented on the CAT.

5.1 Process for Strategy Selection

As a starting point for emission reduction strategy selection, the CAT relied upon information provided by the Tellus Institute, Center for Clean Air Policy, CEC's Integrated Energy Policy Report, and other existing evaluations of climate change emission reduction policies. The CAT agency representatives then went through a brainstorming exercise and each representative contributed to a larger list of potential emission reduction strategies that either their own agency or other agencies could implement.

The CAT as a whole discussed each strategy and reviewed work plans that included implementation steps, a timeline, and estimated potential emission reductions and costs. From these work plans it was determined which emission reduction strategies could be recommended to the Governor and Legislature at this time and which were either infeasible or would require further analysis.

The CAT then held two public workshops to review the strategies with the public. CAT representatives also met with representatives from low-income and minority communities, environmental organizations, industry representatives, and non-government organizations to review and discuss the list of strategies. Based on comment received at those workshops and meetings, the group made revisions and developed a final list of recommended strategies included in this document.

5.2 Strategies Cal/EPA Will Implement Over the Next Two Years

Table 5-1 Table 5-2 lists all of the strategies that Cal/EPA will implement over the next two years. By 2020, the Air Resources Board's vehicle climate change emission standards will provide the largest emission reductions of any of the strategies being recommended by the Climate Action Team. The large auto manufacturers are currently challenging California's right to set climate change emission standards for vehicles. Governor Schwarzenegger has pledged his support in defending the State's right to require the sale of cleaner cars. The Integrated Waste Management Board will continue to pursue stringent waste reduction and recycling goals and is working towards better understanding of landfill gas emissions and best practices for capture and use of those emissions.

Table 5-1. Environmental Protection Agency

Climate Change Emission Reductions (Million Metric Tons CO ₂ Equivalent) ¹		
	2010	2020
Air Resources Board		
Vehicle Climate Change Standards	1	30
Diesel Anti-Idling	1	1.2
Other New Light Duty Vehicle Technology	0	4

Improvements		
HFC Reduction Strategies	2.7	8.5
Transport Refrigeration Units, Off-road Electrification, Port Electrification (ship to shore)	<1	<1
Manure Management	1	1
Semi Conductor Industry Targets (PFC Emissions)	2	2
Alternative Fuels: Biodiesel Blends	<1	<1
Alternative Fuels: Ethanol	<1	3.2
Heavy-Duty Vehicle Emission Reduction Measures	0	3
Reduced Venting and Leaks in Oil and Gas Systems	1	1
Hydrogen Highway	Included ²	
Integrated Waste Management Board		
Achieve 50% Statewide Recycling Goal	3	3
Landfill Methane Capture	2	3
Zero Waste—High Recycling		3

¹ These estimates are based on best available current information and will be updated as needed.

² The benefits of the Hydrogen Highway have been captured in other programs such as the motor vehicle regulations and green buildings initiative.

A summary description of each of the strategies in Table 5-1 is included below:

Vehicle Climate Change Standards

With the passage of AB 1493, Pavley, Chapter 200, Statutes of 2002, California moved to the forefront of reducing vehicle climate change emissions. This bill required the state to develop and adopt regulations that achieve the maximum feasible and cost-effective reduction of climate change emissions emitted by passenger vehicles and light duty trucks. Regulations were adopted by the ARB in September 2004.

The ARB analysis of this regulation indicates emissions savings of 1 million tons CO₂ equivalent (MMtCO₂e) by 2010 and 30 million tons CO₂ equivalent by 2020.²³ This analysis also suggests that operating cost savings will more than offset the incremental costs of improved technologies, resulting in consumer savings of \$5 billion annually by 2020.

Diesel Anti-Idling

Reduced idling times and the electrification of truck stops can reduce diesel use in trucks by about 4 percent, with major air quality benefits. In July 2004 the ARB adopted a measure to limit diesel-fueled commercial motor vehicle idling.²⁴ ARB

analysis indicates that anti-idling measures could reduce climate change emissions by 1.2 MMtCO₂e in 2020.²⁵ ARB also estimates that the proposed measures would provide savings of up to \$575 million (NPV through 2013) to California businesses as a result of fuel savings and reduced engine maintenance costs.

Other New Light Duty Vehicle Technology Improvements

In September 2004 the California Air Resources Board approved regulations to reduce climate change emissions from new motor vehicles. The regulations apply to new passenger vehicles and light duty trucks beginning with the 2009 model year. The standards adopted by the Board phase in during the 2009 through 2016 model years. When fully phased in, the near term (2009–2012) standards will result in about a 22 percent reduction as compared to the 2002 fleet, and the mid-term (2013–2016) standards will result in about a 30 percent reduction.

New standards would be adopted to phase in beginning in the 2017 model year (following up on the existing mid-term standards that reach maximum stringency in 2016). Assuming that the new standards call for about a 50 percent reduction, phased in beginning in 2017, this measure would achieve about a 4 MMT reduction in 2020. The reduction achieved by this measure would significantly increase in subsequent years as clean new vehicles replace older vehicles in the fleet—staff estimates a 2030 reduction of about 27 MMT.

Hydrofluorocarbon Reduction Strategies

ARB staff has identified five possible measures to reduce HFC emissions from vehicular and commercial refrigeration systems:

1. *Ban the retail sale of hydrofluorocarbon (HFC) in small (mostly 12-oz.) cans.* This would end the loss of can “heels” (small amounts of HFCs remaining in the can after service is complete) and prevent do-it-yourself re-filling of vehicular air conditioning systems.
2. *Require that only low-GWP refrigerants be used in new vehicular systems.* For vehicles subject to the ARB motor vehicle climate change emission reduction regulations, this requirement would take effect in 2017 because the adopted regulations already specify standards and compliance options through 2016. For medium- and heavy-duty vehicles not subject to the AB 1493 regulation, the requirement would take effect in the 2010 timeframe.
3. *Adopt specifications for new commercial refrigeration.* Limit the global warming potential of refrigerants used in refrigerators in retail food stores, restaurants, and refrigerated transport vehicles (trucks and railcars) and/or require that centralized systems with large refrigerant charges and long distribution lines be avoided in favor of systems that use much less refrigerant and lack long distribution lines.
4. *Add refrigerant leak-tightness to the “pass” criteria for vehicular Inspection and Maintenance programs (all vehicles) and adopt an “inspect*

and repair” measure for commercial systems. Require that systems either be leak-free at smog-check or be empty and inoperable.

5. *Enforce the federal ban on releasing HFCs.* This measure would focus on reducing emissions during the servicing and dismantling of vehicular air conditioners and commercial refrigeration systems.

Transportation Refrigeration Units, Off-road Electrification, Port Electrification (ship to shore)

Transportation Refrigeration Units

Require all new transportation refrigeration units (TRU) to be equipped with electric standby.

Require cold storage facilities to install electric infrastructure to support electric standby TRUs.

The technologies to be employed in this measure include electric standby for TRUs and electric infrastructure at cold storage facilities.

Emission reduction estimates are about 0.14 MMT in 2020 assuming 50 percent electrification and TRU operation at a facility of about 30 percent.

Off-road Electrification

Off-road electrification would likely be achieved using a combination of regulatory and incentive approaches. ARB could conduct outreach to encourage replacement of diesel engines with electric motors to take advantage of the incentive rate structure and Moyer funding, and to comply with District and pending ARB regulations.

The in-use stationary diesel agricultural engine regulation currently under development at ARB will propose emission performance standards for engines rather than mandate electrification or any other specific technology. Staff believes that most engines will be replaced with new cleaner certified diesel engines or with electric motors. Retrofit and alternative fuels are other potential means of compliance.

Port Electrification

ARB would require phase-in of vessel modifications and infrastructure to support expanded use of shore-side power.

Technologies to be employed in this measure include vessel modifications and shore-side infrastructure.

Shore-side power could be used in 2 to 5 percent of ship visits in 2010 and 20 to 25 percent of ship visits in 2020. The reductions in CO₂ emissions are calculated as the difference between the CO₂ emissions resulting from the generation of shore-side power supplied by utility companies and the CO₂ emissions resulting from power generated by shipboard diesel generators.

2010

Goal: 5 percent of ship visits use shore-side power

Estimated CO₂ reduction: 0.016 MMT

2020

Goal: 25 percent of ship visits use shore-side power

Estimated CO₂ reductions: 0.18 MMT

Manure Management

Proposed San Joaquin Valley Rule 4570, Confined Animal Facilities, is intended to reduce volatile organic compounds (VOC) from confined animal facilities and is in the initial stages of development. Some general concepts that may appear in the rule include: (1) different requirements based on facility size; (2) specific control requirements included on a list of technologies; (3) a mix of control options selected from a list; and (4) a facility-wide control efficiency that will achieve a certain percentage reduction. Possible control options include management practices, manure handling practices, and lagoon/liquid waste control options.

Emission reduction estimates of approximately 1 million tons (MMT) could be achieved through the use of biogas digesters along with the production of electricity and/or heating applications. ARB estimates of climate change emission reductions through implementation of anaerobic digesters have yet to be determined.

Semi Conductor Industry Targets (PFC Emissions)

ARB could help target climate change emission reductions through development of a model rule to be considered for adoption by the districts. Based on the voluntary target outlined in the Memorandum of Understanding between the U.S. EPA and the Semiconductor Industry Association, emission reduction estimates of approximately 2 MMT for semiconductor operations in both 2010 and 2020 are possible.

Alternative Fuels: Biodiesel Blends

ARB would develop regulations to require the use of 1 to 4 percent biodiesel displacement of California diesel fuel. A climate change emission reduction of about 0.4 MMT would be achieved in 2010 based on 2 percent displacement of diesel fuel. ARB and CEC staff estimate that biodiesel could likely provide up to a 4 percent displacement of diesel fuel by 2020. This would provide about 0.8 MMT of climate change emission reductions. It is important to note, however, that current supplies of biodiesel are limited in California. Thus this strategy presumes significant market expansion in addition to regulatory steps.

Alternative Fuels: Ethanol

More than 200,000 flexible fueled vehicles are present in California today that could use E-85 without any equipment modifications. This number will increase as manufacturers continue to produce additional new cars that are E-85 compatible. If E-85 became widely available at prices competitive with gasoline, a significant portion of the fleet could be fueled primarily with ethanol by 2015.

The percentage of ethanol used in gasoline could be increased to the maximum 10 percent (E-10) that is compatible with current vehicles. (The current gasoline supply contains 5.7 percent ethanol). However, significant permeation emissions caused by low percentage ethanol blends used in the summertime suggest that low percentage blends are best limited to wintertime use. In addition, other fuel properties may need to be adjusted to ensure that the use of E-10 does not increase emissions of smog forming compounds.

If ethanol used in California continues to be derived from corn or other similar grains, the climate change emission benefits due to increased use of E-85 would be negligible in 2010 and 2.7 MMT in 2020 (assumes that about 10 percent of the entire light duty vehicle fleet uses E-85 regularly.) Use of ethanol derived from biomass or waste material would more than double the climate change emission reduction benefit.

Using 10 percent ethanol content in gasoline during the wintertime (six months) would result in ethanol use roughly equivalent to the level required under the recently adopted federal energy bill, and thus produce no additional climate change emission reduction benefits.

Heavy-Duty Vehicle Emission Reduction Measures

Climate change emissions can be reduced with improved aerodynamics, climate engine-based improved efficiency, vehicle weight reduction, and rolling and inertia resistance improvements. ARB has also identified other possible measures, such as an education program for the heavy duty vehicle sector as well as the light and medium duty vehicle sectors that would educate drivers as to how to optimize vehicle operation.

Emission reduction estimates of about 0.2 MMT for 2010 and about 3 MMT for 2020 were derived assuming an efficiency improvement of 65 percent from 1990 levels is possible by 2030. These estimates were based on ARB/CEC estimates of fleet-wide diesel-use reductions achievable under a national approach based on DOE's 21st Century Truck Program.

Reduced Venting and Leaks in Oil and Gas Systems

A model rule would be developed to be considered for adoption by the Air Pollution Control Districts. This measure involves improved management practices and does not rely on the application of new technology.

Estimated potential climate change emission reductions of 1 MMt CO₂ equivalent were derived assuming reduced leak and venting in the production, processing, transport, and distribution of oil and natural gas in 2010 and 2020. This goal is based on U.S.EPA estimates that approximately 33 percent of emissions from oil and gas systems can be avoided cost-effectively.

Hydrogen Highway

The California Hydrogen Highway Network (CA H2 Net) is a State initiative to promote the use of hydrogen as a means of diversifying the sources of transportation energy in order achieve a secure energy future, address

environmental, public health, and economic challenges, and work in partnership with other State programs to advance energy efficiency and renewable energy. The CA H2 Net mission is to assure that hydrogen infrastructure is in place as fuel cells and other hydrogen technologies reach commercial readiness.

Hydrogen can be derived from a variety of sources including petroleum based feedstock to a range of renewable resources. To assure that the production of hydrogen and operation of hydrogen fueled vehicles is environmentally beneficial the CA H2 Net has the clearly defined goals of utilizing at least 20 percent renewable resources in the production of hydrogen, reducing climate change emissions by at least 30 percent, and to not increase smog forming and toxic pollutants relative to fossil fuel vehicle use.

Achieve 50% Statewide Recycling Goal

Achieving the State's 50 percent waste diversion mandate as established by the Integrated Waste Management Act of 1989, (AB 939, Sher, Chapter 1095, Statutes of 1989), will reduce climate change emissions associated with energy intensive material extraction and production as well as methane emission from landfills. Currently a diversion rate of 48 percent has been achieved on a statewide basis. This strategy would result in achieving an additional 2% waste diversion of recyclables from landfills using existing authorities and mandates, collection infrastructures, and recycling processes.

Landfill Methane Capture

Methane production varies greatly from landfill to landfill depending on site-specific characteristics such as the quantity of waste in place, waste composition, moisture content, landfill design and operating practices, and climate. Unless captured first by a gas recovery system, methane generated by the landfill is emitted when it migrates through the landfill cover to the atmosphere and becomes a potent climate change emission.

Landfills can install direct gas use projects or electricity projects with backup flare systems to capture and use methane. The technical applicability of any mitigation option is dependent on the amount of landfill gas generated by landfills in a given size category.

Zero Waste—High Recycling

Additional recovery of recyclable materials from landfills will reduce the climate change emissions associated with energy intensive material extraction and production as well as methane emission from landfills. Transforming organics/biomass and plastic waste into marketable products will also reduce the amount of material going to landfill, and therefore will further reduce climate change emissions. Currently, the State is mandated to divert 50 percent of waste going to landfills as established by the Integrated Waste Management Act of 1989. Efforts to exceed the 50 percent goal would allow for additional reductions in climate change emissions.

5.3 Strategies the Resources Agency will Implement over the Next Two Years

Table 5-2 lists all of the strategies that Resources Agency will implement over the next two years. The Forest management efforts promise not only climate change emission reductions but also protect biodiversity, water quality and habitat resources. For three decades the California Energy Commission has led the world with the most progressive new building and appliance efficiency standards. These efficiency standards have provided substantial climate change emission reductions and have saved consumers about \$1,000 per household in California. Finally, by reducing the energy used to transport and deliver water in the State and increasing water use efficiency California can both protect our water supply and reduce climate change emissions.

Table 5-2. Resources Agency

Climate Change Emission Reductions (Million Metric Tons CO ₂ Equivalent) ¹		
	2010	2020
Department of Forestry		
Forest Management	1-2	2-4
Forest Conservation	4.2	8.4
Fuels Management/Biomass	3.4	6.8
Urban Forestry	0	3.5
Afforestation/Reforestation	0	12.5
Department of Water Resources		
Water Use Efficiency	0.4	1.2
Energy Commission		
Building Energy Efficiency Standards in Place	1	2
Appliance Energy Efficiency Standards in Place	3	5
Fuel-Efficient Replacement Tires & Inflation Programs	1.5	1.5
Building Energy Efficiency Standards in Progress	TBD	TBD
Appliance Energy Efficiency Standards in Progress	TBD	TBD
Cement Manufacturing	<1	<1
Municipal Utility Energy Efficiency Programs/ Demand Response	1	5.9

Municipal Utility Renewable Portfolio Standard	<1	3.2
Municipal Utility Combined Heat and Power	0	<1
Municipal Utility Electricity Sector Carbon Policy	3	9
Alternative Fuels: Non-Petroleum Fuels	TBD	TBD

¹ These estimates are based on best available current information and will be updated as needed.

