CALIFORNIA
ENERGY
COMMISSION

CLIMATE CHANGE AND CALIFORNIA

Prepared in support of the
2003 Integrated Energy Policy Report
Proceeding (Docket # 02-IEP-01)

STAFF REPORT

October 2003
100-03-017D

Gray Davis, *Governor*

CALIFORNIA ENERGY COMMISSION

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ACKNOWLEDGEMENTS

This report was prepared with contributions from the following Energy Commission staff:

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Information contained in Chapter 5 related to potential climate change strategies was derived in large part from deliberations of a multi-agency team focused upon mitigation and adaptation opportunities in California. In particular, the authors of this report would like to acknowledge contributions of the following individuals:

Gregory Greenwood	California Resources Agency
William Vance	California Environmental Protection Agency
Cynthia Praul	California Energy Commission
Bart Croes	California Air Resources Board
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EXECUTIVE SUMMARY

Climate change represents a significant risk to California as a result of a warming and increasingly variable climate. The signs of a global warming trend continue to become more evident and much of the scientific debate is now focused on expected rates at which future changes will occur. Rising temperatures and sea levels, and changes in hydrological systems are threats to California's economy, public health, and environment.

In 1988, the California Legislature recognized that climate change could adversely affect the state and called for an assessment of impacts and identification of potential strategies. Since then California has inventoried its greenhouse gas emissions, improved energy efficiency and conservation, created a voluntary greenhouse gas registry, established ambitious goals for renewable energy, and is now preparing regulations to achieve reductions in greenhouse gas emissions from motor vehicles. While California has been a leader in addressing climate change, more can be done to better prepare for an uncertain climate future and improve the resiliency of the state's economy. Taking appropriate steps to address risks posed by climate change can help insure a more sustainable future and benefit the state's citizenry and natural and economic resources.

California needs a more comprehensive strategy to address climate change. Significant reduction of greenhouse gas emissions and adaptation to the causes resulting from these emissions rely upon both technological and behavioral changes. Decreasing the state's dependence on fossil fuels, the primary source of greenhouse gas emissions, will require integrated policies and short- and long-term strategies. The feasibility, benefits, costs, and priority of climate change strategies need to be evaluated using a consistent life-cycle emissions approach. California must prepare to adapt to the impacts of climate change. The state's ability to develop appropriate adaptation measures will be enhanced by ongoing and new research to better understand and predict future changes in California's climate. Consideration of climate change needs to be reflected in critical state and local planning processes.

Finally, California should pursue partnerships with neighboring states and countries to jointly take leadership positions in addressing the challenges presented by global warming. On September 22, 2003 the governors of California, Oregon, and Washington announced the launch of a West Coast climate change initiative to develop and implement new regional strategies. Such partnerships can lead to the crafting of innovative solutions and provide a public process that is open to all interested stakeholders. Regional partnerships can lead to progress in transportation energy efficiency, renewable energy and electricity generation, research and development, building and appliance energy efficiency, and greenhouse gas accounting through registries and improved emissions inventories.

CHAPTER 1: CLIMATE CHANGE AND CALIFORNIA

Change is happening to California's climate. The frequency of extreme climatic events worldwide indicates that climate variability may be on the rise and scientists predict global warming will significantly increase that variability in the future. California needs to develop a more comprehensive strategy to effectively and efficiently address a wide range of issues related to climate change risks, impacts, uncertainties, and opportunities. The purpose of this report is to provide the context for climate change in California, recognize past and ongoing activities related to this topic, identify strategies and recommend new measures to tackle the potential challenges the state faces with a changing and more variable climate.

There is little question that California's economy, populace, and natural resources are vulnerable to a number of adverse consequences that result from increased climate change and variability. The state can initiate new actions to address climate change while working to better understand the complexities of climate science. Responses to climate change can strengthen the economy and allow California to maintain a leadership role in worldwide efforts to address the challenges presented by global warming. The specific topics that will be discussed in this section include:

- What is the greenhouse effect?
- Evidence of climate change and vulnerability
- Actions taken to address climate change
- Trends in emissions of greenhouse gases
- Strategies to reduce greenhouse gas emissions and adapt to future changes
- Strengthening the state's response to climate change

SIGNS OF A CHANGING CLIMATE:

- Earlier melting of the Sierra snowpack
- Continued and accelerated rise in sea level
- More frequent and longer wet or dry periods
- Increased number and spread of invasive species

EXAMPLES OF ADVERSE CONSEQUENCES:

- Reduced summer water supplies and increased agricultural water demand
- Rising demand for and spending on energy
- More frequent and intense wildfires
- Loss of low-lying wetlands and increased cost to protect beaches and coastal infrastructure

The signs of a significant global warming trend are increasingly evident, more visible at the high latitudes of the Earth's poles but detectible as well in the mid-latitudes and at the equator. Several regions are experiencing earlier onset of spring and less severe winters. Modern technologies allow the collection, storage, and processing of vast amounts of observational data related to the physical, chemical, biological and social systems of our planet. So what does this large increase in scientific data collection tell us about our atmosphere, oceans, landscapes and most importantly climate that we live in and come to expect each day?

Much of what these observations tell us is that the Earth's systems are complex and interrelated, from periodic oscillations of ocean currents to the role of airborne particles in cloud formation. A great deal of uncertainty remains when it comes to predicting long-term changes in small-scale regional climates. Also difficult to fully understand is the potential for abrupt non-linear changes in climate systems. The U. S. Environmental Protection Agency (U. S. EPA) says:

> "[L]ike many pioneer fields of research, the current state of global warming science can't always provide definitive answers to our questions. There is certainty that human activities are rapidly adding greenhouse gases to the atmosphere, and that these gases tend to warm our planet. This is the basis for concern about global warming. The fundamental scientific uncertainties are these: How much more warming will occur? How fast will this warming occur? And what are the potential adverse and beneficial effects? These uncertainties will be with us for some time, perhaps decades."[1]

Scientific uncertainty about the degree of human influence and the finer workings of these systems should not be a call for inaction outside of research, but rather a call for a diverse set of actions that match the magnitude of the stakes associated with a significant trend in rising global average annual temperatures.

WHAT IS THE GREENHOUSE EFFECT?