A summary description of each of the strategies in Table 5-2 is included below:

Forest Management

Strategies for storing more carbon through forest management activities can involve a range of management activities such as increasing either the growth of individual trees, the overall age of trees prior to harvest, or dedicating land to older aged trees. With roughly 4 million acres of private managed forestland in California, changes in forest management can produce significant amounts of climate change emission reduction benefits for the state.

Inclusion of the forest sector in climate mitigation policy can lead to additional local environmental benefits that may help the state’s resources adapt to potential negative effects of climate change. Overall changes in forest management can enhance and protect biodiversity, water quality, and habitat resources that the state will increasingly seek to protect in the advent of climate change.

Forest management projects could be included in a broader multi-sector climate change emission market-based program or climate trust system. In a market-based program, forest management projects could provide offsets that would be purchased by capped entities. In a climate trust program, the state would fund forest management projects and recapture the costs by selling carbon credits to industries needing to reduce their climate change emissions.

The regulatory framework for timber harvesting requires landowners to secure permits from a large number of agencies to meet the requirements of the Forest Practice Act, Endangered Species Act, and Clean Water Act. Together the time and cost of obtaining these permits have led to conversions of timberlands to other uses and made it more difficult and time consuming to implement forest management activities that would increase carbon storage. Simplification of the permitting processes for forest management and timber harvesting would result in additional carbon being stored over a larger number of acres.

Forest Conservation

Conservation projects are designed to minimize/prevent the climate change emissions that are associated with the conversion of forestland to non-forest uses by adding incentives to maintain an undeveloped forest landscape.

California is losing forestland at increasing rates: 35,000 to 40,000 acres of private forestland is converted annually to non-forest uses (Bill Stewart, 2005),

which could contribute as much as 12 million tons of CO₂ emissions annually. Policies designed to minimize or prevent forestland conversion to non-forest uses could provide significant benefits by 1) preventing or minimizing climate change emissions that are associated with increasing forestland conversion in California and 2) maintaining the opportunity to increase forest carbon stocks on these lands through additional sequestration over time.

Forest conservation can also enhance and protect biodiversity, water quality, and habitat resources that the state will increasingly seek to protect from the negative effects of climate change. Finally, in contrast to the other forest sector strategies such as reforestation, the climate benefits of forest conservation are immediate.

Specific actions that can be taken include establishing a state forest conservation program that operates independently from the federal Forest Legacy program; increasing Forest Legacy Program Funding with an \$11 million annual investment that could prevent the conversion of 14,000 acres of forestland. Another step could include directing the Wildlife Conservation Board, the State Conservancies, and other state land acquisition and easement programs to consider climate benefits in evaluating and ranking projects to be funded. Finally, the state could include forestland conservation as an emission reduction project in a broader multi-sector climate change market-based program or climate trust system.

Fuels Management/Biomass

Large, episodic, unnaturally hot fires are an increasing trend on California's wild lands because of decades of fire suppression activities, sustained drought, and increasing insect, disease, and invasive plant infestations. Actions taken to reduce wildfire severity through fuel reduction and biomass development would reduce climate change emissions from wildfire, increase carbon sequestration, replace fossil fuels, and provide significant local economic development opportunities.

Fire management and biomass development projects could be accelerated by establishing a new state goal of thinning, removing, and treating 212,000 acres of public and privately owned forestland annually by 2010, and 275,000 acres by 2020. Such projects would: 1) reduce the intensity of wildfires and their associated climate change emissions; 2) increase the carbon stock of the remaining trees, 3) remove pests that create mortality of live stored carbon and reduce large damaging wildfires, 4) reduce state and local fire suppression costs; 5) provide a source of renewable alternative fuel; and 6) provide significant rural economic development opportunities.

Urban Forestry

This strategy would expand the State Urban Forestry Program. A new state-wide goal of planting 5 million trees in urban areas by 2020 would be achieved through the expansion of local urban forestry programs. At a cost of \$100 per tree, \$500 million would have to be invested by local urban forestry programs to meet this target.

This could be achieved by issuing an Executive Order to establish a new statewide goal and directing the Board of Forestry and California Department of Forestry to launch an aggressive public assistance and outreach campaign to expand local urban forestry programs. The state could request that the California Climate Action Registry develop and adopt a protocol for the certification of climate change emission reductions from local urban forestry programs.

This strategy would develop new urban biomass programs. The California Department of Forestry would develop an urban biomass utilization program to provide technical advice, planning, education, and seed money for local government marketing centers for biomass waste.

Afforestation (Planting Trees)/Reforestation Projects

Reforestation projects focus on restoring native tree cover on lands that were previously forested and are now covered with other vegetative types. Recent studies have estimated that approximately 9 million acres of land in California could be reforested to increase carbon stocks and provide other benefits. Each of these acres has the potential to store between 150 to 230 tons of carbon.

Specific actions that could be taken include: establishing a new statewide goal of reforesting 500,000 acres of forestlands by 2020, including 250,000 acres on private lands and 250,000 acres on federal lands; seeking \$30 million annually, or \$300 million in bond funds to meet these targets; establishing a long-term loan program to fund private land reforestation; establishing a multisector market-based program where reforestation projects can be included as offsets in a broader, multi-sector climate change market-based program; and establishing a state-owned carbon bank, modeled after Oregon's Climate Trust, as part of a market-based program.

Water Use Efficiency

Approximately 19 percent of all electricity, 30 percent of all natural gas, and 88 million gallons of diesel are used to convey, treat, distribute and use water and wastewater. The California Energy Commission (CEC) estimates 44 million tons of CO₂ emissions are expelled annually on average to provide the 44 million acre feet (MAF) of water used statewide.

The key to the reduction of climate change emissions through water use efficiency is strategic investment in measures tied to water energy intensity. When a unit of water is saved, so too is the energy required to convey, treat, affect local delivery, perform wastewater treatment and safely dispose of that unit of water. In short, saving water saves energy. Saving water that gets treated as wastewater saves more energy. Saving water that gets heated or additionally pressurized saves still more.

Region, elevation, water use sector, and energy source, among other factors, all influence water energy intensity. The statewide average for climate change emissions per acre foot is skewed by the wide local variation in the water energy intensity. Everything else being equal, a cooling tower condenser meter installed in an industrial plant in Northern California will save 2,920 kWh compared to

9,270 kWh saved annually in a comparable plant south of the Tehachapi Mountains.

Increased water use efficiency is the key element in the California Water Plan Update (Bulletin 160-05) plans to meet the state's needs for water in 2030 with a growing population. The plan calls for reducing urban water use by 1.1 to 2.3 MAF per year and agricultural water use by 0.5 to 2.0 MAF per year by 2030. Accelerating the investment to attain that water use savings by 2015 would result in an estimated additional climate change emission reductions of approximately 30 million tons cumulatively by 2030. Accelerating the investment to 2010 would result in a further cumulative reduction of 10 million tons.

The California Bay-Delta Authority's larger estimated potential for 3.0 MAF per year urban water use reduction requires a greater rate of local and state/federal investment in conservation. Incentive driven advances in water-saving technology over the next 25 years potentially could further push savings beyond the levels indicated.

A comprehensive program focused on the state's water and wastewater agencies and their customers would yield significant benefits to the state including: meeting the state's water plan, increasing energy system reliability and price stability, meeting the state's renewable portfolio standard goals and reducing the state's climate change emissions. Following are measures to include in this comprehensive program:

- Accelerate investment in water use efficiency: Accelerate implementation of best management practices and efficient water management practices (EWMP) and incentives. Coordinate this accelerated investment with the state's investments in energy efficiency. Start in the areas of the state with most energy-intensive water use cycles.
- Increase the energy efficiency of all water and wastewater treatment operations. Develop long-term programs to better mesh with the long-term investments in water and wastewater infrastructure.
- Improve price signals so that water-related energy use can be shifted off periods of peak energy demand.
- Increase water storage to increase operational flexibility throughout the water use cycle and reduce peak electric system energy requirements.
- Identify suitable locations for new pumped storage facilities. Construct facilities at these locations.
- Increase energy production by water and wastewater agencies from renewable sources such as in-conduit hydropower and biogas. Add generation from solar and wind resources.

Building Energy Efficiency Standards in Place

Public Resources Code 25402 authorizes the Energy Commission to adopt and periodically update its building energy efficiency standards (that apply to newly constructed buildings and additions to and alterations to existing buildings). The

Energy Commission updates the standards at its discretion (i.e. three-year cycle for building standards). In addition to the long existing legislative mandates, recent policies have placed priority on and established specific goals for updating of the standards.

The Energy Action Plan and the Integrated Energy Policy Report both call for ongoing updating of the standards, including meeting energy efficiency goals, addressing demand response and promoting the combination of solar photovoltaics and high-energy efficiency buildings. The Energy Commission has also initiated work for the building standards that will go into effect in 2008 (i.e. the first of three update cycles that will occur prior to 2015).

Appliance Energy Efficiency Standards in Place

Public Resources Code 25402 authorizes the Energy Commission to adopt and periodically update its appliance energy efficiency standards (that apply to devices and equipment using energy that are sold or offered for sale in California). The Energy Commission updates the standards at its discretion. In addition to the long existing legislative mandates, recent policies have placed priority on and established specific goals for updating of the standards.

New standards for a variety of appliances were adopted in December 2004. Some standards under consideration in December were delayed to further consider manufacturer comments. Those standards are being developed by the Energy Commission at the present time. The estimates in Table 5-1 represent the expectation of full adoption of these standards.

Fuel-Efficient Replacement Tires and Inflation Programs

State legislation (Chapter 912, Statutes of 2001) directed the Energy Commission to investigate and to recommend ways to improve fuel efficiency of vehicle tires. The bill established a statewide program to encourage the production and use of more fuel efficient tires, and required the Energy Commission to:

- Establish a test procedure for measuring tire fuel efficiency.
- Develop a database on the fuel efficiency of existing tires in order to establish an accurate baseline of tire efficiency.
- Develop a rating system for tires that provides consumers with information on the fuel efficiency of individual tire models.
- Develop a consumer-friendly system to disseminate tire fuel-efficiency information as broadly as possible.
- Study the safety implications of different policies to promote fuel efficient replacement tires in the consumer market.
- Evaluate a mandatory fuel efficiency standard for all after-market tires sold in California.

- Develop consumer incentive programs that would offer a rebate to purchasers of replacement tires that are more fuel-efficient than the average replacement tire.
- Study ways to improve the fuel-efficiency of vehicles in the State's fleet.
- AB 844 later required tire manufacturers to report to the Energy Commission the rolling resistance and relative fuel economy of replacement tires sold in California.

Building Energy Efficiency Standards in Progress

As part of the process of updating the Building Energy Efficiency Standards, the Energy Commission evaluates new and emerging technology for possible inclusion in the standards. The CEC administers an ongoing "compliance option" process which evaluates to what extent compliance credit should be approved for new technologies and develops algorithms that can be used to properly evaluate their energy consequence within building simulation computer programs that are used for standards compliance.

Upon commission approval, compliance options can be used to demonstrate compliance with the performance approach in the standards. Once a compliance option has been in existence for a period of time, the commission often considers whether or not the compliance option should be made a requirement of the standards (as a prescriptive requirement and basis of the energy budget established for the performance standards).

Appliance Energy Efficiency Standards in Progress

As part of the process of updating the Appliance Energy Efficiency Standards, the CEC evaluates new and emerging technology for increasing the energy efficiency of appliances and equipment for possible inclusion in the standards. The Commission's Buildings and Appliances Office works on an ongoing basis with the Public Interest Energy Research (PIER) program and with the Utility Codes and Standards Programs to track promising new technologies and consider their appropriate inclusion in the standards.

Fundamentally, the standards updating process is achieved thorough technology assessment of the potential to include new technologies in the standards, and the program is continuously evaluating new technologies.

Cement Manufacturing

This strategy involves cost-effective reductions to reduce energy consumption and to lower carbon dioxide emissions in the cement industry. There is a large technical potential to improve energy efficiency in cement operations at a reasonable cost.

Climate change emissions from burning fossil fuels in the manufacturing of cement produces 1.5 to 2.0 percent of U.S. carbon dioxide emissions. Roughly half is from fossil fuel combustion and roughly half is from the conversion of limestone (45 million tons per year). California's cement industry produced 5.6

million metric tons in 2001; total statewide climate change emissions approached 500 million metric tons in 2001.

Annual emissions from the manufacturing of cement are growing at a rate of 2 percent per year, according to industry sources and using California-specific data. Direct emissions of carbon dioxide are estimated to rise from 10.4 million metric tons in 2005 to more than 15 million metric tons in 2025. Use of limestone Portland cement and the use of blended cement account for 70 percent of the potential emission reductions and would cost less than \$10 per metric ton.

State policy options can take several forms, including technology mandates, financial incentives, negotiated agreements, voluntary commitments, emissions-intensity benchmarking, or mandatory measures. Policy changes would be needed to encourage the use of limestone and blended cement and to allow waste tires to be used as a fuel in cement manufacturing. Based on CEC's analysis, these measures have been shown to provide cost-effective climate change emission reduction benefits.

Municipal Utility Energy Efficiency Programs

The Energy Commission and the California PUC are collaborating on additional energy efficiency programs beyond those programs already adopted.

While the Energy Commission does not have regulatory authority over the publicly owned utilities in the way that the CPUC regulates the IOUs, the publicly owned utilities are required to report their energy savings to the CEC. A process to ensure comparability between public benefit program savings and funding data reported by public and investor-owned utilities will need to be established.

Possible steps for implementing this strategy include:

- Pursuing statutory modifications or a cooperative agreement with the publicly owned utilities to achieve the needed CO₂ reductions.
- Seeking statutory modifications or the establishment of a formal memorandum of understanding (MOU) with the utilities to achieve these targets.
- Pursuing statutory modifications or another mechanism to ensure that all load-serving entities account for climate change emissions and emission reductions in a manner consistent with investor-owned utilities.

Municipal Utility Renewable Portfolio Standard

California's Renewable Portfolio Standard (RPS), established in 2002, requires that all load serving entities achieve a goal of 20 percent of retail electricity sales from renewable energy sources by 2017, within certain cost constraints. The *2003 Energy Action Plan* and the *2003 Integrated Energy Policy Report (2003 Energy Report)* accelerated the 20 percent goal from 2017 to 2010. The *2004 Energy Report Update* further recommended an increased goal of 33 percent renewable by 2020, which the California Public Utilities Commission (CPUC) and the California Energy Commission (Energy Commission) adopted in the *2005 Energy Action Plan II*.

The Energy Commission and the CPUC are responsible for implementing the RPS for the investor-owned utilities, electric service providers, and community choice aggregators. The publicly-owned utilities are responsible for implementing their own RPS programs.

The CPUC has undertaken a study to identify the steps necessary to achieve the 33 percent goal for the state's IOUs. The Energy Commission is undertaking a similar related study on RPS programs adopted by publicly-owned utilities, including barriers and policy options to accelerate those programs to reach the 20 percent goal by 2010 and 33 percent goal by 2020. Possible steps for implementing this strategy include:

- Pursuing a cooperative agreement with the publicly-owned utilities to achieve the needed climate change emission reductions.
- Seeking statutory modifications to require the publicly owned utilities to contribute proportionally to the state's RPS goals.
- Seeking statutory modifications or a cooperative agreement to ensure that publicly-owned utilities account for climate change emissions and emission reductions in a manner consistent with investor-owned utilities.

Municipal Utility Combined Heat and Power

This strategy constitutes cost-effective reductions from fossil fuel consumption in the commercial and industrial sector through application of on-site power production to meet both heat and electricity loads. To effectively implement this strategy, various policy instruments will likely be needed to attain the realistic market potential and subsequent climate change emission reductions.

These policy mechanisms may include regulatory incentives to encourage utilities to promote customer and utility-owned CHP, utility rate structures that are transparent and connected to market forces where externalities such as environmental impacts and transmission and distribution constraints are internalized, rules and regulations enabling easier access to wholesale markets, production tax credits for CHP, and other measures or incentives directed at key commercial and industrial activities in California.

Through existing efficiency commercialization programs at the CEC where relationships have been well established with the commercial and industrial sectors, a set of implementation activities will be developed that include:

- Utility tariffs to enable CHP owners to sell excess on-site electricity generation to the utility at prevailing wholesale prices. Existing analysis suggests this would be very effective in stimulating the near-term (next 5 years) market.
- Climate change emission reduction credits to reflect the net reduction of climate change emissions for the CHP systems compared to the avoided electricity and boiler fuel emissions.
- Transmission and distribution benefit payments that reflect the local and temporal benefits CHP provides utilities.

- Utility regulatory incentives to encourage utilities to promote installation of customer- and utility-owned CHP projects.

Municipal Utility Electricity Sector Carbon Policy

The Energy Commission and the CPUC are collaborating on additional programs to address ways to transition investor-owned utilities away from carbon-intensive electricity sources. Some publicly owned utilities have historically relied on coal-based generation, and many of these facilities will reach the end of their design life by 2020. The Energy Commission will explore options to encourage municipal utilities to transition away from carbon-intensive generation to low-carbon alternatives, and to reduce purchases of carbon-intensive power. Options include establishing emissions targets or caps, providing incentives for preferred generation options, and setting a climate change emission performance standard for new utility resource procurement, including both coal and non-coal resource additions.

In its recently adopted *2005 Integrated Energy Policy Report*, the Energy Commission recommends:

- Any climate change emission performance standard for utility procurement should be set no higher than emission levels achieved by a new combined-cycle natural gas turbines. In the case of coal-fired generation, the capacity to capture and store carbon dioxide safely and inexpensively is essential for meeting these standards.
- The state should specify a climate change emission performance standard and apply it to all utility procurement, including in-state generation and out-of-state purchases, coal, and non-coal resources.
- Additional consideration is needed before determining what role climate change emission offsets could play in complying with such a standard.
- The Energy Commission should work with the CPUC to develop a framework that accounts for the financial risk of reliance on carbon-based generation.
- California should have a consistent electricity carbon policy for all electric utilities within the state that applies to both in-state generation and out-of-state power purchases.

Alternative Fuels: non-Petroleum Fuels

This strategy involves increasing the use of non-petroleum fuels in California's transportation sector, as recommended in the Energy Commission's *2003 and 2005 Integrated Energy Policy Reports*. The Governor has also directed the Energy Commission to develop a workable, long-term transportation fuels plan that will result in significant reductions in gasoline and diesel use and that will establish realistic and achievable objectives. The Bio-Energy Interagency Working Group, which the Energy Commission is leading, has been asked to recommend options for optimizing the market potential for bio-fuels through a coordinated state level effort.

State policy options can take several forms, including technology performance standards, financial incentives, negotiated agreements, voluntary commitments, emissions-intensity benchmarking for fuel producers or automobile manufacturers, or other mandatory measures, such as fuels or motor vehicle standards or a market-based program. Based on our analysis, some alternative fuels have been shown to provide cost-effective climate change emission reduction benefits. But they face economic, market, or regulatory barriers that are impeding their use.

To achieve the benefits of this strategy, the following implementation issues would need to be overcome:

- The high first cost of alternative-fuel vehicles, when compared to conventional vehicles using internal combustion engines.
- The absence of a convenient retail fueling network to dispense alternative fuels to customers.
- Other regulatory and market barriers.

5.4 Strategies Other State Agencies will Implement over the Next Two Years

Table 5-3 lists all of the strategies that other state agencies will implement over the next two years. Many participants at the Climate Action Team public meetings, particularly in Southern California, indicated that smart land use and increased transit availability should be a priority in the state. The participation of Business, Transportation and Housing Agency on the Climate Action Team has highlighted the fact that such strategies can provide substantial climate change emission reductions. Similarly the efforts of the Department of Food and Agriculture and the State and Consumer Resources Agency provide benefits beyond their climate change emission reduction potential.

Table 5-3. Other State Agencies

Climate Change Emission Reductions (Million Metric Tons CO ₂ Equivalent) ¹		
	2010	2020
Business, Transportation and Housing		
Measures to Improve Transportation Energy Efficiency	1.8	9
Smart Land Use and Intelligent Transportation	5.5	18
Department of Food and Agriculture		
Conservation tillage/cover crops	TBD	
Enteric Fermentation	<1	<1

State and Consumer Services Agency		
Green Buildings Initiative	0.5	1.8
Transportation Policy Implementation	TBD	

¹ These estimates are based on best available current information and will be updated as needed.

A summary description of each of the strategies in Table 5-3 is included below:

Measures to Improve Transportation Energy Efficiency

This strategy builds on current efforts to provide a framework for expanded and new initiatives including incentives, tools and information that advance cleaner transportation and reduce climate change emissions.

The effort includes the following:

- Incorporating energy efficiency and climate change emissions reduction measures into the policy framework governing land use and transportation, including framework for developing energy element in state transportation and regional planning documents. Better coordination on cross-agency climate change and energy policy framework to ensure a concerted effort and synergy among state agencies' climate change emission reduction activities.
- Increasing incentives and accelerating technology applications to improve transportation system productivity and move toward cleaner and more efficient vehicles, especially for the public sector fleet. Enhancing outreach and educational programs to bring a coordinated message of sustainable transportation and root causes of climate change emissions.
- Diversifying transportation energy infrastructure and advancing measures to slow the rate of vehicle miles traveled growth and excessive reliance on petroleum.

Smart Land Use and Intelligent Transportation

Smart land use is an umbrella term for strategies that integrate transportation and land-use decisions. Such strategies generally encourage jobs/housing proximity, promote transit-oriented development, and encourage high-density residential/commercial development along transit corridors. These strategies develop more efficient land-use patterns within each jurisdiction or region to match population increases, workforce and socioeconomic needs for the full spectrum of the population.

Intelligent Transportation Systems (ITS) is the application of advanced technology systems and management strategies to improve operational efficiency of transportation systems and movement of people, goods and services. Smart growth/land use and ITS would minimize the need for major capital improvements and can provide a host of benefits including more livable communities, transportation energy efficiency, lower emissions from mobile sources, and a lower-cost provision of public services (e.g., sewer, water).

Governor Schwarzenegger is finalizing a comprehensive 10-year strategic growth plan with the intent of developing ways to promote, through state investments, incentives and technical assistance, land use, and technology strategies that provide for a prosperous economy, social equity, and a quality environment. The Administration is pursuing funding and budgetary measures to support the strategic growth plan.

Smart land use, demand management, ITS, and value pricing are critical elements in this plan for improving mobility and transportation efficiency. Specific strategies include: promoting jobs/housing proximity and transit-oriented development; encouraging high density residential/commercial development along transit/rail corridor; valuing and congestion pricing; implementing intelligent transportation systems, traveler information/traffic control, incident management; accelerating the development of broadband infrastructure; and comprehensive, integrated, multimodal/intermodal transportation planning.

Conservation/Tillage Cover Crops

Conservation tillage and cover crops practices are increasingly being used by California farmers for a variety of reasons, including improved soil tilth, improved water use efficiency, reduced tillage requirements, saving labor and fuel, and reduced fertilizer inputs. However, due to the wide diversity of California agriculture, these practices must be demonstrated in a wide variety of cropping systems, soil types, irrigation regimes, and climate conditions.

This diversity also creates difficulty in quantifying both carbon emissions and potential carbon sequestration benefits from implementing conservation tillage and cover crops in the myriad of California cropping systems. This potential needs to be verified through extensive research directly applied to California conditions. Thus, the potential climate change emission reductions for 2010 and 2020 remains to be determined.

Enteric Fermentation

Enteric fermentation is the process of feed digestion by ruminant animals (primarily dairy and beef cattle). This process results in methane emission from the animals. To reduce climate change emissions resulting from enteric fermentation, feed adjustments may be made that improve milk and meat productivity.

New measures would include establishing a research initiative to quantify emission changes from enteric fermentation resulting from changing feed regimens versus productivity impacts. Different animal populations would have differing abilities to manage feed rations. For example, grass-fed beef would have little to no ability to reduce enteric emissions. Dairy operators vary feed rations based on numerous factors. Feed rations are a complex system that not only provide nutrition to the animal, but also provide cost-effective and efficient use of other agricultural by-products including food processing residuals, fruit culls, almond hulls, cotton seed, and even rice straw.

This system would have to be carefully analyzed to determine overall climate change emission effects if the use of these other residuals is altered. This analysis would include both a technical analysis and a cost effectiveness analysis that would be initiated in 2006.

Pricing of food commodities to reflect embodied climate change emissions is not recommended for any action at this time. A “calcium crisis” currently exists in this country, where a significant portion of women and children are calcium deficient. Milk and dairy products are a major source of calcium that should be available to these at-risk populations, especially those of low and moderate income, at affordable prices.

Green Buildings Initiative

Governor Schwarzenegger’s Green Building Executive Order, S-20-04, sets an ambitious goal of reducing energy use in public and private buildings by 20 percent by the year 2015, as compared with 2003 levels. The Executive Order and related action plan spell out specific actions state agencies are to take with state-owned and -leased buildings. The order and plan also discuss various strategies and incentives to encourage private building owners and operators to achieve the 20 percent target.

Preliminary estimates indicate that 6.5 million tons of CO₂ will be reduced annually by the year 2015 through building efficiency efforts in commercial and institutional buildings. This number is based on the average displaced power generation being an efficient natural gas combined cycle turbine. The 6.5 million-ton estimate has been adjusted in Table 5-2 to ensure against double counting amongst other strategies being recommended by the CAT.

5.5 Strategies the Public Utilities Commission will Implement Over the Next Two Years

Table 5-4 lists all of the strategies that the Public Utilities Commission will implement over the next two years. Working in cooperation with the Energy Commission, the Public Utilities Commission has implemented the most progressive Renewable Portfolio Standard in the nation. The Public Utilities Commission has also been progressive in energy efficiency and clean energy programs for investor-owned utilities. Many stakeholders indicated that these programs should apply to the publicly-owned utilities as well.

Table 5-4. Public Utilities Commission

Climate Change Emission Reductions (Million Metric Tons CO ₂ Equivalent) ¹		
	2010	2020
Accelerated Renewable Portfolio Std to 33% by 2020 (includes load-serving entities)	5	11

California Solar Initiative	0.4	3
Investor Owned Utility Energy Efficiency Programs(including LSEs)	4	8.8
Investor-Owned Utility (IOU) Additional Energy Efficiency Programs/Demand Response	NA	6.3
IOU Combined Heat and Power Initiative	1.1	4.4
IOU Electricity Sector Carbon Policy	1.6	2.7

¹ These estimates are based on best available current information and will be updated as needed.

A summary description of each of the strategies in Table 5-4 is included below:

Accelerated Renewable Portfolio Standard (33 percent by 2020)

The Governor has set a goal of achieving 33 percent renewables in the State’s resource mix by 2020. The joint PUC/Energy Commission September 2005 Energy Action Plan II (EAP II) adopts the 33 percent goal. The PUC and Energy Commission have already commenced review of the legal, regulatory, and infrastructure changes necessary to achieve the Governor’s goal.

The Center for Resource Solutions has prepared a preliminary report for the CPUC entitled *Achieving a 33% Renewable Energy Target* (The Center for Resource Solutions, November 1, 2005), which concludes that the 33 percent target by 2020 is achievable and discusses the major hurdles and necessary implementation steps. The report is a starting point for further review by the CPUC on instituting a 33 percent goal.

California Solar Initiative

The solar initiative includes installation of 1 million solar roofs or an equivalent 3,000 MW by 2017 on homes and businesses, increased use of solar thermal systems to offset the increasing demand for natural gas, use of advanced metering in solar applications, and creation of a funding source that can provide rebates over 10 years through a declining incentive schedule.

Legislation to codify the Governor’s initiative (SB 1) failed to pass the California Assembly in the fall of 2005. However, the PUC, in cooperation with the Energy Commission and the Governor’s Office, will implement the California Solar Initiative under its existing statutory authority.

Investor-Owned Utility Energy Efficiency Programs

In September 2004, the PUC adopted aggressive savings targets for the investor-owned utility energy efficiency programs through 2013. The savings targets through 2013 are challenging goals to meet, and the PUC will reassess these targets and adopt more realistic goals during each three-year program cycle.

The PUC funds energy efficiency programs through the Public Goods Charge and the resource procurement budgets of the utilities. For the 2006–2008 program cycle, the total energy efficiency budget for all of the investor-owned

utilities is approximately \$2 billion, for a total projected annual net savings of 7,371 gigawatt hours and 121,989 million therms. These projections exceed the savings targets by 108 percent and 109 percent respectively. By 2008 these programs will reduce annual carbon dioxide emissions by more than 3 million tons per year.

Investor Owned Utility Additional Energy Efficiency Programs/Demand Response

In September 2004, the PUC adopted aggressive savings targets for the IOUs' energy efficiency programs through 2013. The savings targets through 2013 are stretch goals and the PUC will reassess these targets and adopt the actual goals during each three-year program cycle. The PUC funds energy efficiency programs through the Public Goods Charge and the IOUs' resource procurement budgets. For the 2006–2008 program cycle, the total energy efficiency budget for all of the IOUs is approximately \$2 billion, for a total projected annual net savings of 7,371 gigawatt hours and 121,989 million therms. These projections exceed the savings targets by 108 percent and 109 percent respectively. By 2008 these programs will reduce annual carbon dioxide emissions by more than 3 million tons per year.

Over the next year, the PUC will develop a risk/reward incentive mechanism for the IOUs and refine energy measurement and verification protocols. In 2008, the PUC will evaluate and adopt the 2009–2011 energy efficiency savings goals and programs of the IOUs.

Investor-Owned Utility Combined Heat and Power Initiative

This strategy encourages the installation of on-site power production to meet both heat and electricity loads, known as combined heat and power projects (CHP). The PUC's existing Self-Generation Incentive Program allocates \$0.80 per watt to eligible CHP projects in the territories of the IOUs, up to a capacity size of 5 MW. Currently, all SGIP funds are reserved through 2007, although funding may become available if proposed projects do not materialize.

This strategy would seek to develop additional programs to further encourage the development of CHP. These additional programs are not yet underway, will require further consideration, and could likely require administrative, legislative, regulatory, and budget initiatives. To effectively implement this strategy, it is likely various policy instruments will be needed to attain the realistic market potential and subsequent CO₂ reductions.

These policy mechanisms may include regulatory incentives to encourage IOUs to promote customer and utility-owned CHP, changes to IOU rate design, market rules and regulations enabling easier access to wholesale markets, production tax credits for CHP, and other measures or incentives directed at key commercial and industrial activities in California. Statutory modifications are required in order to apply a similar strategy for CHP programs implemented by publicly-owned utilities.

Investor Owned Utility Electricity Sector Carbon Policy

The PUC is currently investigating various strategies and incentives to encourage the IOUs to make cost-effective procurement decisions that are based in part on reducing climate change emissions. These strategies include emissions targets or caps, incentives for preferred procurement options, and incentives for portfolio optimization and total cost minimization.