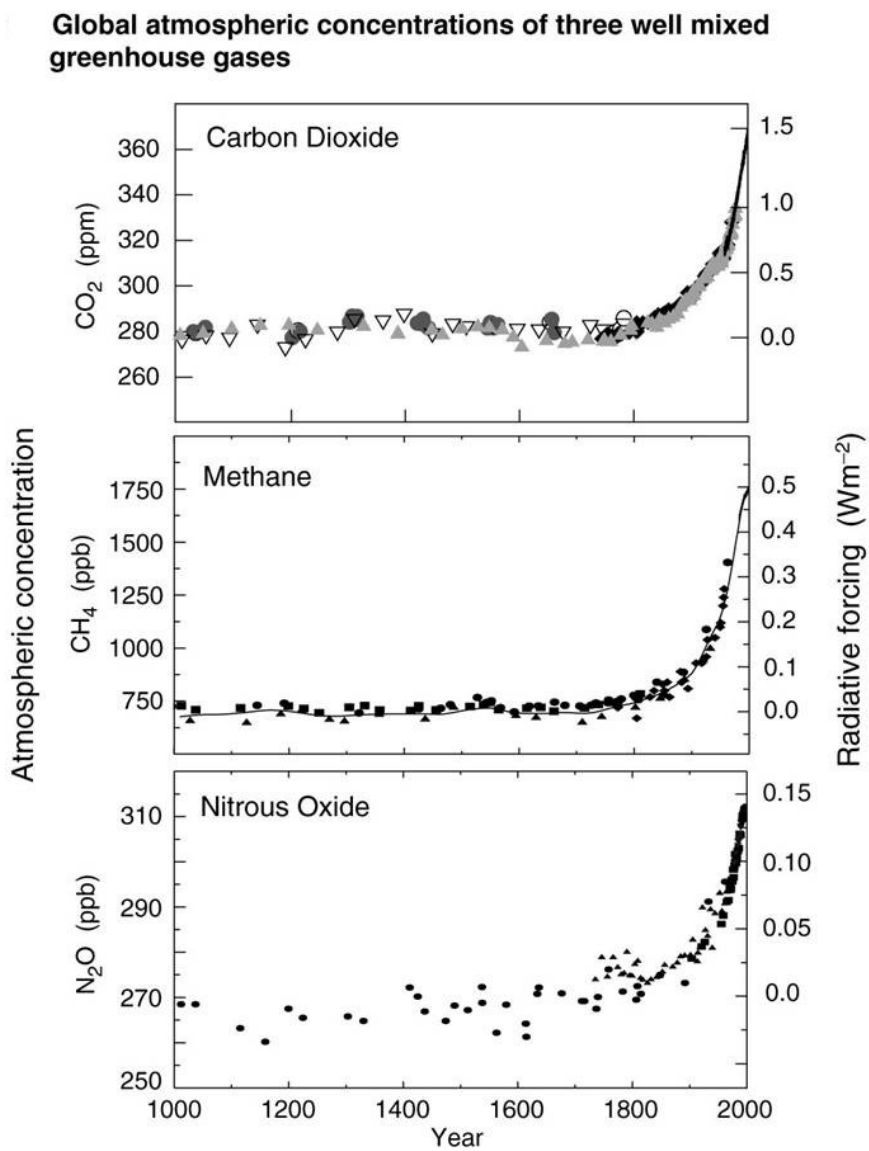
One topic universally agreed upon by atmospheric scientists is the existence of a layer of gases surrounding the Earth that have the ability to trap heat. This phenomenon has been labeled the "greenhouse effect." These greenhouse gases have accumulated for millions of years and are essential to maintain temperatures on Earth that are suitable for humans and other living organisms. There are many types of greenhouse gases, the most common being water vapor followed by gases such as carbon dioxide (CO_2), methane, troposheric ozone, halocarbons (manmade compounds) and nitrous oxide. Certain greenhouse gases such as CO_2 and methane have both natural and human-induced sources of emissions to the atmosphere. Other gases like the refrigerants in most motor vehicle air conditioners have only human-caused sources that contribute to the greenhouse effect. The term "radiative forcing" is used to describe a change in the balance between incoming solar radiation and outgoing infrared radiation. The addition of greenhouse gases to the atmosphere traps a higher percentage of the outgoing infrared radiation, with some of the trapped radiation coming back toward the Earth's surface and creating the warming effect.

RISING LEVELS OF CARBON DIOXIDE AND OTHER GREENHOUSE GASES

The rapid increase of CO_2 levels in the atmosphere has been well documented over the last four decades and is generally not disputed. Controversies arise when scientists attempt to predict the rate at which this effect will increase global average temperatures and the relative

importance of anthropogenic (human) sources of greenhouse gases. Scientists have established a parallel relationship between increased CO_2 concentrations and changes in atmospheric temperature based upon several sources of information related to historical climates. After remaining relatively constant from 1000 to 1700, **Figure 1-1** shows CO_2 and two other prominent greenhouse gas concentrations began to rise sharply and have increased 30 percent since pre-industrial times. [2]

Figure 1-1
Rising Concentrations of Greenhouse Gases



Rapid rise in concentrations of carbon dioxide, methane, and nitrous oxide is evident over the last one hundred and fifty years.

The primary source of human contribution to atmospheric concentrations of greenhouse gases comes from the use of fossil fuel energy, to light our cities, power our factories, supply our industries, and fuel our transportation. The burning of gasoline, diesel, natural gas, and coal releases CO_2 as a byproduct of the combustion process. Another important source of greenhouse gas emissions is change in land uses and the removal of vegetation that had served as a reservoir of stored carbon. These rapid increases in greenhouse gases coincide with the onset of the industrial era.

The U. S. Department of State produced in May of 2002 the third national communication under the United Nations Framework Convention on Climate Change (UNFCCC).[3] This report identifies an important finding of a distinguished committee of the National Research Council that concluded: "[h]uman-induced warming and associated sea level rises are expected to continue through the 21st century."[4] Recognizing the need to address California's largest contributing source to rising levels of greenhouse gases in the atmosphere, Governor Gray Davis signed landmark legislation in July of 2002 drafted by Assemblymember Fran Pavley (Assembly Bill 1493, Chapter 200, Statutes of 2002) and stated in his signing message:

> "This legislation is based four-square on sound science. The vast majority of scientists has concluded unequivocally that, if we don't reduce the emission of greenhouse gases, we'll disrupt our climate, foul the air and put our children and grandchildren at risk. Global warming is no longer a theory. It's an urgent reality. In time, every state – and, hopefully, every country – will act to protect future generations from the threat of global warming."[5]

The following chapter discusses evidence of a changing climate in California and provides examples of why the state is particularly at risk to various adverse consequences of an increasingly warmer and more variable climate.

CHAPTER 2: EVIDENCE OF CLIMATE CHANGE AND VULNERABILITY

The climate of a particular region can change gradually along a particular path or trajectory. For example, night-time temperatures can slowly warm on average or the total amount of annual rainfall can steadily increase or decrease. Separate from these types of gradual changes in a region's climate is the potential for increased variability of the climate. Examples of increased climate variability include longer drought or wet periods and increases in the frequency of extreme storm events. California has evidenced both a changing climate and increased variability of climate, particularly related to its water resources.

Put simply, California is vulnerable to potential adverse consequences of a warmer and more variable climate. The California Regional Assessment released in June 2002 provides a discussion of the susceptibility, vulnerability, and adaptability of the state's natural, economic, and social systems to potential future scenarios of climate change.[6] This interdisciplinary team of authors state very clearly: "The climate is changing. Climate change and variability pose significant potential challenges to California's businesses, communities, and natural resource and ecological systems."[7]

Currently, the most comprehensive source of information on global climate change is the Intergovernmental Panel on Climate Change's (IPCC) Third Assessment Report.[8] Based upon increasingly larger amounts of observational data and extensive modeling work, this report highlights expected changes that will be experienced by the next four generations: average global temperature rise between 2° F and 10° F, longer duration dry and wet periods, decrease in area covered by ice and snow, and sea level rise between 0.3 foot and 3.0 feet.

CALIFORNIA'S WATER SYSTEMS FACE CHALLENGES

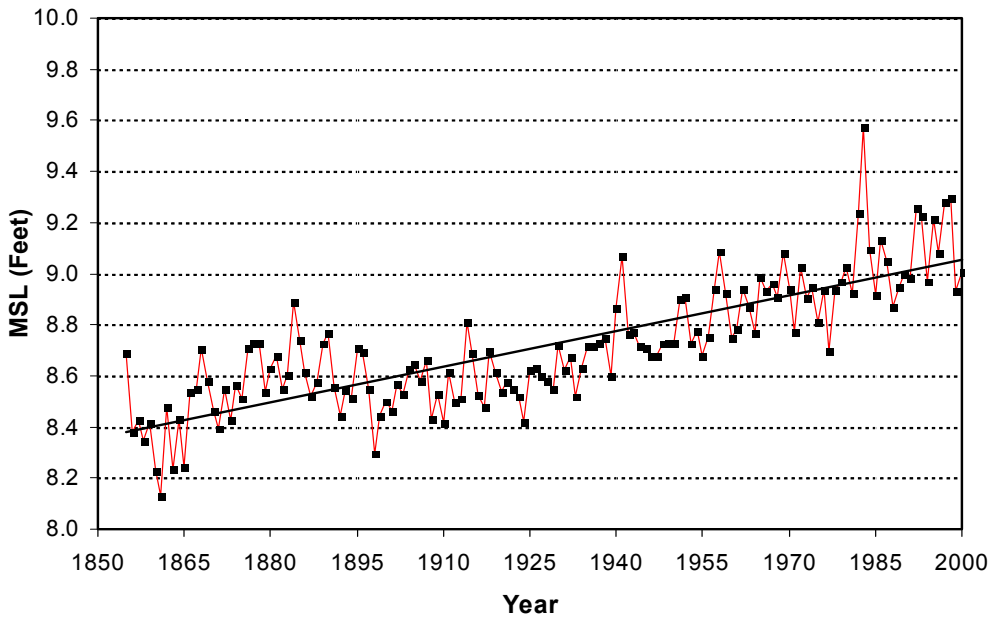
The California Department of Water Resources (DWR) recognizes that climate change and variability can have important consequences for the state's water resource systems. Warmer temperatures combined with increased variation in the timing and quantity of precipitation can significantly influence, for example, snowpack in the Sierra Nevada Mountains, water runoff patterns, water supply and demand, water temperatures, hydroelectric power production, wildfires, and soil moisture and groundwater levels. Scientists face significant challenges when it comes to documenting increased climate variability and predicting changes in the frequency of extreme weather events. Record breaking events like the 1996-97 storm patterns in California highlighted the state's vulnerability to climate variability and the need to prepare for the possibility of increases in frequency of extreme weather events.