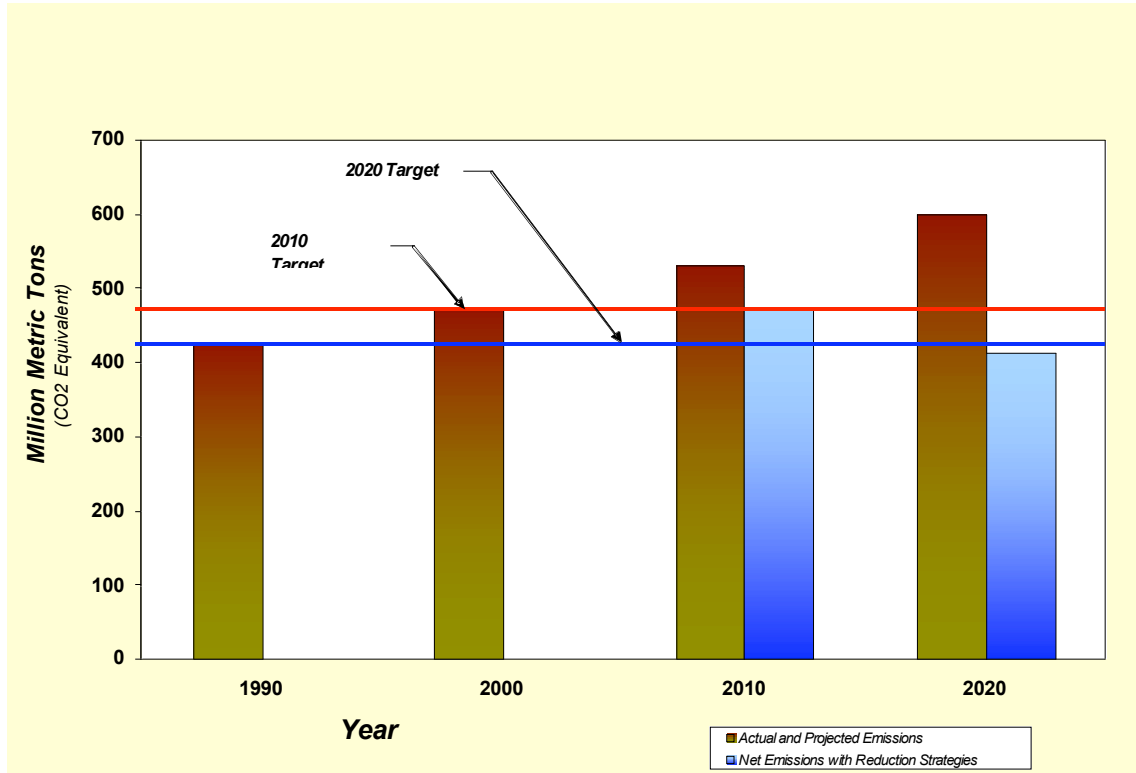
The PUC conducted workshops in March 2005 on the procurement incentive framework and issued a staff report in March 2005. The post-workshop comments were filed in April and May 2005. A final decision to include a carbon cap on emissions associated with all utility procurement activities was adopted in February of 2006. This strategy includes the following steps:

- Determine a methodology the IOUs will use to report their climate change emissions.
- Continue to work with the CEC to ensure that the IOUs and the municipal utilities use consistent methodologies to report their emissions.
- Begin work to establish emission baselines for IOUs.

5.6 The Governor's Targets Can Be Met

Based on the emission reduction potential demonstrated in the tables above and illustrated in Figure 2-1 below, it is clear the Governor's targets are achievable. However, continued top-down leadership as has been demonstrated by this Governor as well as a coordinated agency-level effort as has been achieved via the Climate Action Team will be essential to success.

Figure 5-1. California's Target Can Be Met



5.7 Emission Baseline Development

For the purposes of this report, it is necessary to use historical climate change emissions for the years 1990 and 2000 and projected climate change emissions for 2010 and 2020.

Table 5-5 illustrates the baseline data that was used:

Table 5-5 Baseline Inventory Estimates*

Climate Change Emission Baseline				
(Million Metric Tons CO ₂ Equivalent)				
Year	1990	2000	2010	2020
Baseline Emissions	426	473	532	600

* Not including international marine bunker fuels

The baseline climate change emissions used to compute reductions needed to meet Governor’s targets were developed with the assistance of Tellus Institute working with the ARB and CEC. The CEC publishes climate change emission inventory updates on a regular basis and updates its Integrated Energy Policy Report in odd years. In 2007, the Energy Commission will update both reports and integrate these efforts to produce projected 2010 and 2020 climate change emissions.

5.8 Economic Assessment

The overall economic impact of implementing the strategies in Section 5.2 were estimated using a computable general equilibrium (CGE) model of the California economy. A CGE model simulates the functioning of a market economy in which different sectors interact with one another (one sector supplies inputs to another, or purchases the outputs of another) and where prices and production adjust in response to changes caused by government policies applied to specific sectors. The CGE simulates these relationships among California producers, California consumers, government, and the rest of the world. Because of the interconnection between sectors, an intervention in one sector has impacts on all others, which are captured by the CGE model analysis.

The results of a preliminary assessment of the macroeconomic impacts associated with the climate change emission reduction strategies show that the overall impacts of the climate change emission reduction strategies on the California economy are expected to be positive. Specifically, when the strategies already underway as well as new strategies being proposed are considered in total, the resulting impacts on the economy are expected to translate into job and income gains for Californians. For example, in 2020 the implementation of the strategies is expected to increase jobs and income by an additional 83,000 and \$4 billion, respectively, above and beyond the substantial growth that will occur between today and 2020.

The favorable impacts on the economy are possible because of the reduced costs associated with many of the strategies. The additional job growth is expected to come from the net savings to consumers associated with the implementation of the strategies. The savings will in turn promote further business expansion and job creation.

A subsequent refined analysis is planned over the next year. The refined analysis will incorporate updated cost and savings estimates for the strategies. It will also assess the cost-effectiveness of the various individual strategies. Thus, the refined economic analysis will provide additional information to decision-makers as they proceed with implementation of the strategies.

6 MARKET-BASED OPTIONS FOR CALIFORNIA

Market-based programs can be integral to California's strategy for reducing climate change emissions. Options considered by the Climate Action Team would set an emissions cap that can be phased down over time but allow regulated sources flexibility to comply with the cap. Such flexibility would be designed to provide the greatest certainty of benefits at the least cost possible.

Because climate change emissions originate from diverse sources and are long-lived gases in the atmosphere, setting an overall emission cap and allowing flexibility through trading, allocation schemes such as auctioning credits, and/or offsets is recognized as a particularly effective strategy for reducing emissions from many (but not all) climate change emission sources. This approach is best applied to sources with emissions that can be measured or calculated reliably.

Emission sources that are diffuse, difficult to quantify, or small, are not good candidates for inclusion in market-based programs.

The European Union (EU) adopted a market-based approach to reduce climate change emissions from four energy-intensive sectors: (1) energy (electric power, oil refineries, and coke ovens); (2) metal ore, iron and steel production; (3) minerals (cement, lime, glass, and ceramics); and (4) pulp and paper. Initiated in 2005, the EU program is the largest market-based program in the world, involving 25 countries and more than 12,000 installations.

In the U.S., the Acid Rain Trading Program and the Northeast NO_x Program/NO_x SIP Call Program have successfully implemented a market-based programs to limit air emissions.²⁶ The ability to trade emission allowances has been credited with lowering significantly the cost of reducing emissions under these programs.²⁷ Additionally, compliance has been nearly 100 percent, so that emissions have been reduced as scheduled.²⁸

The primary weakness associated with implementing a market-based program in California is that it will be vulnerable to emission “leakage.” If the state implements the program without other states, there will be an incentive for activities that emit climate change emissions to shift to neighboring states to avoid the emission cap. If this occurs, emissions may decline in the state, only to increase in other states.

A coordinated national approach to capping climate change emissions within an international framework would be the best approach for addressing this leakage problem. In the absence of national action, leakage may be partially mitigated through the design of the program and ongoing efforts to coordinate with other states, such as the Northeast States or other Western states that are taking action to reduce climate change emissions.

As part of the implementation of a market-based program, data should be collected over time to assess the extent to which leakage occurs, and its impacts on businesses and on the effectiveness of the emissions cap.

6.1 Market-Based Program Design Options

Realizing the emissions certainty and the cost advantages of a market-based program leads to two overarching program design principles:

Broad Coverage is Preferred

- Broad coverage enables the program to have a direct impact on a large portion of total climate change emissions.
- By covering a broad range of emission sources, the program can capture the least-cost emission reduction opportunities.
- Broad coverage enlarges the set of emissions sources with an incentive to innovate to find ways to reduce emissions.

Flexibility is Preferred

- Compliance flexibility lowers the cost of reducing climate change emissions.
- Sources can meet their obligation under the cap using diverse methods.
- Sources can bank early emission reductions to reduce compliance costs in subsequent time periods.

The desire for broad coverage and flexibility must be tempered by administrative realities and source-specific considerations. For example, sources with emissions that are difficult to measure or calculate reliably may not be suitable for including under the cap. Similarly, sources that derive from numerous small emission points may be administratively burdensome to include.

There is no one best answer for how to design a market-based program to reduce climate change emissions. Rather, trade-offs are required to create a program that promotes real low-cost emission reductions in a framework that is equitable and administratively feasible.

The market-based program design options are described in terms of:

- *Scope*: The scope of the program defines the sectors, sources, or activities that are included under the cap.
- *Allowance distribution*: Emission allowances can be auctioned or given to regulated sources.
- *Emission offsets*: Offsets are verified emission reductions achieved by facilities. Offsets can replace or augment emissions trading.
- *Other Program Design Elements*: The climate change emissions included; whether to place restrictions on trading, offsets or auctioning of emission allowances; the manner in which allowances can be banked for future use or borrowed against future limits; and the manner in which compliance and enforcement will be performed must be defined.

Program Scope

The program scope defines the entities included in the market-based program. The market-based options subgroup examined three representative alternatives for defining the program scope: a sector-based emissions cap; an emissions cap on major stationary source combustion; and a fuels-based carbon cap.

A sector-based emissions cap could cover up to 30 percent of the state's climate change emissions by focusing on five key industries: electric power; oil refining; oil and gas extraction; landfills; and cement production (see Table 6-1).

Reaching this level of coverage requires that the electric power sector be defined to capture all the emissions from electricity consumed in the state.

Approximately 10 percent of state climate change emissions come from in-state generation of electricity, and another 10 percent of emissions comes from out-of-state generation of electricity that is consumed in the state. To include the out-of-state emissions in a market-based program, the electric sector can be defined as Load Serving Entities (LSE) rather than electric generation facilities.

LSEs are responsible for procuring and delivering electric power to customers. In California there are three investor owned utilities (IOU) that are LSEs: Pacific Gas and Electric; Southern California Edison; and San Diego Gas and Electric. Municipal utilities, irrigation districts, the Department of Water Resources, and private electric service providers are also LSEs.

Under an LSE-based definition, each LSE would be required to hold emission allowances that cover the emissions associated with the power they deliver to their customers. To comply with its emission cap, each LSE would track or calculate the emissions associated with all the electricity it delivered, regardless of whether it was produced in California or out of state.

This LSE approach differs fundamentally from the option of focusing on in-state generators. Under the LSE approach, LSEs hold the emission allowances—not the generators. Each LSE would have the responsibility to obtain power from the set of generators that enables it to comply with its emission cap. LSEs could trade emission allowances: those with extra allowances could sell to those who need additional allowances, given their procurement decisions.

Table 6-1. Market-Based Scope Defined by Sectors

Sector	# Entities	Portion of State Climate Change Emissions
Electric Power Sector:		
Generation Based: In-state generators (≥25 MW)	≈313 facilities	≈10%
Load Serving Entity Based: All Load Serving Entities	≈47 LSEs	≈20% ^a
Other Sectors:		
Oil Refining	21 refineries	≈3%
Oil and Gas Extraction	429 facilities	≈3%
Landfills	≈300 landfills	≈2%
Cement Production	11 cement plants	≈1.5%
Others	(various)	<1%
Mobile Sources:		
Motor Gasoline (light duty vehicles, on and off road)	(Not Applicable)	≈28%
Diesel—on road		≈7%
Domestic Aviation		≈6%
Other		<2%

a. Includes emissions from electricity imports.

Source: Climate change emissions estimates from Bemis, Gerry and Jennifer Allen, *Inventory of California Greenhouse Gas Emissions and Sinks: 1990 to 2002 Update*, California Energy Commission Staff Paper, Sacramento, California, Report CEC-600-2005-025, June 2005.

This LSE-based approach has several advantages.

The LSE-based approach captures a larger portion of climate change emissions than a generator-based definition of the electric power sector.

The LSE-based approach mitigates the emission leakage problem that arises under an in-state generator-based approach. Under the LSE-based option, in-state and out-of-state generation are treated equally, and the cap applies to total emissions associated with all electricity consumed in the state. Therefore, there is no opportunity to avoid the cap and there is no leakage.

The LSE-based approach motivates emission reduction opportunities that are not motivated by a generator-based system. To comply with its emission cap, an LSE could promote energy efficiency among its customers as a means of reducing the load itself. LSEs can also procure renewable-based power or shift to fossil-generated power sources with lower emissions. An LSE by its nature has a broader set of opportunities for achieving its emissions cap, as compared with an individual power plant owner/operator.

To implement the LSE-based option, the power sector must track emissions associated with all (or nearly all) power generation through the market to its eventual delivery. Such a tracking system does not currently exist, and developing it presents significant challenges. There are several workable approaches for solving this problem, and the effort is worthwhile to enable an LSE-based approach to be used.

The other industrial sectors with significant climate change emissions are oil refining, oil and gas extraction, landfills, and cement production. These industries have a manageable number of facilities that could be included in a market-based program (see Table 6-1).

The mobile source sector, the largest individual source of climate change emissions in California (42 percent), is not easily accommodated in a market-based program defined in terms of sectors. Diverse factors affect climate change emissions from mobile sources, including the demand for mobility; the cost, availability, and convenience of travel options, including private vehicles and mass transportation; and the emissions per passenger mile of the transportation mode used, which is driven by the technology employed and the fuel used.

A coordinated set of policies is needed to address the factors that influence mobile source climate change emissions: a sector-based cap is necessarily a partial solution. The main practical sector-based option would be to make vehicle manufacturers the point of regulation.

Based on the emission intensity of each vehicle (emissions per mile) and the expected annual miles driven by each vehicle type, the emissions “embedded” in new vehicle sales could be calculated. The manufacturers could be provided with an emission cap for their total new vehicle sales each year. Manufacturers would comply with their caps by reducing the emission intensity of their vehicles or by shifting the mix of vehicles sold toward those with lower emission intensity.

This vehicle manufacturer cap is similar to recently adopted vehicle climate change emission standards that limit average emissions per mile. The standards do not cap total emissions—emissions can increase or decrease as new vehicle sales increase or decrease. By putting a cap on total emissions, the manufacturer-based emission cap would constrain emissions even if new vehicle sales increase.

While the two regulatory policies do not necessarily conflict, it would be critical to coordinate the two policies if they were to be enacted simultaneously. However, such a cap is probably not needed in the short term, while the emission standards come into force for the first time. Emissions associated with the mobile sector could be monitored over time to assess whether a cap is needed.

An alternative to a sector-based program is an emissions cap on major stationary source combustion in the state. This approach would encompass all major stationary sources of carbon dioxide (CO₂) emissions, without reference to specific sectors as being either in or out of the cap. This scope would not capture mobile source emissions.

Based on preliminary analyses, CO₂ emissions from these sources appear to be concentrated in about 750 facilities statewide. These facilities account for more than 90 percent of CO₂ emissions from stationary fossil fuel combustion, or nearly 20 percent of total state climate change emissions. As discussed above, it may be preferred to define the electric power sector as LSEs to capture emissions associated with imported power and to address the potential for leakage.

The resulting program would be a hybrid approach: the electric sector would be defined to include all LSEs, and all remaining major stationary combustion sources (not including in-state generation) would be included under the stationary source definition.

A third approach to defining the scope of the program is to set a fuels-based carbon cap. This comprehensive fuels approach would reduce climate change emissions by placing a cap on the total carbon content of oil, gas, and coal consumed in the state. The primary advantage of this approach is that it encompasses all sectors that use fossil fuels. Consequently, all options for reducing fossil fuel combustion across all sectors can contribute to achieving the emissions cap.

To achieve climate change emission reductions via this cap, “carbon allowances” would be required to be held by entities at specific points in the distribution or use of fossil fuels in the state. The points at which allowances are required should be

selected to minimize administrative burden and maximize coverage and effectiveness. For fuel markets, these considerations favor an “upstream” approach to regulating the total carbon content of fossil fuel combustion: fuel producers and importers would be required to hold carbon allowances for the fuels they produce in the state or import into the state.²⁹

For liquid fuels, carbon allowances could be required where liquid fuels enter into commerce at refineries, marine terminals, and storage facilities. An alternative is to track the carbon content of the crude oil and natural gas liquid inputs to refineries. This refinery input tracking may be simpler than tracking the carbon content of multiple products. Additionally, it has the advantage of incorporating in the cap the carbon emissions from refinery operations. The carbon content of imported refined products would need to be tracked under either option.