The climate factor of most significance to California's water systems is the timing and quantity of precipitation. Currently, there is significant agreement amongst scientists that average annual temperatures will rise in California. There is somewhat less agreement on

expected changes in future precipitation patterns. The Scripps Institution of Oceanography is partnering with DWR and the Public Interest Energy Research (PIER) Program of the California Energy Commission (Energy Commssion) to improve data collection and regional climate modeling in an effort to reduce the uncertainty surrounding predictions of how precipitation patterns may change in California.

DWR has information documenting sea levels that dates back to the mid-1800s measured at San Francisco Bay. The trend shown in **Figure 2-2** shows that sea level rise is less about increased variability (i.e., yearly peaks and troughs) and more about a gradual rise due to thermal expansion and additional contributions of freshwater.[9] The approximately seven inch rise in sea level is expected to continue, possibly at a faster rate. When combined with possible increases in extreme storm events that include runoff surges, some of which will occur during high tides, the data suggests that California's bays, deltas, and low-lying coastal areas are vulnerable to increased flooding events.

Figure 2-2
Sea Level Rises Seven Inches Since 1855



San Francisco Yearly Mean Sea Level (MSL) 1855-2000

Water that flows from Sierra Nevada Mountain watersheds is increasingly coming earlier in the calendar year. DWR has information that dates back to the early 1900's regarding both the timing and volume of water flows within watersheds of the Sierra Nevada Mountains. The data shows that April through July flow volumes have steadily declined while January through March flows have increased over this period. DWR estimates these watersheds annually supply a total of 14 million acre-feet of freshwater on average or nearly 40 percent

of California's net demand for agricultural and municipal uses. **Table 2-1** identifies the types of impacts expected to result from warmer temperatures and reduced snowpack in the Sierra Nevada Mountains. DWR is evaluating these risks and considering adaptive measures as part of the state's planning process related to water resources.[10]

Table 2-1
Vulnerability of California's Water Systems to Climate Change

Warmer average temperatures can result in:	• Snow levels moving to higher elevations, reduced spring snowmelt and earlier seasonal runoff • Higher winter runoff flows that cannot be stored due to the state's need to manage flood risk • Rising sea levels that combine with more severe storms to damage levees in the Sacramento-San Joaquin Delta and increase saltwater intrusion
Reduced snowpack in Sierra Mountains can lead to:	• Reduced annual hydroelectric power production • Lower total yearly freshwater yields • Lower summer reservoir water levels

If California's water resource systems face challenges from climate change and variability, so too will the state's agricultural sector. While agricultural production is potentially vulnerable to climate change risks associated with adverse water system impacts, this sector faces other risks that come with increasingly unpredictable variations in both temperature and precipitation. For example, increases in the frequency of extreme weather at inopportune times can cause significant declines in agricultural productivity.[11]

SENSITIVITY AND VULNERABILITY OF CALIFORNIA'S ECOSYSTEMS

California has many "micro-climates" within its borders and a large number of plants and animals uniquely adapted to these climatic conditions. Highlighted by the state's large number of threatened or endangered species, these resources are exceptionally vulnerable to the effects of climate change and variability. While more difficult to model or predict smaller-scale regional climatic changes, it is clear that even gradual changes can impose added stress to the state's unique climate regimes, such as the kelp forests along the central coast of California.

Many areas of California are currently under siege by invasive non-native species and the vulnerability of these ecosystems to foreign invaders can only increase with the additional

stresses caused by climate change.[12] Current and future increases in climate change and variability pose short-term and even greater long-term risks to biological diversity that exists within the varied ecosystems inside California's borders.

CLIMATE CHANGE AND PUBLIC HEALTH CONCERNS

Climate change and variability can adversely affect human health, in both direct and indirect ways. While an assessment focused at the national level, many of the health outcomes described in ***The Potential Health Impacts of Climate Variability and Change for the United States*** are broadly applicable to California.[13] This report identifies five areas of health concern. Increases in average temperatures and more frequent and intense heat waves can cause a greater number of heat-related illnesses and deaths. Thousands of people died as a result of an August 2003 extended heat wave in France. Many that lost their lives prematurely were elderly people with no air conditioning and living alone. This calamity shows how vulnerable an industrialized country can be to health risks associated with extreme climatic events.[14]

More frequent and extreme weather events will increase physical dangers to people living in the affected areas. Rising temperatures and prolonged heat waves result in people using more electricity in the summer months, likely increasing fuel consumption and air pollution from power generation. Changing weather patterns and storm events can also affect water quality and increase the risks of a variety of water-borne diseases. Finally, changing climate patterns can lead to more favorable conditions for elevated cases of certain diseases such as Valley Fever, West Nile Virus, and Hantavirus. California's health care systems and capability for early detection help to reduce the risks associated with health-related consequences of climate change and variability.[15]

CHAPTER 3: ACTIONS TAKEN TO ADDRESS CLIMATE CHANGE

Many of the risks and impacts from climate change will be imposed upon the next generation of Californians. These risks are partly a function of choices made by previous generations, but increasingly will be the result of actions of decision makers today and tomorrow. The potential for climate change to diminish the natural resource endowment of future generations is significant and therefore a concern of the people and institutions of California and cause for appropriate action.

Climate change is at once a global and a local issue, reflected in actions by all levels of government and private organizations. Businesses are taking leadership positions and voluntarily cutting their greenhouse gas emissions. Local and state governments are responding with specific measures to cut emissions within their jurisdictions. The U. S. government has set a goal of reducing "greenhouse gas intensity"[16] by 18 percent over the next decade, potentially achievable by cutting emissions and increasing economic productivity.[17] Partnerships of public and private organizations like the Prototype Carbon Fund and the Global Environmental Facility are helping to make climate-friendly energy projects a greater reality in developing countries.[18]

Initial activities at the international level were solidified in 1992 with crafting of the UNFCCC. This agreement established broad voluntary targets for greenhouse gas emission reductions to be achieved by the year 2000. This convention was followed by more specific reduction commitments for industrialized countries in the Kyoto Protocol, negotiated in 1997 in Japan. This protocol had 39 countries commit to specific greenhouse gas emission reduction targets based upon 1990 emission levels, to be achieved as an average over the 2008-2012 commitment period. As examples, Canada agreed to a six percent reduction below 1990 emission levels, the U. S. a seven percent reduction, and the European Community an eight percent reduction. In early 2001, the U. S. withdrew from the process to ratify the Kyoto Protocol citing concerns related to impacts to the U. S. economy and lack of commitments from developing countries.

CALIFORNIA'S RESPONSE TO CLIMATE CHANGE

The California Legislature was one of the first state efforts to address concerns about climate change, when it passed a bill authored by Assemblyman Byron Sher in 1988. This legislation directed the Energy Commission to assess the likelihood of adverse consequences to the state and recommend strategies to mitigate those impacts. The Energy Commission prepared the first statewide inventory of greenhouse gas emissions as a staff report in 1990.[19] The first report to recommend climate change strategies was prepared in 1991 by the Energy Commission[20] and both the greenhouse gas inventory and strategies were updated in a

January 1998 report.[21] Two workshops were held in 1999, one to review actions taken by business leaders and the other to clarify the status of climate science.

Legislation authored by Senator Byron Sher in 2000 led to the creation of the California Climate Action Registry (CCAR), a non-profit organization with the primary function of promoting voluntary annual reporting of greenhouse gas emissions by California entities.[22] This legislation also directed the Energy Commission to update and maintain the statewide greenhouse gas emissions inventory, as well as identify and communicate mitigation strategies, technologies, and approaches that efficiently and equitably address climate change in California.

CCAR was launched in the September of 2002 and currently 35 participants from business, industry, government, and other types of organizations have volunteered to inventory and report their emissions. The State of California agrees to provide appropriate consideration of these certified emissions results in the future, when possible regulatory regimes may be implemented to reduce greenhouse gas emissions at the international, national, or state level. CCAR is working with its members to promote and document measures that reduce the participant's direct and indirect generation of greenhouse gas emissions.