The upstream point for tracking natural gas flows would be at major pipeline transfer points and the natural gas utilities. Coal does not appear to have a convenient upstream point in the market for tracking carbon consumption. Because relatively small amounts of coal are used in the state, it may be easiest to track coal combustion downstream; for example, in major boilers.

The comprehensive fuel carbon cap covers about 75 percent of the state climate change emission inventory, including mobile sources. Limits on fossil fuel supply provide incentives for both: (1) improving the efficiency with which fossil fuels are used; and (2) developing non-fossil energy sources. Comprehensive mobile sector improvements are motivated, including shifting modes of transportation, improving vehicle efficiency, and adopting non-fossil based fuels.

This comprehensive fuel approach has several drawbacks. Non-fuel related emissions are, by definition, excluded from the scope of the program. To cover these emissions, a separate program component would be needed for the specific non-fuel related sources and processes. Alternatively, emission reductions from these sources could be motivated by making them eligible to produce and sell emission offsets.

Perhaps most significantly, the comprehensive cap on fossil fuel carbon essentially creates an absolute limit on the availability of fossil fuels in the state. The supply constraint would lead to increases in the prices for fuels, which would be the primary motivation for improving fuel use efficiency and for developing alternative fuels. The size of the price increase will depend on the level of the carbon cap and the cost and availability of alternative fuels. During a transition period, prior to the widespread availability of alternative fuels, price increases could be substantial if the fossil fuel carbon cap is set too low.

The impacts of increased fuel prices would need to be mitigated in order to make this approach viable. If the impacts of increased fuel prices could be managed, California businesses could realize a competitive advantage through access to a more diverse fuel supply that is both less susceptible to price shocks and supply disruptions and more sustainable economically and environmentally. The key to realizing this outcome is to adopt a gradual phase-down of fossil-carbon based

fuels that allows improved efficiency and alternative fuels to constrain the rate of price increases.

One way to prevent unacceptably high fuel price increases is to put a maximum value on the carbon allowances, and to make additional carbon allowances available at that maximum value. This “safety valve” for the market sets an upper bound on the impact of the carbon cap on fuel prices. However, it also effectively removes the cap when the maximum value is reached. Nevertheless, a safety valve of this type may be needed to help ensure that unacceptable price increases are avoided during transition periods.

The implementation of this comprehensive fuel approach would need to address the vulnerability of the electricity sector to leakage: the cap on fossil-carbon based fuels would not cover electricity imports. This electric-sector leakage could be addressed by adopting the LSE-based approach discussed above.

The resulting program would be a hybrid: an emissions cap would be placed on the electric sector, defined to include all LSEs, and a cap on fossil-carbon based fuels would also be in place (any fuels used to produce electricity delivered by the LSEs would not count against the fuel cap). The two caps, one on LSE emissions and one on carbon in fuels, could be traded to allow emissions to flow to their most highly valued uses.

If California is the only state in the western U.S. to implement this comprehensive fuel approach, a “black market” for fuels may develop, particularly for liquid transportation fuels. Although marine terminals, storage facilities, and refineries could be tracked, gasoline is easily transported long distances in tanker trucks. Fuel from neighboring states could be trucked into California without the proper carbon allowances. Policing this activity could be difficult, and if significant fuel volumes move through a black market, the effectiveness of the cap will be eroded.

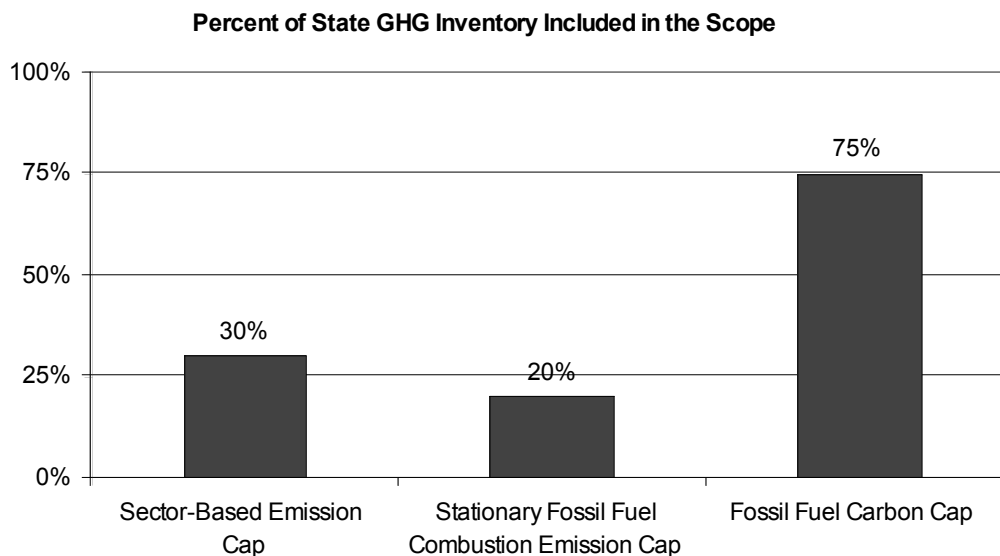
We can make several observations regarding the three representative approaches for defining the scope of a market-based program for reducing climate change emissions in California:

- The fuel-based carbon cap is the most comprehensive, encompassing the greatest diversity of emission reduction opportunities and motivating action across the broadest set of emission sources (see Figure 6-1).
- The sector-based approach focuses attention on the specific industries that contribute most to state climate change emissions. Stationary sources in the largest sectors cover about 30 percent of the state emission inventory. To significantly increase coverage beyond 30 percent, mobile sources, with about 42 percent of the emission inventory, would need to be included in the cap. However, mobile sources are not conducive to a sector-based approach.
- The stationary source definition of program scope encompasses all major stationary sources of CO₂ emissions from fossil fuel combustion, without reference to specific sectors as being either in or out of the cap.

Approximately 750 facilities could be included in the program to cover the overwhelming majority of emissions from these sources. This scope does not capture mobile source emissions, and consequently is limited to about 15 to 20 percent of the state inventory. An additional 10 percent of emissions can be covered if emissions associated with imported electricity are captured using a hybrid approach that includes a comprehensive definition of the electricity sector.

- All three methods for defining the scope of a market-based program are vulnerable to emissions leakage. A coordinated national approach to capping climate change emissions within an international framework would be the best approach for addressing this leakage problem. In the absence of national action, or even regional action, the leakage issues can be partially mitigated.
- All three methods appear to be administratively workable. Also, it may be preferred to cap emissions from the electric power sector under all three scope definitions using the LSE-based approach.
- All three approaches to defining the program scope could be leveraged into a regional or national climate change emission reduction program. An assessment of the relative likelihood of any of the three approaches being adopted nationally is beyond the scope of this assessment. However, it can be observed that the sector and stationary source approaches are more similar to past national and regional regulatory regional programs than the comprehensive fuel approach.

Figure 6-1: Climate Change Emissions Covered Under Three Definitions for Program Scope



Sector-Based Emission Cap for five sectors, not including mobile sources. See text.

Stationary Fossil Fuel Combustion Emission Cap covering approximately the 750 largest sources. See Text.

Allowance Distribution

A market-based program requires that each facility under the cap hold sufficient emission allowances to cover its emissions. Emission allowances can be auctioned (i.e., sold) or given away. If given away, the allocation algorithm can have a significant impact on the amount of allowances received by each facility. A hybrid approach can also be used, in which some allowances are given away and some are auctioned.

Much has been written regarding the pros and cons of giving allowances away versus auctioning them.³⁰ When allowances are given to entities covered by the cap, those entities receive something of value: the emission allowances. When the allowances are auctioned, the government collects a portion of the value of the allowances in the amounts paid in the auction. Both approaches can result in essentially the same cost of controlling emissions, and both approaches are expected to have the same impact on consumer prices in most cases.

If an auction is not used, the process for distributing the allowances typically considers facility-specific factors to promote equity among the regulated facilities. Although various factors can be considered, two primary factors are commonly discussed as bases for distributing emission allowances:

Baseline Emissions. Emission allowances can be distributed on the basis of recent emissions as defined in a baseline for each facility. This method has the potential to distribute fewer allowances to those entities that reduced their emissions prior to the baseline period, thereby penalizing them for taking early action.

Baseline Output. Emission allowances can be distributed using an average emission intensity for each industry and baselines of recent facility output. The average emission intensity for an industry would be equal to the total emission cap for the industry divided by the total baseline industry output. Each facility's allocation would be the product of the relevant industry average emission intensity and the individual facility's baseline output. By using this approach, past actions by a facility that reduced its emission intensity are rewarded.

Insofar as emission allowances are distributed on the basis of past emissions or output, new sources would not receive a share of the distribution of allowances. To address this issue, a portion of the emission cap can be set aside for new sources, so that they can be allocated a share of the cap. Alternatively, a share of the cap could be set aside to be auctioned off, so that all sources, new and existing, could bid for additional emission allowances over and above the allowances they receive through a distribution.

Facilities that have relatively high emissions will favor distributing allowances on the basis of recent emissions, because under this approach they will receive more allowances. Facilities that have relatively low emission intensities will favor

distributing allowances on the basis of an industry-average emission intensity. Facilities with growing levels of emissions or output would want to ensure that the method allows flexibility in the selection of the baseline year, so that recent periods of high emissions or output could be considered.

The specification of a distribution algorithm requires balancing divergent interests. One way to satisfy competing interests in this situation is to be overly-generous in the initial allocation of emission allowances. In doing so, all parties can receive a share of the emission cap that meets their current needs. In this case, care must be taken to reduce the cap over time, and to ensure that the extra allowances are not banked indefinitely in a manner that reduces the effectiveness of the emission cap over the long term.

Emission Offsets

Emission offsets are verified emission reductions achieved by entities that are outside the cap. The benefits of emission offsets are:

- Offsets help lower the cost of reducing emissions: facilities covered by the cap can purchase low-cost emission reductions from outside the cap as a means of complying with their emission limit.
- Offsets provide sources outside the cap with a financial incentive to develop low-cost emission reduction projects, thereby broadening the set of emission reduction opportunities that are motivated to be undertaken by the market-based program.

Although the forestry sector is not a strong candidate to include under an emission cap due to the diffuse nature of its emissions (and sinks), stakeholders and others have emphasized that forest management projects in California could be an important source of emission offsets. The funds received from selling the offsets could make forest management projects financially attractive. Of note is that the projects would generate multiple benefits beyond the sequestration of carbon.

To ensure that offsets do not compromise the emission reduction goal of the program, they must be real or additional, quantifiable, surplus to any regulatory requirement, enforceable, and permanent. Also, they cannot be counted toward any other climate change emission reduction targets.

Protocols for verifying offsets will be required for each of a variety of “prototype” emission reduction projects that are deemed eligible for producing emissions offsets under the state’s market-based program. Each protocol would address the requirements specific to its prototype project. The California Climate Action Registry’s Forest Project Protocol is an example of the type of protocol that would be needed.

A final issue to address regarding offsets is whether the market-based program should rely solely on the market to generate emission offsets, or whether an entity dedicated to producing offsets should be created. A dedicated organization could develop expertise and procedures that enable it to identify and execute emission reduction projects efficiently. The organization could specialize

in projects that are particularly relevant to California and qualify under the California program. Following initial funding for start-up, the organization could have the goal of becoming financially self-sustaining.

The primary benefit of creating an organization dedicated to creating offsets is that it can expand the availability of low-cost emission reductions. Initial experience under the primary international offset program (the Clean Development Mechanism) indicates that offset projects may be slow to materialize. The Climate Trust is an example of an organization that was formed to create emission offsets.

Other Program Design Elements

To define a market-based program fully, the following additional program design elements must be addressed:

Climate Change Emissions Included: To capture as many emission reduction opportunities as possible under the cap, all climate change emissions should be included. However, consideration should be given to limiting coverage, particularly during initial implementation, to those gases and sources that can be measured or calculated reliably.

Trading/Offsets/Auction: Flexibility is fundamental to a market-based program. However, unlimited trading, offsets, or availability of credits via auction may raise concerns about the potential concentration of emissions in impacted communities. Restrictions could be used to address this issue.

Emission Banking and Borrowing: Banking and borrowing are consistent with the use of a market-based program to achieve emission reductions at the lowest possible cost. Banking, in particular, can motivate early action and reduce overall compliance costs.

6.2 Compliance Tracking and Enforcement

Under all formulations of a market-based program, emissions and compliance must be tracked for all the entities covered by the cap, and appropriate action must be taken if entities fail to comply.

Emissions Tracking

Reporting procedures will be required to ensure that facilities produce consistent and reliable emission reports. The California Climate Action Registry has developed and adopted two levels of emission reporting protocols:

A General Reporting Protocol is used by sources that do not have unusual reporting or calculation needs. The GRP can be used by a wide variety of entities.

Industry-specific protocols are used to address data, measurement, calculation, or other issues that are specific to certain industries.

To date the registry has developed protocols specific to the forest sector and the power/utility sector, and work is well along in developing a protocol for the cement production industry. Additional industry-specific protocols will be

required if a multi-sector program is adopted, for oil refining, oil and gas extraction, and landfills. The registry's methods produce emission reports that are sufficiently precise to be used by the emissions sources likely to be included in a market-based program.

The registry currently requires that emission reports be verified by qualified third-party certifiers, with the cost of certification borne by the reporting entities. With mandatory reporting, we need to assess whether the current process should be continued, or whether a new approach should be used, such as the organization receiving the emission reports being responsible for verifying the emission reports. Both approaches can ensure consistency and maintain quality control of the emission reports. However, centralizing responsibility for verification of the emission reports in the entity that receives the reports may enable efficiencies to be realized.

Compliance Tracking

Compliance is tracked by comparing the emission reports to the official record of emission allowances and emission offsets. A system for tracking the ownership of emission allowances and emission offsets is needed, including "expiring" the allowances and offsets when they are used to cover emissions in a compliance period. The compliance tracking needs to be done in a timely manner, so that compliance can be evaluated shortly after the end of the compliance period.

Enforcement

Enforcement provides consequences in the event that an entity cannot surrender emission allowances in sufficient quantity to cover its actual emissions. The design and implementation of the enforcement requirements will determine the strength of the incentives that entities have to comply. Additionally, the enforcement scheme can have a significant impact on whether the desired emission reductions are achieved.

Options for the consequences of non-compliance include:

- Require the entity to acquire emission allowances or offsets to make up its shortfall. Including this requirement will ensure that emissions are reduced to the emission cap.
- Require the entity to pay a fee per ton for which they did not have sufficient allowances. Including this requirement provides a financial incentive to comply.
- Require that the entity implement controls to reduce emissions. This requirement would reduce compliance flexibility.

If the sole enforcement method is a fee per ton of excess emissions, this would provide a "safety valve" on compliance costs. The fee would become the upper bound for the price of emission allowances. The risk of this approach is that if the fee were set too low, the emission cap may become ineffective, as entities choose to pay the fee rather than reduce emissions.

To ensure that the emission cap remains effective, the non-complying entity may be required to acquire emission allowances or offsets to make up its shortfall. The risk of maintaining the cap in this way is that the cost of the additional allowances may become very high, particularly during a period of non-compliance by many entities.

Significant volatility in the cost of complying can adversely affect the program, and could lead to the cap being relaxed in response to unsustainably high compliance costs. This situation is not hypothetical: the RECLAIM Program in 2000 displayed these conditions.³¹

Specifying the enforcement penalties requires balancing these benefits and risks. Analyses can forecast likely compliance costs and allowance prices. Because there is no track record for a climate change emission market-based program in the United States, the forecasts will necessarily be uncertain.

6.3 Conclusions and Next Steps

- A market-based program can be integral to California's strategy for reducing climate change emissions. The primary benefits of a market-based program are its ability to establish a firm climate change emission limit and to reduce emissions at the least cost.
- A market-based program can be implemented as part of a comprehensive emission reduction effort that includes complementary programs and initiatives.
- A national program to cap climate change emissions within an international framework would be the most effective approach. In the absence of national action, or even regional action, California can lead by example by developing a workable market-based program as a model for national action. The added benefit and impact on the state of taking unilateral action must be assessed.
- There is no single, best solution for designing an effective market-based program. Trade-offs are required to create a program that promotes real low-cost emission reductions, in a framework that is equitable and administratively feasible. Divergent interests must be balanced in designing the program scope, emission allowance distribution, and other program elements.
- A carbon cap on all fossil fuels provides the broadest single opportunity to reduce emissions, covering about 75 percent of state climate change emissions, including both stationary and mobile fossil fuel combustion. As an alternative, an emission cap focused on five industrial sectors would cover about 30 percent of state emissions. Mobile source emissions, accounting for about 42 percent of state emissions, are not easily incorporated into a sector-based emission cap. However, alternative strategies can focus on mobile sources.
- New legislative authority is required to implement a market-based program to reduce climate change emissions.

The CAT finds that a market-based program should be considered an integral part of California's approach to reducing climate change emissions. The next steps in considering a market-based program include the following:

- Facility-level emission reporting is needed, not only to support the detailed design of a market-based program, but to better understand current emissions and options for reducing emissions. Consequently, facility-level emission reporting requirements should be adopted, along with the industry-specific reporting protocols needed to support the reporting.
- Several complete market-based programs should be defined in detail, representing the range of program design options. The program alternatives should be evaluated, including their impacts on climate change emissions; cost of reducing emissions; state competitiveness, business, and jobs; and impacted communities with environmental justice concerns.
- Administrative options for implementing a market-based program should be developed. The budget requirements to support the administration of the program should be assessed.
- The legislative authority required to implement a market-based program should be identified.

7 IMPLEMENTATION OPTIONS

This chapter discusses possible implementation options that can be used to reduce climate change emissions in the state as shown in Table 7-1. Some of these options, such as the programmatic and voluntary options, are already being implemented and will continue forward. Others, such as the public good charge for transportation fuels, cut across options and can be used to ensure success. A market-based approach is regarded as an attractive means of reducing emissions and was discussed in detail in Section 6. This section discusses fee-based options; however, such an approach would require more extensive examination of the environmental and economic consequences.

In general, the CAT supports the use of multiple implementation options designed to support one another and provide the greatest possible emission reductions for the least cost.

Table 7-1. Implementation Options for Meeting Statewide Climate Change Emission Reduction Targets

Implementation Options
Programmatic
<p>Programs implemented by agencies.</p> <p>Examples of existing programs include ARB’s motor vehicle regulations, energy efficiency standards, Renewable Portfolio Standard.</p>
Market-Based Program
<p>Climate change emission cap established for industrial sectors.</p> <p>Flexibility through trading, offsets and or auctioning of emission credits.</p>
Public Goods Charge for Transportation
<p>Transportation is by far the largest source of emissions in the state. A public goods charge on transportation could be used to reduce emissions from transportation sources. Specific emphasis would be placed on transportation fuel diversity that would both benefit the environment and stabilize the economy.</p>
Fee-based Option
<p>Fees could be assessed based on entity emissions, with an emphasis on largest emission sources; or they could be broadly based on energy sources at point of origin or as close to point of origin as possible.</p> <p>Proceeds could be used to provide incentives or otherwise fund emission reduction projects.</p>
Offset Program
<p>Allowing for the purchase of offsets can lower cost. However, it is essential to ensure that offsets are real, quantifiable, surplus, enforceable, and permanent.</p>
Voluntary Emission Reduction Program
<p>Participants work with the state to establish agreed-upon emission reduction activities in support of the Governor’s statewide targets.</p>
Mandatory Reporting
<p>Necessity for all programs, tracking, and accountability.</p>

A more detailed description of each of the implementation options in Table 7-1 is included in the subsections below. Mandatory reporting is included in this table because it is key to all of the options considered. Mandatory reporting is also discussed below.

7.1 Programmatic

The programmatic approach has been the mainstay of the agencies represented on the CAT and is reflected in Section 5. State agencies have long been implementing programs that have provided tremendous environmental and economic benefits to the state, including those based on regulations, education, and incentives. Such programs will continue and would be used in combination with other implementation options discussed in this section.

7.2 Market-Based Program

Market-based program options are discussed in detail in Section 6. Further analysis is needed to determine how best to design a market-based program for the state. However, a well-designed market-based program has the potential to significantly reduce emissions while also providing industry with flexibility and reduced compliance costs.

7.3 Public Goods Charge for Transportation Fuels

Transportation is the largest source of emissions in the state. Accounting for more than 40 percent of the statewide emissions, it dwarfs the next largest sources of emissions—the industrial and electricity sectors—at about 20 percent each. Although both the industrial and electricity sectors are somewhat diversified as to energy source, the same cannot be said of the transportation sector. Petroleum accounts for 99 percent of the fuel used in the transportation sector. The state's dependence on petroleum has been shown to be harmful to public health and the environment.

In further contrast, a relatively small public goods charge is applied to all other energy sources in the state. The public goods charge on electricity has contributed to the fact that Californians use 30 percent less electricity per capita than the average U.S. citizen. Californians benefit from building and appliance energy efficiency programs funded with the public goods charges on electricity and natural gas that provide a net saving of more than \$1,000 per household annually.

Demand for petroleum in California and around the world has skyrocketed. Petroleum is a limited resource and much of the supply is located in politically volatile parts of the world. Even so, the demand for petroleum products continues to increase, despite the fact that increases in price have reached new peaks that are being sustained for longer periods of time.

The economic consequences of the state's dependence on petroleum can be measured in personal goods and services, and macro-economic terms. Consumers have less disposable income and those with little or no disposable income suffer disproportionately.

The costs of almost all goods and services increase when the cost of petroleum increases and many businesses cannot pass these costs on to consumers. This results in lower profits. In general, small businesses are at greatest risk. Finally, the price of crude oil is the single largest cost in the

production of transportation fuels, accounting for between 42 to 56 percent of the retail price of gasoline. California's demand for crude oil, like the U.S., is increasingly being met by international suppliers. Over the past two years, the price of crude oil has nearly doubled, which has resulted in an increasing percentage of California's consumer wealth being exported outside the state's economy.

The environmental consequences of petroleum are significant. As indicated above, climate change emissions from the transportation sector are large and growing. Using less petroleum also reduces smog-forming and toxic pollutants that occur at each point in the distribution system. Many alternative-fuel vehicles produce fewer emissions than their gasoline and diesel counterparts while also contributing to the need for fuel diversity in the transportation sector.

The Energy Commission in its 2005 Integrated Energy Policy Report³², which is the state's energy plan submitted to the Governor, has identified and recommended the concept of a public goods charge to finance programs that reduce petroleum demand and emissions for the transportation sector. A public goods charge on gasoline and diesel, if constructed appropriately, could be a very effective, fair, and efficient means to reduce climate change emissions from the transportation sector and mitigate these damaging consequences to our environment and our economy. Crucial questions about how the funds are administered and expended need to be addressed before a public goods charge for transportation fuels could be proposed.

7.4 Fee-Based Option

Fee-based options exist and merit further evaluation but have not been fully explored at this point. The primary attractiveness of such programs is that they can be centrally managed and can be targeted towards the largest sources or broadly targeted at energy sources at point of origin or as close to point of origin as possible. Proceeds could be used to provide incentives or otherwise fund emission reduction projects.

At this time the CAT would not recommend this option as it cannot guarantee emission reductions. The extensive consultation with industry and other stakeholders necessary also has not been completed.

7.5 Offset Program

Allowing for the purchase of offsets can lower cost. However, it is essential to ensure that offsets are real, quantifiable, surplus, enforceable, and permanent. A preliminary investigation into offset programs indicates that there are successful examples of such programs.

In Oregon and Washington, the Climate Trust program generates offsets for purchase by industry that take into consideration climate change emission reductions as well as reductions in other pollutants. The focus is to ensure high-quality, cost-effective offsets that provide a permanent and viable nexus between

those responsible for climate change emissions and the currently available solutions to reduce and eliminate those emissions over time.

A program similar to the Climate Trust program could be considered for California. Such a program could be designed to address the critical need to reduce pollution in low-income and minority communities and other priority issues in our state. Further analysis and review is needed for this implementation option, so the CAT has no specific recommendation regarding offsets at this juncture.

7.6 Voluntary Actions

There are many proactive industries that are taking actions to reduce climate change emissions. The Sustainable Silicon Valley group is made up of a number of large companies including Calpine, Hewlett-Packard Company, and Pacific Gas and Electric, who have pledged to voluntarily reduce their emissions to 20 percent below 1990 levels by 2010. The California Climate Action Registry allows companies to register their climate change emissions and assists these companies in tracking and reducing these emissions. British Petroleum, Eastman Kodak, Pacific Forest Trust and U.S. Borax are among the more than 50 companies that are currently members of the registry.

Such voluntary actions are instrumental in the effort to meet statewide targets. The CAT encourages such efforts as evidence that many in the business community as well as with local governments clearly believe action must be taken to reduce climate change emissions.

One of the overarching recommendations, which has been championed by industry and environmental groups alike, is recognition of early actions in any and all emission reduction programs implemented. Recognition of early action is also important as California joins its western state partners and the North East States in cooperative efforts to reduce emissions. State partnerships are expected to lead to national and international cooperative efforts.

7.7 Mandatory Emission Reporting

One of the overarching recommendations included in this report is the need for some level of mandatory reporting that builds upon the California Climate Action Registry. We simply don't have the basic information needed to track and account for emission reductions. The Energy Commission maintains a planning inventory that provides an overall picture of where emissions are coming from in the state. However, this inventory cannot be used for the purposes of determining baseline emissions from a source or for tracking emission reductions from a source.

The California Climate Action Registry does have emissions data that can be used for tracking emissions from a source and for accounting purposes. However, the Registry is voluntary, and many of the largest emitters in the state have not yet joined. There is no way to determine whether or when emission sources will join under the current provisions of law.

A preliminary estimate of the largest sources for which emissions data is needed in the state indicates that it would be prudent to begin with data collection from the electric power sector, oil refining and oil and gas extraction sector, landfills, and cement production. To the extent that industries have joined the registry voluntarily, the CAT believes this fulfills any reporting requirement for climate change emissions data.

As this state moves towards mandatory reporting of climate change emissions, the question as to where that data should be stored and managed arises. The CAT does not believe that such a program can be managed under a non-government organization such as the current Registry. However, some of the current duties and functions of the Registry could be placed within government for the purposes of mandatory data collection. The registry represents an excellent starting point for the process of mandatory reporting.

The role of Air Quality Management Districts, Local Enforcement Agencies, and other entities within the state that have permit and enforcement authority will need to be determined. These entities already collect much of the data that would be needed under a mandatory reporting program and have existing enforcement and permit authority. This should be considered as a mandatory reporting program is developed.

8 ECONOMIC ASSESSMENT

This section discusses the results from a preliminary assessment of the macroeconomic impacts associated with the climate change emission reduction strategies presented in this report. The results show that the overall impacts of the climate change emission reduction strategies are expected to be positive. Specifically, when the strategies already underway as well as new strategies being proposed are considered in total, the resulting impacts on the economy are expected to translate into job and income gains for Californians.

In summary, the net impact of the strategies on jobs in year 2020, when the strategies are expected to be fully implemented, is expected to be a gain of 83,000 above what the California economy would gain without the climate change emission reduction strategies. The implementation of the strategies is also likely to add an additional income of about \$4 billion to Californians in 2020, again, above what the economy is expected to produce without the strategies.

These favorable impacts on the economy are possible because of the reduced operating costs associated with many of the strategies. The additional job growth is expected to come from a net savings to consumers associated with the implementation of the strategies. The savings will in turn promote further business expansion and job creation.

The results presented in this section are considered preliminary because the cost and potential savings information associated with most of the individual strategies have not yet been fully developed. Therefore, when available, other sources have been drawn on to provide an initial assessment of the costs and

savings. Although this analysis needs refinement, we expect that the fundamental conclusion--that the suite of strategies discussed in this report has a net positive impact on California's economy--will stand.

The subsequent refined analysis will incorporate updated cost and savings estimates for the strategies. It will also assess the cost effectiveness of the various individual strategies. Thus, the refined economic analysis will provide additional information to decision-makers as they proceed with implementation of the strategies.

The remainder of this section discusses the model of the California economy used for the assessment, the analysis of the strategies in Section 5, a discussion, as well as a summary.

8.1 Economic Model

This economic assessment uses a computable general equilibrium (CGE) model of the California economy called E-DRAM, developed by the University of California, Berkeley. It has been used by the Department of Finance for the revenue impacts of tax and other State policies, by the California Energy Commission and ARB to assess impacts of reducing petroleum dependency (AB2076)⁵, and by ARB for the Vehicle Climate Change Standards⁶, the State Implementation Plan⁷ analysis, and others. As a part of the application of the model to these analyses, it has been peer reviewed and calibrated to be representative of the California economy.

⁵ CEC 2004. Attachment to Appendix A (Revised): Impacts of Petroleum Reduction Strategies on the California Economy. At http://energy.ca.gov/fuels/petroleum_dependence/documents/2004-02-10_ATCHMNT_APNDX_A.PDF

⁶ ARB 2005a. Regulations To Control Greenhouse Gas Emissions From Motor Vehicles: Final Statement Of Reasons. At <http://www.arb.ca.gov/regact/grnhsgas/fsor.pdf>

⁷ ARB 2003, 2003 State and Federal Strategy for the California State Implementation Plan. At <http://www.arb.ca.gov/planning/sip/stfed03/stfed03.htm>

A CGE model simulates the functioning of a market economy in which different sectors interact with one another (one sector supplies inputs to another, or purchases the outputs of another) and where prices and production adjust in response to changes caused by government policies applied to specific sectors. The CGE simulates these relationships among California producers, California consumers, government, and the rest of the world. Because of the interconnection between sectors, an intervention in one sector has impacts on others, which are captured by the CGE model analysis.

The inner workings of the CGE model can be graphically illustrated. Figure 8-1 shows a simplified version of the sectors that interact and participate in goods, services, and labor flows that make up the economy. The diagram shows that the households sell factors of production (labor and capital) to the firms which use the factors to produce goods and services to sell to the households. It also shows the flow of payments that accompany the transactions between the firms and the households. The diagram includes the flow of transactions between the firms; this is, how the firms buy and sell intermediate goods amongst themselves to produce the final products sold to the households.