Three bills were signed into law by Governor Davis in 2002 that will help California significantly reduce its contribution of greenhouse gases to the atmosphere. Assemblymember Fran Pavley authored Assembly Bill 1493 (Chapter 200, Statutes of 2002) which directs the California Air Resources Board (CARB) to adopt regulations "that achieve the maximum feasible and cost-effective reduction of greenhouse gas emissions from motor vehicles," providing a direct response to the state's largest source of greenhouse gas emissions.[23] Senator Byron Sher authored two important bills signed into law in 2002 that will lead to greenhouse gas reductions. He drafted the renewables portfolio standard legislation that will achieve greenhouse gas reductions by increasing the state's reliance upon non-fossil fuel energy for production of electricity (Senate Bill 1078, Chapter 516, Statutes of 2002). His other piece of legislation calls upon CCAR to develop protocols that account for additional carbon stored in California's forests and landscapes, fostering management activities that reduce greenhouse gas emissions (Senate Bill 812, Chapter 423, Statutes of 2002).

Several state agencies are actively working to reduce greenhouse gas emissions. CARB is currently developing regulations to achieve greenhouse gas emission reductions from motor vehicles starting with the 2009 model year. The Department of General Services supports emissions reductions through efforts such as the "Driving Green Task Force." The Integrated Waste Management Board mitigates emissions through actions contained in the "Sustainable Building Implementation Plan." The departments of Water Resources, Forestry and Fire Protection, Food and Agriculture, and Transportation all have activities underway to help California mitigate its greenhouse gas emissions and better prepare for the expected outcomes of current and future changes in climate.

The California Department of Transportation has a Director's Policy titled "Energy Efficiency and Conservation Policy."[24] This policy calls for the incorporation of efficiency and conservation measures into transportation plans to minimize the use of fuel and other

energy resources. The Director's Policy also promotes environmental stewardship, sustainable transportation, reductions in greenhouse gas emissions, and educational programs.

California's Energy Commission, Public Utilities Commission, and California Power Authority have agreed to support cost-effective and environmentally sound energy strategies that will protect the public's health and safety, ensure quality of life, and take into account considerations of global climate change.[25] The state's *Energy Action Plan* also recognizes that decreases in per capita electricity use, through energy conservation and efficiency, helps to minimize the need for new generation, reduces criteria and toxic air pollutants, and lowers California's emissions of greenhouse gases.

The Energy Commission has several program activities linked to climate change including: energy efficiency, renewable energy, research and development, education and outreach, and interagency coordination on climate-related policies. The PIER Program has created a virtual research center, the California Climate Change Research Center (CCCRC), to implement prioritized research projects. CCCRC will enhance on-going national and international research efforts regarding climate change to produce policy-relevant California-specific studies. Currently, CCCRC has three components which are located at Scripps Institution of Oceanography, University of California at Berkeley, and the University of California's Office of the President (UCOP). Scripps concentrates on scientific research related to climate variability and change. The Berkeley campus research focuses on economic and social aspects of climate change. The UCOP manages a competitive grant program related to climate change. The PIER Program intends to form a fourth component of CCCRC to research carbon sequestration in both terrestrial ecosystems and geological formations.

In August 2003, the U. S. Department of Energy selected the West Coast Regional Carbon Sequestration Partnership as one of seven regional groups to evaluate a range of carbon sequestration options. California and neighboring states will examine opportunities to capture and store CO_2, including issues related to transport, permitting, monitoring, verification, and public outreach. This regional partnership approach is a cooperative effort between federal, state, and private organizations and described as "the centerpiece" of federal efforts to understand the potential of carbon sequestration to help mitigate greenhouse gas emissions.

OTHERS ARE RESPONDING TO CLIMATE CHANGE

The mounting international effort to ratify the Kyoto Protocol has spurred political activity in the European Union (EU). Efforts within most member countries related to energy or environmental taxation are being combined with an EU-wide initiative to establish a greenhouse gas emission cap and emission trading system for large emitting industries. This "cap-and-trade" system is slated to begin in 2005. In a cap-and-trade system, a set quantity of emissions permits are allocated to emitters of greenhouse gases and then entities are allowed to buy and sell their permits to cover their actual emissions. Those entities with lower costs

of cutting emissions can reduce more than required and sell excess permits to those facing higher costs to reduce.

The United Kingdom has a carbon levy or fee on energy use applied to the business and public sectors as an incentive to reduce emissions. Businesses can choose to participate in an emissions trading system and earn an 80% rebate of the carbon levy. Denmark instituted a mandatory cap-and-trade system for the electricity sector in 2001. Japan and Norway have plans to implement greenhouse gas emission trading systems within the next few years. Both Denmark and Sweden have introduced energy taxes in efforts to lower energy demand and reduce greenhouse gas emissions. The Netherlands has a CO_2 tax on fuel inputs for electricity generation and has established programs to acquire emission reduction credits through the flexibility mechanisms of the Kyoto Protocol. Countries like Belgium, France, Ireland, and Norway are planning to introduce taxes on energy, carbon emissions, or fossil fuel consumption, all aimed at reducing the levels of greenhouse gas emissions.

Several U. S. states have set specific goals for reducing greenhouse gas emissions. New Jersey established a target of 3.5 percent below 1990 levels by 2005. Maine recently set a target of 10 percent below 1990 emissions by 2020. Six New England states and five Canadian provinces have together established a regional target of 10 percent below 1990 levels by the year 2020. **Table 3-1** shows the greenhouse gas emission reduction targets set by various states. The states of Oregon, New Hampshire, and Massachusetts have issued regulations pertaining to greenhouse gas emissions from their electricity sectors. Several states have work underway to establish greenhouse gas emission registries, all of which intend to coordinate with CCAR.

A number of states including California, Connecticut, Hawaii, Maine, Massachusetts, Nevada, and New York have established renewable portfolio standards that set minimum levels of electricity to be generated from renewable resources.

Table 3-1
State Commitments to Reduce Their Greenhouse Gas Emissions

Maine	10% below 1990 levels by 2020
New York	5% below 1990 levels by 2010 and 10% below 1990 levels by 2020
New Jersey	3.5% below 1990 levels by 2005
Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont in cooperation with five Canadian Provinces	10% below 1990 by 2020

Local governments are also making commitments to reduce their greenhouse gas emissions. Currently, 139 cities across the U. S. have joined an International Council for Local Environmental Initiatives (ICLEI) campaign called Cities for Climate Protection.[26] Several of California's largest cities are members of this campaign. Some of these cities have also agreed to inventory their greenhouse gas emissions each year as a participant in CCAR. **Table 3-2** highlights some of the commitments made by California local governments to address climate change by cutting their greenhouse gas emissions.

Table 3-2
Cities Commit to Cutting Greenhouse Gas Emissions

Chula Vista	20% below 1990 levels by 2010
San Francisco	20% below 1990 levels by 2012
Oakland	15% below 1990 levels by 2010
Berkeley	15% below 1990 levels by 2010
San Jose	10% below 1990 levels by 2010
Los Angeles	30% below 1990 levels by 2010 (for municipal operations)

CORPORATIONS ARE SHOWING LEADERSHIP

Climate change is both a local and global issue. While impacts are and will be felt locally, the solutions must come from global cooperative efforts. Much of the industrialized international community has committed to some absolute level of greenhouse gas emissions reduction, a sign of their concern over climate change. California businesses with linkages to international commerce are becoming increasingly aware of concerns about climate change, responsibility to reduce emissions, and related economic opportunities abroad. A variety of U. S. firms are taking action to reduce their greenhouse gas emissions and promote the development and use of low-carbon emitting technologies abroad. For more information on this topic, see the international energy market section of the ***Public Interest Energy Strategies Report***.

Business sector climate initiatives can range from companies making a reduction commitment and publicizing their achievements to participation in organizations such as CCAR or the Chicago Climate Exchange, a pilot program for greenhouse gas emissions trading. Corporations such as DuPont, IBM, and Alcoa have all committed to significant greenhouse gas reductions and many of these companies are having their emission levels certified by an independent organization. Often companies find that cutting greenhouse gas emissions through energy efficiency measures turn what was perceived as a cost into a profit through reduced expenditures on energy and higher worker productivity. Initiatives such as

the U. S. EPA's Climate Leaders and the World Business Council for Sustainable Development's Energy and Climate Project work with businesses to address climate change and promote market-based solutions.[27]

Stockholder groups of large public corporations are beginning to ask for evidence that the company is thinking about its greenhouse gas emissions and developing plans to reduce this potentially important environmental liability in the future. The insurance industry is thinking about climate change, both from the damages side of extreme weather events to the corporate officer liability side of responsible management practices. **Table 3-3** presents a list of diverse types of corporations that have committed to reducing their output of greenhouse gas emissions.

Table 3-3
Corporations Commit to Greenhouse Gas Reductions

Alcoa	25-50% reduction below 1990 by 2010
American Electric Power (AEP)	4% below 2000 by 2006
British Petroleum	10% below 1990 by 2012
DuPont	65% below 1990 by 2010
Ford Motor	4% below 1998-2001 average by 2006
General Motors	10% below 2000 by 2005
International Business Machines (IBM)	63% below 1990 by 2005
International Paper	4% below 2000 for U. S. emissions by 2006
Johnson & Johnson	7% below 1990 by 2010
Royal Dutch Shell	5% below 1990 by 2010
Toyota	5% below 1990 by 2005

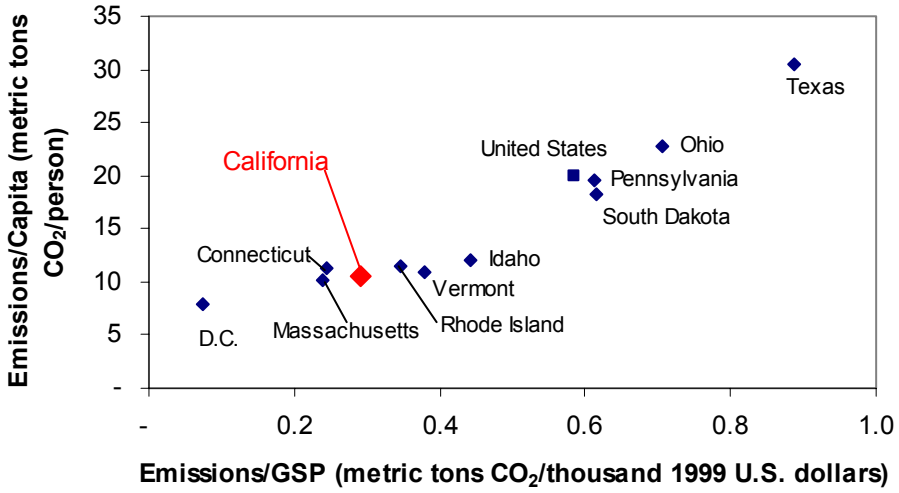
In addition to state and local governments, approximately 25 organizations with operations in California have taken a leadership role in estimating and reporting their greenhouse gas emissions. They have voluntarily joined CCAR and now have the ability to accurately record the progress made in reducing their emissions of greenhouse gases to the atmosphere.

CHAPTER 4: TRENDS IN EMISSIONS OF GREENHOUSE GASES

Emissions of greenhouse gases are predominantly linked with fossil energy use. California's interest in emission trends dates back at least to 1957 when a scientist named Roger Revelle highlighted the fact that humans were taking carbon out of long-term storage as coal, oil and natural gas, and returning it to the atmosphere and oceans at an increasingly rapid pace. California emits a large amount of greenhouse gases to the atmosphere every year, second only to Texas in annual emissions within the fifty states. Taking into consideration the size of the state's population, economy, and geography, comparisons can be made along the lines of efficiency by looking at emissions per capita and per dollar of gross state product. When taking into account the population and economic size of the state, Californians emit significantly lower levels of greenhouse gases than the average citizen of the United States.

California emits a variety of greenhouse gases to the atmosphere. In 1999, CO_2 accounted for 84 percent of the state's greenhouse gas emissions. Methane accounted for 8 percent, nitrous oxide 6 percent, and various synthetic gases such as refrigerants reached 2 percent of total emissions. Shown in **Figure 4-1** is a comparison of statewide CO_2 emissions on a per person basis vertically and based upon size of the economy horizontally.[28] Recognizing that many greenhouse gas compounds have a long lifespan in the atmosphere, it is important to monitor trends in total emissions by type of greenhouse gas, as well as monitor trends in emissions relative to factors such as population size and level of economic activity.

Figure 4-1
1999 CO_2 Emissions Based on Size of Population and Economy

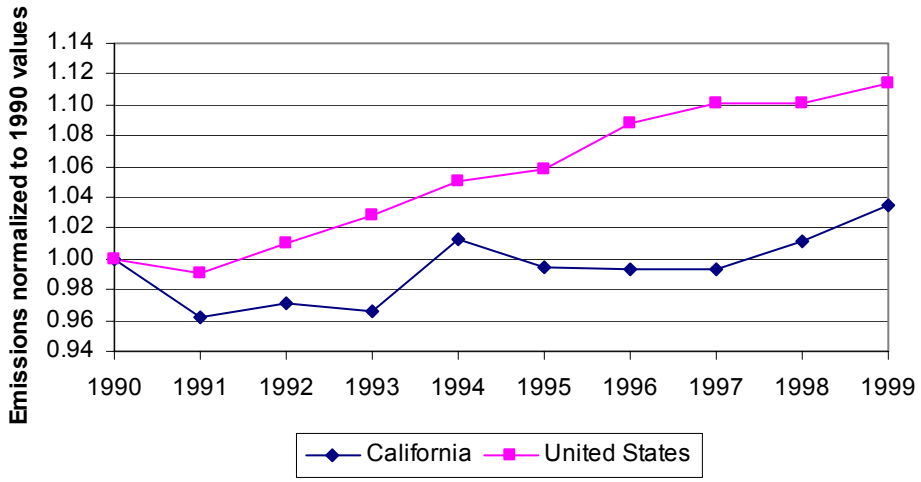


Few states emit less greenhouse gases than California on a per person or a gross state product (GSP) basis.

Total emissions of greenhouse gases in California rose slightly over the decade of the 1990s. The state's programs to promote air quality, numerous forms of energy efficiency, renewable sources of energy, and clean energy technologies all contributed to slower growth in greenhouse gas emissions relative to the rest of the country. Changes in the economy towards less energy intensive industries and activities also contributed to a slowed growth in emissions over this period.

The graphs in **Figure 4-2** compare growth in gross annual greenhouse gas emissions (does not include net changes of carbon stored as vegetation) for the U. S. and California with 1990 as the base year.[29] Emissions for the U. S. rose almost 12 percent over the decade, while gross emissions within California rose by less than 4 percent over the same period. A number of factors contributed to California's slower rise in greenhouse gas emissions including: growth of less energy intensive industries, stable per capita electricity consumption, energy efficiency and air quality policies, additional co-generation and renewable energy, and a slight increase of imported electricity.

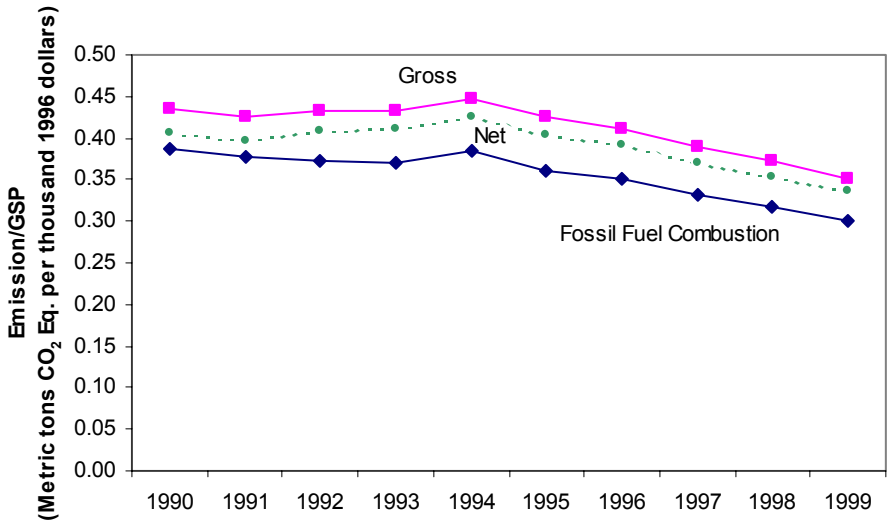
Figure 4-2
Percent Change in Gross Greenhouse Gas Emissions: 1990-1999



Percentage growth in total United States greenhouse gas emissions was significantly higher between 1990 and 1999 than the growth of emissions in California.