Figure 8-1 Circular Flow of Goods and Services in the Economy

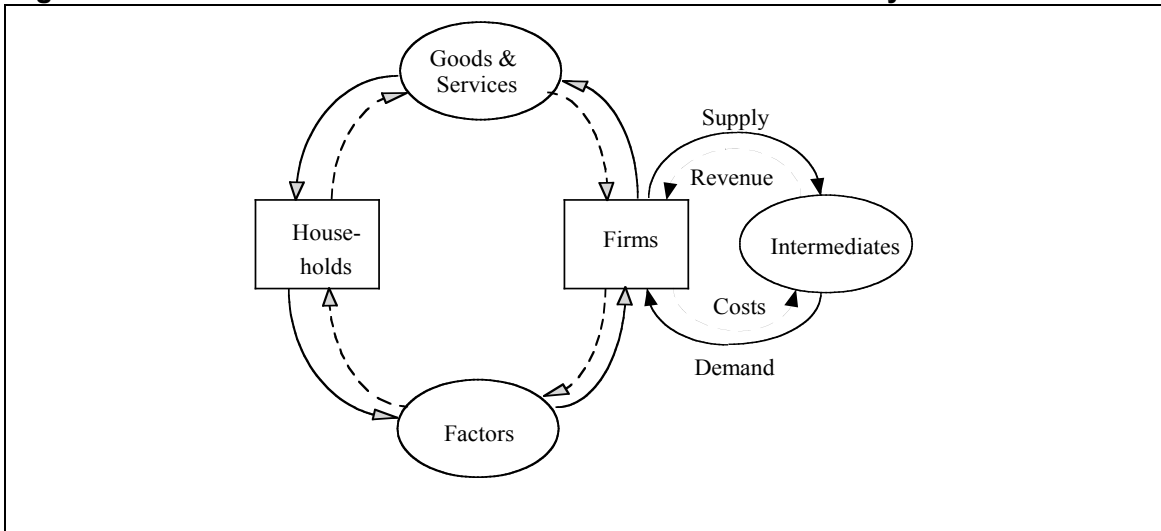
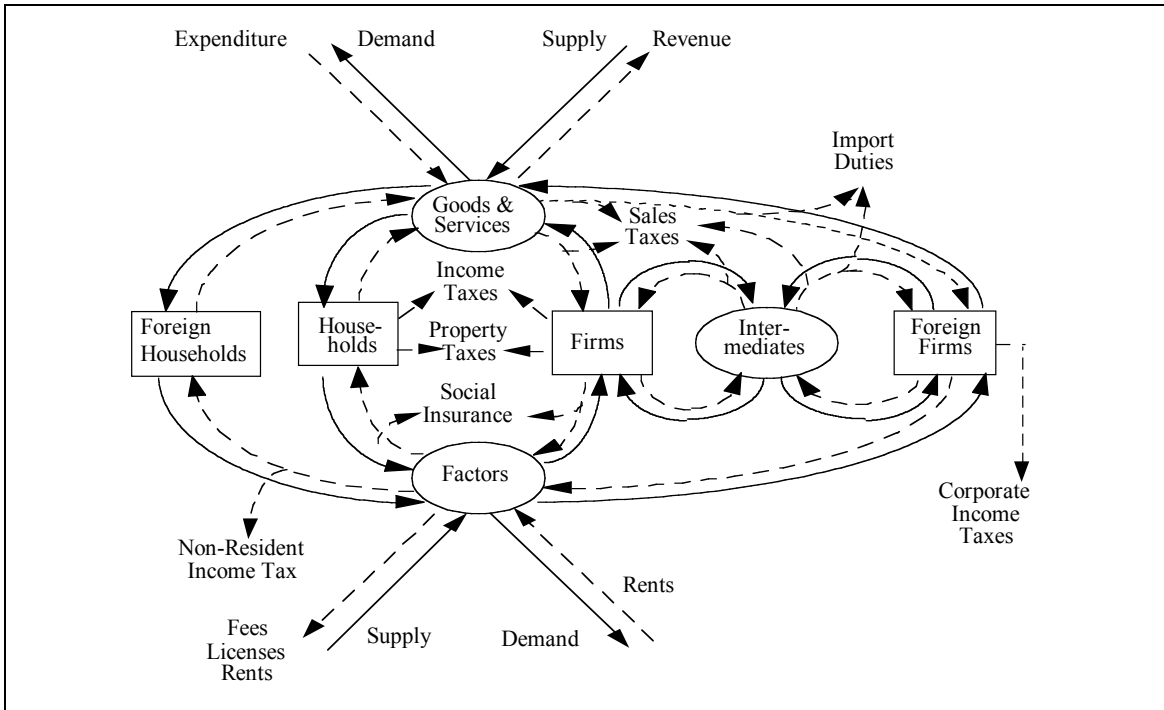


Figure 8-2 shows the complexity of the complete California economy and the many sectors involved in producing goods and services for final consumption by the households inside and outside of California.

Figure 8-2 Complete Circular Flow of Goods and Services in the Economy



The E-DRAM model accounts for all of the flows in the California economy using many equations. When a regulation or a policy is adopted that could affect costs of production in one part or sector of the economy, the rest of the economy has to adjust to the perturbation through price or employment changes. The CGE tracks the changes and produces results that show how much each sector has changed. The main economic indicators are number of jobs and income. It is believed that these two key indicators are particularly informative for characterizing the impact of potential policies on California's economy. Jobs are an important indicator for decision-making, and income closely follows the gross state product, which is an indicator of overall economic well-being in the State. This economic assessment presents the changes in these two indicators as the net economic impacts of the strategies.

8.2 Analysis of Climate Change Emission Reduction Strategies

The strategies evaluated in this analysis are taken from Section 5. The objective of the analysis is to draw on available cost and savings data to provide an overall assessment of the impact of the strategies on California's economy.

The E-DRAM model of the California economy was run with the strategy costs and savings as inputs into the model to assess the economic impacts for years 2010 and 2020. Two major economic indicators were selected to

demonstrate economic well-being. Job creation indicates a healthy economy providing opportunities to Californians. Income is an indicator of the output of goods and services and therefore gauges progress in economic activity. The impacts are shown as the difference between the predicted economic indicators with and without implementation of the strategies.

Table 8-1 shows the impacts of the strategies on income and employment in 2010. Many of the strategies have both costs and savings. Generally, the costs are incurred for technology and/or changes in behavior that reduces emissions, and savings are accrued from reduced operating costs. The costs of the strategies for the year 2010 are estimated at \$1.3 billion, and the savings at \$2.9 billion for a net savings of \$1.6 billion. The net savings stimulate additional economic activity and generate about \$2 billion of additional income (about a 0.13% increase in total income) and 19,000 new jobs (about 0.11% of the 2010 total employment). For context, Table 8-1 and Table 8-2 also show the growth expected for the economy between 2004 and 2010 or 2020 irrespective of the strategies discussed in this report.

Table 8-1. Impacts of Achieving the Climate Change Emission Reduction Targets on California Economy in 2010*

Economic Indicator	In 2004	Without the Strategies**	With the Strategies	Impacts	Percentage of the Total
Income (Billions of 2005\$)	1,317	1,527	1,529	2	0.13%
Employment (thousands)	16,460	17,969	17,988	19	0.11%

* We display several digits to make it clear how we calculated the difference associated with the strategies.

** This column indicates the income and employment forecast for 2010 without the implementation of the strategies presented in this report. Note that between 2004 and 2010, the economy is expected to realize substantial growth (e.g., income increases by about \$200 billion while the number of jobs increase by about 1.5 million).

By 2020, additional savings from the strategies stimulates the economy further. The strategy costs are on the order of \$7.9 billion, with a savings of \$16.9 billion for a net savings of \$9.0 billion. Table 8-2 shows the impacts of the strategies in 2020. The results also reflect the fact that the strategies that would be in effect by 2020 have a different mix of costs and savings than those in 2010.

The impact on income is about \$4 billion, about a 0.19% increase, and the impact on jobs is creation of 83,000 new jobs, about a 0.40% increase, in the year 2020 for the California economy.

Table 8-2. Impacts of Achieving the Climate Change Emission Reduction Targets on California Economy in 2020*

Economic Indicator	In 2004	Without the Strategies**	With the Strategies	Impacts	Percentage of the Total
Income (Billions of 2005\$)	1,317	2,128	2,132	4	0.19%
Employment (thousands)	16,460	20,704	20,787	83	0.40%

* We display several digits to make it clear how we calculated the difference associated with the strategies.

** This column indicates the income and employment forecast for 2020 without the implementation of the strategies presented in this report. Note that between 2004 and 2020, the economy is expected to realize substantial growth (e.g., income increases by about \$800 billion while the number of jobs increase by about 4.3 million).

Although these of the economic impacts seem small when considered as a percentage of the total economy, the positive direction of the impacts indicate that the California economy is highly unlikely to suffer negative impacts from achieving the climate change emission reduction targets as directed by the Governor’s Executive Order. Rather, implementation of the suite of strategies indicates a positive net impact on the economy. Refinement of the strategy cost and saving estimates, which is planned for the near future, will provide further details regarding the impacts of strategy implementation on the California economy.

With the exception of the Green Building Initiative and the strategies in Section 5 for which reductions are not reported, the economic impacts shown in Table 8-1 and Table 8-2 reflect the combined effect of all of the strategies (those underway and those proposed). The strategies not included in this analysis will be included in the subsequent refined analysis along with updated costs and savings information for the strategies analyzed thus far. However, the inclusion of these additional strategies is not expected to change the fundamental conclusions presented in this analysis because the additional strategies are, in total, expected to result in a net savings.

Discussion of the Economic Assessment of the Strategies Already Underway in California: One key observation on the strategies already underway is that almost all of them result in increased energy efficiency, which historically been shown to be highly cost effective. It is thus expected that the net effect of strategies underway, by themselves, will be to benefit the economy by providing additional jobs and income. As previously indicated, a subsequent economic

analysis will draw on refined cost and savings information for these strategies to support a more robust macroeconomic assessment of the individual strategies as well as their combined impact. Discussions of the strategies already underway are presented below. The cost and savings estimates are preliminary and are already being evaluated for refinement.

The Vehicle Climate Change Standards strategy was developed to support a regulation approved by the Air Resources Board in 2004. The staff report including the economic analysis is fully documented and was the subject of several public workshops. For example, the ARB economic analysis of the strategy concluded that by 2020, jobs increase by 53,000. The benefits result from operating cost savings by consumers which in turn are spent on other goods and services, generating additional jobs and income beyond what the economy normally would produce. Further, the Diesel Anti-idling strategy is expected to save several hundred million over its implementation by reducing diesel fuel consumption⁸. Because of the savings, its impact on the economy is expected to be positive.

In general, energy efficiency programs positively impact the economy. Most of the strategies already underway concern efficiency improvements. Although the State agencies developing these strategies may not have completed a refined assessment of the associated costs and savings, analyses of similar strategies by universities and institutes have shown net benefits for these strategies, and thus, positive impacts on the economy. Such strategies include Investor Owned Utility Energy Efficiency Programs, Building and Appliance Energy Efficiency Programs, Achieve 50% Statewide Recycling Goal, and Fuel-Efficient Replacement Tire and Inflation Programs. In total, these programs will almost certainly benefit the economy by producing additional jobs and income for California.

⁸ ARB 2005b. Notice Of Public Hearing To Consider Requirements To Reduce Idling Emissions From New And In-Use Trucks, Beginning In 2008. At <http://www.arb.ca.gov/regact/hdvidle/isor.pdf>

The Green Building Initiative is expected to produce net benefits and therefore positively impact the economy. Based on historical experience, every dollar spent on energy efficiency typically provides about \$2 in benefits. As indicated, the Green Building Initiative will be folded into the subsequent refined analysis.

The California Public Utilities Commission (CPUC) is currently reviewing a statewide solar incentive program proposal. If adopted by the CPUC in January 2006, the proposed California Solar Initiative (CSI) will provide close to \$2.9 billion in incentives between 2007 and 2017. The program is anticipated to bring on line or displace 3,000 MW of power. As costs and savings estimates are further developed they will be included in a refined economic impact analysis of the climate change emission reduction strategies.

In addition to the Solar Initiative, the CPUC commissioned a report entitled "Achieving a 33% Renewable Energy Target" to identify feasibility and next steps to accelerate and expand the current CPUC Renewable Portfolio Standard program. The report determines that after the initial infrastructure costs are borne, the resulting benefits to ratepayers in 2021 and beyond are net positive. Using the CEC's long-term forecast of natural gas prices, the report finds that ratepayers would likely realize a net benefit over a 20 year period.

Discussion of Economic Impacts of the Strategies Needed to Meet California's Targets: All of the strategies presented in Section 5 where estimated climate change emission reductions are available were included in the analysis that generated the results shown in Table 8-1 and Table 8-2. Several sources were drawn on to identify preliminary cost information including analyses done by UC Berkeley, and the Tellus Institute³³. Many of the strategies have implementation costs. However, several strategies also have savings that may cover or exceed the costs.

8.3 Discussion

The economic impacts presented in this analysis are from the combined strategies listed in the tables in Section 5 for which preliminary cost information is available. Some of the strategies in Section 5 have net costs while others have net savings typically due to decreased operating costs. Those with net costs would be expected to adversely affect job growth if considered in isolation. However, those with savings will increase job growth and income. For example, the Air Resources Board's Heavy Duty Vehicle Emission Reduction Strategy would be expected to lower the operating costs of transporting goods.

Lower costs of producing a certain amount of goods or services lead to more economic activity and create more jobs and income as people spend savings from the lower costs.

The refined analysis would be expected to provide additional information to facilitate a focused consideration of each strategy with respect to several factors including cost effectiveness. Further, the refined analyses can include additional strategies that may be identified by stakeholders. Specifically,

stakeholders may identify additional cost-effective strategies that have the potential to provide additional emission reductions. However, as with the analysis presented here, a key product of the subsequent refined analysis will include the macroeconomic impacts of the suite of strategies rather than each strategy.

Subsequent analysis of the strategies may also be affected by overall program implementation methods that have the potential to promote further cost reductions or savings. For example, cap-and-trade policies can unleash internal innovative powers of the private sector to adopt and invest in processes and methods that lower energy use and increase efficiency. Like energy efficiency standards that have been shown to create jobs, the innovative efforts induced by cap-and-trade or other similar tools would likely further enhance the cost effectiveness of reaching the climate change emission reduction targets.

Many of the strategies that end up with net costs may have benefits that are not directly estimated or may not be the focus of the climate change emission reduction efforts. For example, the afforestation strategy has a net cost. However, planting forests may provide indirect benefits to the public or other sectors of the economy that are not captured in this analysis. Specifically, strategies currently believed to result in a net cost may actually provide a savings when both direct and indirect benefits are considered.

Further, the benefits of strategies that already indicate a net savings may not be fully recognized in a conventional economic analysis. For example, several of the energy efficiency strategies may also facilitate increased security through further energy independence. Such indirect benefits should at least be qualitatively identified and considered when evaluating the strategies.

Finally, it may not be appropriate to assign all of the costs of the strategies currently underway to the climate change emission reduction efforts given that there are typically other considerations that contributed to the policy. Specifically, many of the strategies that are underway are being pursued to achieve other objectives (e.g., the Diesel Anti-Idling Strategy from Section 5 focused on reducing the population's exposure and risk associated with diesel particulate emissions as well as reducing smog precursors) with the associated climate change emission reductions being an added benefit. Many of the proposed strategies in Section 5 have the potential to address other programmatic objectives beyond climate change.

8.4 Summary

Based on this preliminary analysis, it appears that the climate change emission reduction targets can be met without adversely affecting the California economy. It is possible to adopt a suite of strategies in a manner that continuously benefits the economy. The strategies that focus on increased energy efficiency and produce net savings can greatly contribute to economic activity while reducing climate change emissions. Further, technology

improvements and innovative implementation of strategies currently estimated to have net positive costs may, in the long-run, result in net savings.

As refined cost information is developed for the strategies, a subsequent analysis of the economic impacts will be performed. In addition to characterizing the overall impacts of the strategies on California's economy, the subsequent analysis will allow individual strategies to be evaluated. The analysis may also facilitate the identification and inclusion of new cost-effective strategies that are not currently presented in Section 5. The analysis will also further inform decision-makers on the approach to strategy implementation that maximizes both environmental benefits and the benefits to the economy.

8.5 Implementation Options Assessment

With the exception of the programmatic option, the implementation options shown in Table 7-1 have not yet been evaluated in terms of their economic impacts.

In the case of the market-based implementation option, an economic analysis will be needed once the state determines the design of such a program. By its nature the market-based option is designed to reduce the costs associated with achieving emission reductions relative to a command and control approach. Therefore, the primary concern with implementation of this option is typically not the economic impacts but rather the assurance of real emission reductions and the implications for low-income and minority communities.

In the case of the public goods charge for transportation, such a charge would be designed to provide economic security, risk reduction and cost savings to the paying public. In the case of the public goods charge on electricity, California consumers save approximately \$1,000 per year as a direct result of conservation efforts.

The public goods charge for transportation would be designed to provide economic benefits as well. Given the current volatility in the price of petroleum, risk reduction for a diversified transportation fuels market and reduced dependence on petroleum will provide a significant benefit to both consumers and to the economy as a whole.

The CAT is not recommending the fee-based and offset program options at this time. Both would require an economic evaluation prior to implementation.

9 IMPACTS ON LOW INCOME AND MINORITY COMMUNITIES

Low-income and minority communities are disproportionately affected by pollution and other adverse environmental damages. Disproportionate access to health care and/or lack of resources have contributed to a situation in which residents of low-income and minority communities are more likely to be exposed to toxics and other pollutants and are less likely to have the resources to adequately respond. The environmental justice (EJ) movement was created as part of the larger social justice movement with the intent to ensure that residents

of low-income and minority communities were equally protected from exposure to toxic and other pollutants.

Environmental justice is an issue that has been embraced as a priority for the Governor and the Legislature. As this state moves forward in reducing climate change emissions, evaluating the impacts of climate change, and considering adaptation strategies, EJ concerns must be addressed.

9.1 Environmental Justice Programs

The Governor's Office of Planning and Research (OPR) is the coordinating agency for environmental justice programs for the state. In 2003, OPR incorporated environmental justice elements within the General Plan Guidelines. This effort marked a beginning to a number of other State agencies, such as California Department of Transportation and the California Resources Agency, in adopting environmental justice policies.