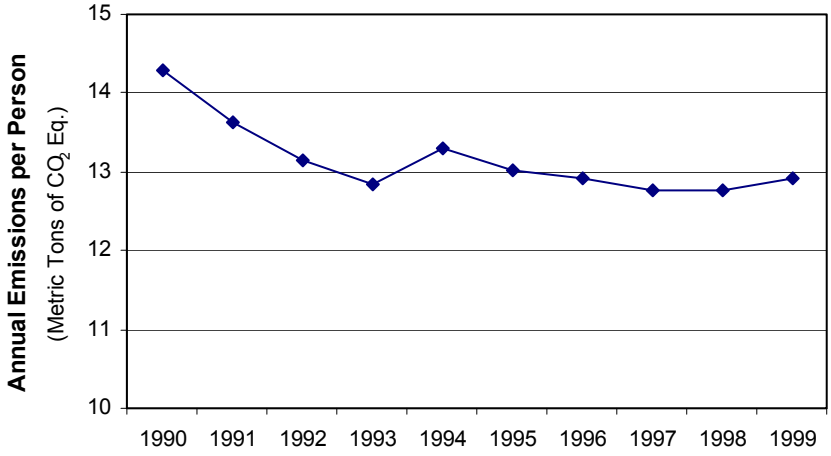
The trends in greenhouse gas emissions based upon changes in the size of California's economy and population are shown in **Figures 4-3** and **4-4**, respectively.[30] The state's greenhouse gas emissions relative to economic output, one measure of greenhouse gas intensity, changed little during the first half of the decade and then declined in the latter half of the 1990s. California's growing economic output combined with the trend towards less energy-intensive industries helped bring about this decline in the state's greenhouse gas intensity. Annual emissions per person were lower in 1999 than levels at the beginning of the decade. The factors described above helped keep statewide greenhouse gas emissions from rising in proportion to increases in population over the decade of the 1990s.

Figure 4-3
California Emissions per Dollar of Gross State Product



Annual greenhouse gas emissions declined relative to changes in economic activity in California over the 1990s

Figure 4-4
California Greenhouse Gas Emissions Per Person

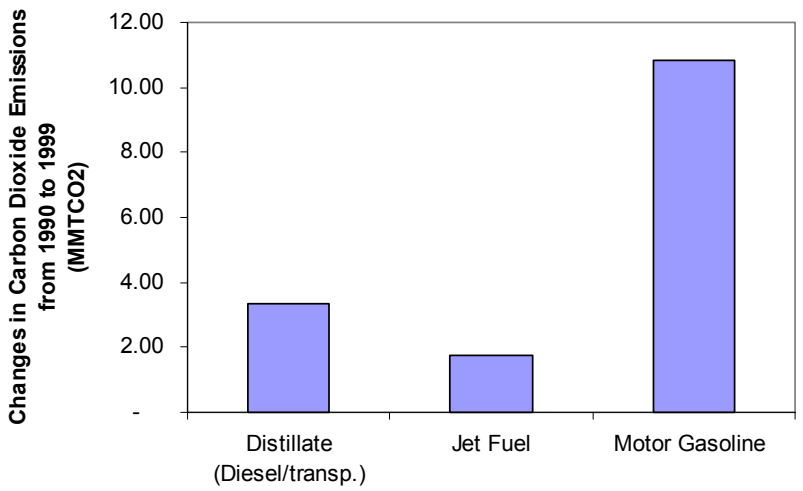


The graph shows that greenhouse gas emissions per person living in California generally declined throughout the 1990s

Californians did not fare nearly as well in the 1990's when it came to greenhouse gas emissions from the transportation sector. Over this ten year period the state's emissions of

CO_2 from motor fuels rose significantly, in large part a result of more vehicles spending more time each year on California's roads. The increase in CO_2 emissions from gasoline, distillate fuel, and jet fuel rose over the decade of the 1990s by 9.4 percent, 14.5 percent, and 4.5 percent respectively. **Figure 4-5** shows that CO_2 emissions from consumption of gasoline rose by approximately 11 million metric tons, a significant increase over ten years.[31]

Figure 4-5
Million Metric Ton Increases in Transportation CO_2 Emissions: 1990-1999



More cars, trucks, and planes traveling more miles resulted in higher greenhouse gas emissions from California's transportation sector between 1990 and 1999

California's CO_2 emissions from the combustion of fossil fuels in 1999, the most recent year totals have been calculated by the Energy Commission, was dominated by the transportation sector (58 percent). Electricity production (16 percent) and industrial emissions (13 percent) followed in distant second and third places, with residential (9 percent) and commercial (4 percent) emissions of CO_2 from fossil energy sources representing even smaller fractions of total statewide CO_2 emissions.

Methane (CH_4) emissions in 1999 accounted for only 8 percent of total statewide greenhouse gas emissions after being weighted by its greater warming potential in the atmosphere (expressed in CO_2 equivalent). Agriculture and landfill operations are sources of a large percentage of the state's methane emissions. Fertilizer use in agriculture also contributes a high proportion of the nitrous oxide (N_2O) emissions in California, another high global warming potential gas but only 6 percent of 1999 statewide greenhouse gas emissions. The fastest growing class of greenhouse gases is the synthetic or man-made halocarbon compounds, such as the hydroflorocarbons (HFCs) in motor vehicle air conditioning systems. At the end of 1999, these compounds totaled only 2 percent of statewide greenhouse gas emissions.

CHAPTER 5: STRATEGIES TO REDUCE GREENHOUSE GAS EMISSIONS AND ADAPT TO FUTURE CHANGES

Climate change mitigation and adaptation strategies can be grouped within three broad categories. The first category contains strategies in the transportation sector, the state's largest source of greenhouse gas emissions and a sector subject to a variety of adverse consequences from increased climate change and variability. The second category contains strategies linked to the electricity sector, including renewable energy and energy efficiency. The final category is used to highlight several strategies in other sectors of California's economy or where specific actions are expected to lead to a beneficial climate change outcome. Examples within this last category include adaptation strategies, carbon sequestration, utilization of emerging greenhouse gas reduction markets, research and development, and public education. While consumption of fossil energy is the state's primary source of emissions, a variety of opportunities to mitigate greenhouse gas emissions exist outside of energy production and use in California.

TRANSPORTATION SECTOR GREENHOUSE GAS REDUCTION STRATEGIES

California has a variety of programs aimed at reducing criteria air pollutants emitted in the transportation sector, many of which also reduce greenhouse gas emissions. Policies and programs to promote a cleaner and more efficient transportation system can be found at the CARB, the Energy Commission, the Department of Transportation, and the Department of General Services.

The state can build upon these programs to achieve greater reductions in greenhouse gas emissions. Decisions we make today that have an influence on land uses, number of miles people travel in motor vehicles, vehicle technologies, and other transportation-related policies will determine the measure of progress towards a cleaner and more sustainable transportation system. In addition to reducing greenhouse gas emissions, a more sustainable transportation system should: 1) provide for more efficient use of transportation resources, 2) reduce dependency on fossil fuels, 3) promote energy security, 4) improve mobility and travel options, and 5) provide more livable communities.

Reducing California's Dependence on Petroleum Fuels

As directed by legislation authored by Assemblyman Shelley (Chapter 936, Statutes of 2000), the Energy Commission and CARB have developed and adopted recommendations for the Governor and Legislature on a strategy to reduce petroleum consumption in California. The strategy includes: 1) a statewide goal to reduce the on-road demand for gasoline and diesel to a level that is 15 percent below 2003 consumption by the year 2020, 2) a recommendation for the federal government to adopt standards that would double the fuel economy of new passenger cars, light trucks, and sport utility vehicles, and 3) a goal to increase the use of non-petroleum fuels to 20 percent and 30 percent of on-road energy demand by 2020 and 2030, respectively.[32]

Development of these recommended goals is based upon an analysis of the net changes in costs and benefits expected to result from a variety of energy efficiency options and fuel substitution options (non-petroleum fuels). The analysis includes additional expenses for different technologies and fuels, the value of net changes in environmental impacts (includes avoided climate change damages), and certain avoided costs associated with petroleum dependency. These costs and benefits were combined for each option and the relative merits of options expressed in the form of net benefit values. This type of analysis allows for an overall petroleum reduction strategy that is created from a portfolio of petroleum reduction options, each with positive net benefits to Californians.

Armed with these analyses and recommendations to reduce petroleum consumption, the Legislature and Governor have a foundation for establishing specific policies consistent with the proposed recommendations. To guide and direct state institutions, the Legislature and Governor should enact legislation that codifies in statute these petroleum reduction goals. This action would then set in motion activities to implement the recommendations and support new work focused upon achievement of the goals.

Since a majority of the state's greenhouse gas emissions come from combustion of fossil fuels in the transportation sector, a reduction in the rate of consumption of gasoline and diesel will lead directly to decreases in greenhouse gas emissions. If the proposed petroleum reduction strategy is implemented, on-road energy demand could be reduced approximately 30 percent below the forecasted demand for 2020. The use of an average light-duty vehicle in this scenario would result in a greenhouse gas footprint that is about one-half the size of a current average gasoline vehicle. Beyond 2020, the demand for gasoline and diesel can be held constant through the use of non-petroleum fuels such as ethanol, hydrogen in fuel cells, natural gas fuels, and biodiesel fuels. Thus, the expected impact on greenhouse gas emissions of achieving the goals to reduce petroleum dependence would be significant.

Implementing the Motor Vehicle Greenhouse Gas Standards Legislation

The Governor's signing of Assembly Bill 1493 (Chapter 200, Statutes of 2002) put in motion a unique effort to mitigate California's largest source of greenhouse gases - motor vehicles. This landmark legislation can provide a significant amount of reductions in greenhouse gas emissions below a business-as-usual scenario without such vehicle greenhouse gas standards. These emission standards will apply to new vehicles starting with the 2009 model year. This particular regulatory approach to greenhouse gas mitigation will also draw upon market-based incentives through the granting of credits for early actions that cut greenhouse gas emissions from new motor vehicles prior to the operative date of the regulations.

Additional Transportation Climate Change Strategies

There is a need to explicitly address greenhouse gas emissions and energy efficiency in most statewide and regional transportation planning processes. Policies that provide resources and incentives can be designed to ensure that climate change issues are addressed in these plans. There are ways to continue to "green" the state and local government motor vehicle fleets and lead the way to a cleaner and more energy efficient transportation sector in California. A broad range of strategies can be utilized to slow the rate of increase in vehicle miles traveled. A focused transportation research program combined with greater efforts to educate the public about the linkages between transportation and climate change, can lead to reductions in greenhouse emissions from this largest and growing source. However, achieving significant greenhouse gas reductions in the transportation sector will require a relatively long period of time.

Specific measures the state should consider as part of a comprehensive strategy to reduce California's transportation sector greenhouse gas emissions include:

- Partnering with local governments, other states, and managers of large private fleets to reduce the purchase cost of commercially available hybrid-electric vehicles
- Actions that assist labeling and marketing of more fuel-efficient replacement tires for motor vehicles
- Expand the use of electrified stalls at truck stops to reduce emissions and fuel consumption from truck idling during rest stops
- Participate in the commercialization of cost-effective grid-connected hybrid-electric vehicles

California's transportation sector is a growing source of greenhouse gas emissions. Evaluation and implementation of the above mentioned measures and other transportation strategies will be an essential component of an effective plan to reduce greenhouse gas emissions within the state. Transportation strategies to mitigate greenhouse gas emissions will be explored further in future editions of the ***Integrated Energy Policy Report***.

ELECTRICITY SECTOR STRATEGIES TO ADDRESS CLIMATE CHANGE

Great progress has been made over several decades to improve energy efficiency and provide cleaner sources of electricity, both efforts that help reduce the state's greenhouse gas emissions. More remains to be done. Greenhouse gases associated with the production of electricity consumed in California is the state's second largest source behind transportation sector emissions. In other parts of the country emissions from electricity generation is much closer to levels emitted within their transportation sector, a fact reflective of both Californians propensity to drive and lack of in-state coal-fired power generation. Because a significant amount of electricity is imported from other states, Californians are indirectly responsible for electricity sector greenhouse gas emissions within the neighboring states that export electricity to California.

Californians have managed to keep their per capita consumption of electricity at a stable level, increasing annually one tenth of one percent on average in the 1990s. Residents consume less electricity on a per person basis than all other states. Based upon existing policies and programs, it is anticipated that per capita consumption of electricity will remain stable over the next decade.[33] By contrast, national consumption per person is expected to increase at a rate several times higher than in California. While electricity consumption on a per person basis may be low, power generation continues to be a large source of greenhouse gas emissions.

California has the first state-sponsored research program on climate change in the nation, funded by electricity ratepayers in the form of a public goods charge. The PIER Program brings new energy services and products to the marketplace and helps create statewide environmental and economic benefits including reduction of greenhouse gas emissions. Recognizing that power plants are a major contributor to greenhouse gas emissions, the PIER Program has funded a significant amount of research to assess the potential impacts of climate change in California, as well as the development of research plans to assist in the evaluation of greenhouse gas mitigation and adaptation strategies for the state.[34]

It is possible for electricity generators to capture and store CO_2, but the ability to do so remains costly for most power producers. The Energy Commission has recently partnered with the Department of Forestry and Fire Protection, the Department of Food and Agriculture, agencies from neighboring states, and private sector organizations to form the West Coast Regional Carbon Sequestration Partnership. The focus of this partnership will be regional opportunities to capture CO_2 from processes such as electricity generation, transport it, store it in geological or terrestrial reservoirs, monitor and verify the long-term storage, and conduct public outreach on the potential value of carbon sequestration alternatives to mitigate greenhouse gas emissions.

Energy Efficiency and Conservation Reduces Greenhouse Gas Emissions

Carbon dioxide is emitted when fossil fuels are burned in California's industrial, residential, commercial, and agricultural sectors, either directly or indirectly through consumption of electricity generated from fossil fuels. Greenhouse gas emissions resulting from electricity generation are the second largest source in California behind the transportation sector. Improved energy efficiency characterizes these sectors over the past decade. Annual CO_2 emissions from these combined sectors from 1990 to 1999 have remained relatively constant, even as the state's population and gross economic output rose 13 and 28 percent respectively. California's ability to reduce greenhouse gas emissions while maintaining economic growth will require intensified efforts to increase energy efficiency and conservation in these sectors. The state can look inward and start by requiring the use of sustainable energy and environmental designs in all of its buildings.

As detailed in Chapter 3 of the ***Public Interest Energy Strategies Report***, demand-side-management (DSM) continues to hold great potential for reducing energy use and the associated reductions in greenhouse gas emissions. DSM activities include increasing energy efficiency, conservation, as well as electricity demand or load management. Energy efficiency improvements can be discovered and acted upon in many ways. In all cases, efficiency improvements that reduce energy demand help cut greenhouse gas emissions to the extent that less fossil fuel is consumed in the overall supply of energy within California. Changes in behavior that lead to energy conservation both improves some type of efficiency (e.g., annual amount of energy to heat or cool a house), saves the end-user of energy some money, and reduces greenhouse gas emissions.

The shifting of electricity demand to off-peak periods through price signals or other measures can lead to important reductions in greenhouse gas emissions. These measures can lead to cuts in greenhouse gas emissions because of the potential to utilize more efficient power generation units than those currently serving peak load electricity demand. These measures can also lead to cuts in greenhouse gas emissions when conservation rather than load shifting results. California has made significant progress in recent years when it comes to reducing peak load demand for electricity.

Initiatives that increase energy efficiency in a cost-efficient manner help reduce energy expenditures in our economy, making businesses more competitive and allowing consumers to save money while living comfortably. Although efficiency programs and policies to reduce growth in demand for electricity and natural gas have resulted in significant consumer savings, research shows that additional cost-efficient savings remain to be achieved. California's *Energy Action Plan* calls for the appropriate use of price signals, improved building and appliance energy efficiencies, increased conservation programs and other incentives to reduce the demand for electricity. These types of efforts can guide California along a path towards greater competitiveness, an improved environment, and reduced emissions of greenhouse gases.