Cal/EPA is the model agency (1999 Statutes) for implementing EJ into its programs, policies, and activities. In 2004, under the Schwarzenegger administration, Cal/EPA established its Intra-agency EJ Strategy, model EJ mission statement, and EJ Action Plan to ensure fair treatment and equity for all Californians regardless of race, age, culture, income, or geographic location.

The EJ Strategy is a long-term planning process and marks an important step toward addressing disproportionate environmental impacts on low-income and minority populations. To compliment the EJ Strategy, Cal/EPA also initiated the EJ Action Plan, a three-year action-oriented process, to explore complex issues such as cumulative impacts and precautionary approaches within six pilot projects throughout various regions in California.

The goal of the action plan is to develop environmental risk reduction plans for children's health, develop guidance for precautionary approaches and cumulative impacts, and improve public participation in the decision-making process. Cal/EPA reports to the Legislature every three years on the status of the EJ Strategy and Action Plan.

9.2 Outreach to Minority and Low Income Communities

In order to solicit comment and promote dialogue with representatives from low-income and minority communities, the Climate Action Team made it a priority to attend local environmental justice community meetings. At these meetings, CAT representatives provided general background information on climate change and updated the groups on climate change activities and potential issues that might arise. Below is a list of meetings attended:

Date	Organization
September 30, 2005	California Environmental Rights (Los Angeles)
October 5, 2005	North Richmond Air Quality Committee (Richmond)

October 11, 2005	North Richmond Municipal Advisory Committee (Richmond)
December 10, 2005	California Coalition Against Toxics (Los Angeles)

9.3 Strategy Evaluation

As the efforts of the CAT agencies to implement strategies outlined in section 5 move forward, outreach to communities must continue. Each of the agencies on the CAT has committed to support this priority.

Implementation of climate change emission reduction strategies will most likely benefit communities. In many cases, such as electrification of ports, efforts to reduce climate change emissions will provide a direct benefit. In these instances, the support of the communities is essential, and the support of the larger EJ movement will be an asset. If implementation of a strategy would require concomitant measures to ensure against harmful consequences to communities, State agencies must work with communities. In all cases, an open public process that is accessible to community representatives will ensure that EJ concerns are addressed and the statewide targets are met equitably.

9.4 Scenario Analysis

When considering the impacts of climate change on California and adaptation measures necessary, the State must also consider impacts specific to communities and the degree to which low-income and minority residents are affected.

The impacts of global warming will have economic and social consequences for low-income and minority communities. The adaptive capacity of people in these communities is lower than for average Californians.

Specific examples of situations in which low-income and minority communities are likely to be more adversely affected include:

Increasing costs for food, water, and energy will disproportionately affect the low-income communities.

Increasing use of pesticides will have an economic and public health impact on the farm workers.

An increase in the number of days Californians are exposed to ozone will disproportionately affect the people who do not have insurance or access to health care resources.

9.5 Market-Based Options

Low-income and minority communities are particularly wary of market-based because of the general belief that emissions trading allows for increased emissions at a local level and those increases are believed more likely to occur in the communities. The principal concern is not with the climate change emissions themselves because, in most instances, these emissions do not directly cause

local air quality problems. Rather, the concern is with the emissions of other pollutants (CO, NO_x, SO_x, PM, toxics) which may be affected by efforts to reduce climate change emissions. Two types of impacts may be of particular concern:

- Options that reduce climate change emissions could increase emissions of pollutants that cause local air pollution. For example, shifting from a fossil fuel to a biomass fuel could increase emissions of smog-forming pollutants unless appropriate emission control technologies are installed as part of the switch.
- Efforts to reduce climate change emissions may result in facilities with lower climate change emissions per unit of output being operated more than would otherwise be the case. Under these conditions, emissions of local air pollutants may increase near the facility that increases its operations.

In both of these cases, a local community could be impacted by increased emissions, even though climate change emissions decline overall. Because a market-based program provides substantial flexibility for facilities to select their preferred methods for achieving the climate change emission cap, the design of the program does not automatically mitigate this concern. Rather, steps must be taken to address this issue through additional measures.

9.6 Implementation Options

For all of the implementation options shown in Table 7-1 it will be essential to involve community representatives as these options are developed. As indicated in Sections 9.5 and 9.6, both the programmatic and market-based program options will need to involve community representatives.

In the case of the Public Goods Charge for Transportation, the State must work with communities to ensure that costs are not unduly burdensome and benefits are equitable.

Although the CAT is not recommending Fee-Based and Offset Program options at this time, both would require an open public process that ensured participation from communities prior to implementation.

10 SUMMARY AND CLIMATE ACTION TEAM RECOMMENDATIONS

This report lays out a path forward to ensure that California's climate change emission reduction targets are met. Following the signing of Executive Order S-3-05, the Secretary of Cal/EPA created a Climate Action Team. The CAT has accomplished three main objectives: completion of a list of recommended strategies to reduce climate change emissions in the state; completion of a significant first step in what will be an ongoing scenario analysis that provides insight into the impacts of climate change on the state and presents adaptation plans; and evaluation of options for a market-based program in the state including next steps recommendations.

The CAT produced two categories of overarching recommendations. First and foremost, the overarching recommendations considered essential by the CAT in

meeting the statewide climate change emission reduction targets. The general recommendations listed in Section 10.2 are second tier recommendations that consist primarily of recommended next steps and indications of where further analysis is needed.

10.1 Climate Action Team Overarching Recommendations

This final report has been revised from the December 2005 draft to reflect the comments, recommendations and suggestions that have been submitted. The final report proposes a path to achieve the Governor's targets that will build on voluntary actions of California businesses, local government and community actions, and state incentive and regulatory programs. The Governor's climate change emission reduction targets are achievable with economic benefit for California.

The climate strategies set forth in this report are in various stages of development. Some of the strategies, such as the California Solar Initiative, are being implemented this year. Other strategies, such as those related to biofuels, may require stationary modification this year for implementation to proceed. Still others, such as Smart Land Use and Intelligent Transportation and Semiconductor Industry Targets, are sound but require further analysis and development and should be allowed to evolve over the next two years. The Climate Action Team preliminary economic assessment, which is based on the Environmental Dynamic Revenue Model, indicates that, by 2020, implementation of these strategies will result in 83,000 new jobs and an increase in personal income of \$4 billion.

The Climate Action Team process for developing this report has been successful and the Team should be charged with the next phase of activity. Since the signing of the Executive Order, under the leadership of Cal/EPA, the Climate Action Team has provided a forum for coordinating State agency actions, program development, and budget proposals in addition to this report. It allows for collaboration, reduced internal competition and conflict, and provides a single point of contact.

The Climate Action Team recognizes that reducing climate change emissions is challenging and will need to be addressed in a deliberative on-going manner. The Team also recognizes that many of the reductions will come from technological innovations that are not yet fully developed. We have identified key recommendations that will help ensure the Governor's targets are met:

- A multi-sector market-based system uses economic incentives to lower costs, protect economic growth and promote innovation. The Climate Action Team should proceed with the development of a multi-sector market-based program which considers trading, emissions credit auction and offsets. The Climate Action Team should develop a multi-sector market-based program and make a recommendation to the Governor on

the structure for such a program no later than January 1, 2008. The Governor's 2020 climate change emission reduction target to reach 1990 emission levels should be the basis for an emissions cap in the development of program. The Climate Action Team should consider working with other western states to develop a multi-state program to minimize emissions leakage.

- Mandatory emissions reporting from the largest sources oil and gas extraction, oil refining, electric power, cement manufacturing and solid waste landfills, that builds on the California Climate Action Registry is essential. Mandatory reporting will ensure an accurate inventory of emissions which is critical to ensure that decision-making is based on real emissions and emission reductions. Equally essential are provisions for early action credit and a mechanism to ensure that companies are not penalized for early action. Early action will be attributed to California businesses that have voluntarily joined the California Climate Action Registry and have reduced emissions. Although the voluntary Climate Action Registry is a foundation, the Climate Action Team believes mandatory reporting must occur through a state government agency.
- A multi-generational public education campaign should be implemented to ensure that the public is informed about the issue of climate change and what they can do to reduce emissions and adapt to adverse consequences. Such a program can build upon successful campaigns in place, such a Flex Your Power. The Education and the Environment Initiative mandates the development of a unified strategy to bring education about the environment into California's K-12 schools through California's Environmental Principles & Concepts and a standards-aligned, State Board of Education-approved model curriculum. It is essential that California's children understand the impacts and consequences of climate change on the State's resources as well as mitigation and adaptation strategies.
- The macroeconomic analysis should be updated to reflect refined data collected over the next year. A cost-effectiveness analysis of all the strategies recommended in this report should be developed. Both should be completed by July 2007 and should incorporate a peer review process.
- Transportation is the largest source of climate change emissions in California. The Air Resources Board's vehicle climate change standards address a significant portion of the transportation sector. However, an aggressive alternative fuels program will significantly reduce climate change emissions. The California Energy Commission working with Cal/EPA and its boards and departments, and the Department of Food and Agriculture is currently developing an aggressive biofuels program that will be available this Spring. This biofuels program should be

considered an essential component of the effort to reduce California's carbon footprint.

- The Governor's climate change emission reduction targets are based in part on the planning assumptions in the California Energy Commission's Integrated Energy Policy Report. Specifically the Integrated Energy Policy Report recommends that all long-term new electricity generated for use in the state must come from sources with climate change emissions equivalent to or less than a new combined cycle natural gas power plant. The Public Utilities Commission's recently adopted proposal for an electricity sector carbon policy is generally consistent with the Integrated Energy Policy Report and will set forth a regulatory scheme for enforcing such a policy applicable to investor-owned utilities. The Climate Action Team recommends the policy, including an accountability mechanism, in the Integrated Energy Policy Report be extended to apply to all load-serving entities in the State, including municipal utilities, electric service providers and community choice aggregators. The Public Utilities Commission will work with the Climate Action Team so that this effort is consistent with the development of a multi-sector market-based program.
- All utilities should meet the energy efficiency goals and the Renewable Portfolio Standard required of investor-owned utilities. The State has adopted energy efficiency goals and a Renewable Portfolio Standard for investor-owned utilities. Publicly-owned utilities should match this level of performance and account for their achievements in a manner consistent with that of investor-owned utilities. Because publicly-owned utilities provide 25% to 30% of the electricity used in California, these entities are essential to the state's overall goal to reduce electricity demand and increase the State's use of renewable resources. The Energy Commission should work with the publicly-owned utilities to develop an accurate accounting system that captures climate emission reduction efforts by publicly-owned utilities so that their performance can be evaluated comparatively to investor owned utilities.
- The California Climate Action Registry, in cooperation with the Energy Commission, should develop emission reporting protocols for local government. Local governments are already contributing to the effort to reduce climate change emissions and an accurate tracking system of their contributions is essential.
- Over time funding will be needed to implement the strategies set forth in this plan and to provide incentives for industry to develop emission reduction technologies for use in California and abroad. A coordinated investment strategy can leverage the talent of California's universities, community colleges, and other entities and to lead technology development and train the next generation of technicians that will be

needed to operate and service those technologies. A public goods charge for transportation that funds key strategies to reduce climate change emissions and to reduce dependence on petroleum should be considered. Overdependence on petroleum fosters undesirable geopolitical, economic, energy, and environmental consequences. Other possible funding could come from the PIER program at the Energy Commission, targeted dedication of other state funds, or philanthropic and corporate investment. The electricity sector and natural gas Public Goods charges should continue at projected levels. Any new funding concepts require additional study until the preliminary recommendations noted above can be more fully developed. Accordingly, the Governor's 2006-07 budget proposes \$7.2 million across several state agencies to begin implementation of the recommendations in this report.

10.2 General Recommendations

General recommendations included in this report are listed below. These recommendations are broken down into broad categories according to their relation to the emission reduction strategies, economics analysis, climate change emission reduction inventory, or market-based program options.

Economic Analysis

The State needs to take the following actions by July 2007:

Complete an analysis of the individual strategies presented in Section 5 to determine the cost-effectiveness for each strategy.

Develop a revised macroeconomic impact assessment to include updated cost estimates for the individual strategies.

Determine preliminary costs associated with the impacts of climate change on public health, water, agriculture, coastlines, and forests in California.

Determine updated costs associated with adaptation.

Climate Change Emission Inventory

It is essential that the California Energy Commission continue to refine the planning inventory they currently keep.

Market-Based Program

A market-based program should be considered further as an integral part of California's approach to reducing climate change emissions. In the absence of national action, California can lead by example by developing a market-based program as a model for national action.

Market-based program alternatives should be defined in detail and evaluated in terms of impacts on emissions; costs of reducing emissions; state competitiveness, businesses, and jobs; impacted communities with environmental justice concerns; and administrative and budget requirements.

Legislative authority required to implement a market-based program should be identified.

Scenario Analysis

California should continue to support research relevant to policy on climate change, including support of the research activities of the California Climate Change Center. Some of the areas of research in need of attention include the study of ecological impacts, the development of probabilistic climate projections for the state, a geographically-detailed analysis of the impacts of sea level rise on the California coast and the San Francisco Bay and Delta, the impact of climate change on energy generation and demand and human health, and new methods for economic impact analyses.

Climate change may disproportionately impact the most vulnerable groups in our society, including children, the elderly and frail, and residents in low-income and minority communities. For this reason, future scenario analysis should strive to identify these potential impacts and suggest solutions.

Given the serious potential consequences of climate change on the State's resources, California should expand its support of climate change research to create the tools, methods, and information that will be needed to develop robust coping and adaptation strategies in the state.

11 LIST OF ACRONYMS AND ABBREVIATIONS

ARB	California Air Resource Board
BT&H	Business, Transportation and Housing Agency
CA H ₂ Net	California Hydrogen Highway Network
Cal/EPA	California Environmental Protection Agency
CAT	Climate Action Team
CCA	Community Choice Aggregators
CDFA	Department of Food and Agriculture
CEC	California Energy Commission
Center	California Climate Change Center
CEQA	California Environmental Quality Act
CGE	Computable General Equilibrium
CH ₄	Methane
CHP	Cooling, Heating and Power
CIWMB	California Integrated Waste Management Board
CO	Carbon Monoxide
CO ₂	Carbon Dioxide
CO ₂ e	climate change emissions expressed as CO ₂ equivalent.
DHS	Department of Health Services
DOE	United States Department of Energy
DWR	Department of Water Resources
EAP	Energy Action Plan
E-DRAM	Environmental Dynamic Revenue Model
EJ	Environmental Justice
EO	Executive Order
ESPs	Energy Service Providers
EWMP	Efficient Water Management Practices
GCMs	Global Climate Models
GFDL	Geophysical Fluid Dynamic Laboratory
GHGs	Greenhouse Gases
GWP	Global Warming Potential
HadCM3	Hadley Centre Climate Model, version 3
HFC	Hydrofluorocarbons

IEPR Integrated Energy Policy Reports
IOU Investor Owned Utility
IPCC Intergovernmental Panel on Climate Change
ITS Intelligent Transportation Systems
IWMA Integrated Waste Management Act
kWh kilowatt hour = 3.6 MJ = 3,412 Btu
LEAs Local Enforcement Agencies
MAF Million Acre Feet
MMt Million Metric Tons
MOU Memorandum of Understanding
N₂O Nitrous Oxide
NAST National Assessment Synthesis Team
NCAR National Center for Atmospheric Research
NMVOCs Nonmethane Volatile Organic Compounds
NO Nitrogen Oxides
NOAA National Oceanic & Atmospheric Administration
NPV Net Present Value
O₃ Tropospheric
°C Celsius
ODS Ozone Depleting Substances
°F Fahrenheit
PCM1 Parallel Climate Model
PFC Perfluorocarbons
PIER Public Interest Energy Research
PM Particulate Matter
PPM Parts per Million
PUC Public Utilities Commission
Registry California Climate Action Registry
RPS Renewable Portfolio Standard
SF₆ Sulfur Hexafluoride
SO₂ Sulfur Dioxide
SRES Special Report on Emissions Scenarios
TRUs Transportation Refrigeration Units

U.S. EPA United States Environmental Protection Agency

UK United Kingdom

VMT Vehicle Miles Traveled

VOC Volatile Organic Compound

W/m₂ Watts per Square Meter

WUI Wildland-Urban Interface

12 ENDNOTES

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