Renewable Sources of Energy

Renewable energy has the potential to be a cornerstone of policies that aim to reduce greenhouse gas emissions. Renewable sources of energy can replace traditional fossil fuels used for electricity generation, as well as reduce the state's reliance upon petroleum in the transportation sector. Examples of renewable energy include solar, geothermal, wind, biomass to energy, landfill gases, and hydroelectric facilities (California statute requires hydroelectric facilities to be 30 megawatts or smaller in size to qualify as renewable). By reducing the state's dependence on imported energy from other states or countries, increased reliance upon the state's renewable sources of energy helps reduce greenhouse gas emissions and helps protect the economy and citizenry from fossil energy price spikes. A comprehensive discussion of renewable energy in California can be found in Chapter 5 of the ***Public Interest Energy Strategies Report***.

Creating a more diverse supply of renewable energy sources increases the resiliency of the state's energy supply portfolio. In addition to potential displacement of greenhouse gas emissions from electricity generated with fossil fuels, renewable sources can often be deployed as small distributed units (e.g., photovoltaics on urban rooftops or small-scale wind turbines in rural locations) and thereby reduce transmission losses and demands on the transmission system. Certain renewable sources, such as biomass from forests to reduce fire risks or municipal waste bound for landfills, serve multiple societal goals besides helping reduce emissions of greenhouse gases. With the passage of the renewable portfolio standard legislation drafted by Senator Sher in 2002, California requires certain electricity retail sellers to obtain 20 percent of their power from renewable sources by the year 2017. The state's *Energy Action Plan* calls for a more ambitious timeline to achieve the goal of 20 percent generation from renewable resources by the year 2010.

The emphasis on renewable power is in large part due to the multiple types of benefits that result from expanded uses of renewable resources. Utilization of additional renewable resources for electricity generation can reduce California's reliance upon natural gas. Most forms of renewable energy also reduce public health risks and environmental impacts associated with emissions of nitrogen oxides, as well as particulate matter and sulfur dioxide from imported electricity generated from coal. Reaching the mandated target for renewable energy by 2017 could reduce CO_2 emissions by 38,000,000 tons from electricity generation within in the Western Electricity Coordinating Council between 2004 and 2013. The accelerated renewable energy goal is estimated to produce a more significant reduction of CO_2 at 62,000,000 tons. For some context, this latter amount is equivalent to the CO_2 emissions that result from the annual driving of more than 6 million automobiles in California.[35]

While California has aggressive policies and programs to promote use of renewable energy resources, there are additional measures the state can take to support increased utilization of renewable energy resources for electricity generation. California can partner with its neighboring states and countries to encourage the development and transmission of renewable sources of electricity generation. A regional partnership could make significant progress in developing an efficient renewable power tracking and certification program. In

collaboration with others or independently, California can increase it's effort to research, develop, and deploy renewable projects, and promote demand for renewable energy as an alternative to electricity generated from fossil fuels.

Regulatory frameworks at the federal, state, and local levels that encourage long-term financial commitments to the development of renewable resources and long-term contracts for electricity generated from renewable energy resources will be key factors. One example is the need to develop transmission infrastructure to support large-scale development of renewable projects. The state can increase demand for renewable energy by providing informational materials to raise consumer awareness of renewable energy and by supporting green pricing programs that are over and above the mandatory requirements of retail sellers to provide renewable energy.

Western states working together can encourage the development and transmission of additional electricity generated with renewable resources. These states should continue to make progress towards creation of an effective western regional renewable generation tracking and certification program. Western states should work to improve the operating efficiency of the Pacific Coast transmission system. Finally, agencies from western states should investigate the potential benefits of biomass-to-energy facilities to address the growing safety concerns associated with wildfires. These and other strategies to develop additional renewable energy resources will be evaluated further in the next ***Integrated Energy Policy Report***.

Mechanisms to Reduce Electricity Sector Greenhouse Gas Emissions

It is important to acknowledge that: 1) in-state electricity generation is relatively efficient on a greenhouse gas basis, 2) greenhouse gas emissions from electricity generation are less than emissions from the transportation sector, 3) California has aggressive renewable energy policies and programs in place that promote improved air quality and greenhouse gas emission reductions, and 4) the following discussion does not reflect advocacy for any particular mechanism. Recognizing the uncertainties associated with future federal or state policies to mitigate greenhouse gas emissions, it is important that individuals planning future long-term investments in power generation consider the financial risks associated with increasing an entity's level of direct or indirect emissions of greenhouse gases.

A variety of mechanisms are currently employed outside of California that lead to reduced greenhouse gas emissions associated with the production of electricity. A number of additional measures are being designed or tested and scheduled to begin in the near future. Mandatory reporting of greenhouse gas emissions is common for large emitters within the electricity sectors of many developed countries. The Energy Commission should consider required reporting of greenhouse gas emissions as part of its facility permitting process. The European Union will launch its greenhouse gas emissions trading program in 2005. Individual countries within Europe also use energy or carbon taxes to provide financial incentives to reduce greenhouse gas emissions within their electricity sectors. A voluntary project that includes power generators, the Chicago Climate Exchange, recently completed

its rulebook and first auction of greenhouse gas reductions in the launch of this pilot emissions trading program.

Several states including Massachusetts, Oregon and New Hampshire established generation efficiency benchmarks for CO_2 emissions from power plants. These benchmarks are typically based upon the best available technologies to reduce greenhouse gas emissions and can be updated as new technologies are developed and marketed. Oregon combines two mechanisms to reduce greenhouse gases from electricity generation, efficiency benchmarks and a requirement to offset a portion of greenhouse gas emissions from new sources of power generation. Offsets can be achieved by funding or implementing projects that reduce atmospheric concentrations of greenhouse gases.

In addition to efficiency benchmarks and required offset projects, a reduction mechanism receiving considerable attention is the "cap-and-trade" system. One connection between these mechanisms is the use of benchmarks as a key factor in determining feasible greenhouse gas emission caps. In a cap-and-trade system, a set quantity of emissions permits is allocated to emitters of greenhouse gases and then entities are allowed to buy and sell their permits to cover their actual emissions. Those entities with lower costs of cutting emissions can reduce more than required and sell excess permits to those facing higher costs to reduce. The states of New York, Connecticut, Vermont, New Hampshire, Delaware, Maine, New Jersey, Pennsylvania, Massachusetts, and Rhode Island have agreed to develop a regional cap-and-trade system for CO_2 emissions within their electricity generation sectors.

The 1990 Clean Air Act Amendments authorized various forms of emission trading systems. U. S. EPA concluded in 2001 that successful trading systems had been in operation for several years and that such systems can be applied to a wide variety of pollution sources. One example of a successful cap-and-trade system is the Acid Rain Program's marketable pollution allowance scheme with sulfur dioxide emissions from electric utilities in the northeast. This was initiated in 1995 and helped reduce annual emissions by 4 million tons and contributed to reduction of the acid content of rainfall by 25 percent.[36] In August of 2003 the U. S. EPA released documents that denied a request to regulate CO_2 emissions from motor vehicles under the Clean Air Act, citing a lack of authority to do so and reversing the position taken by the prior Clinton Administration.[37]

OTHER CLIMATE CHANGE STRATEGIES

As noted earlier, the number of ideas about how to address global warming or climate change is rapidly expanding. Proposals can vary from changing the diet of cows to reduce their emissions of methane, to harnessing the tidal energy of oceans to replace fossil fuel electricity generation. Provided in this next section are examples of activities that could help California reduce greenhouse gas emissions or mitigate the more deleterious affects of climate change. These and other climate change strategies will be evaluated and discussed in greater detail in future productions of the ***Integrated Energy Policy Report***.

Adaptation Measures to Lessen Impact of Future Changes

California needs to adapt to the expected effects of climate change. Without a comprehensive adaptation strategy, there will likely be significant short- and long-term economic and ecological losses resulting from climate changes within the state. Investments in adaptive measures can be appropriately scaled to the magnitude of the particular risk and the degree of certainty regarding the expected adverse climate outcome. Future damages resulting from climate change and variability can be reduced significantly by anticipation, observation, analysis, and planning.

The potential costs attributable to various adaptation strategies can range from little to no-cost measures on the low end and well into the billions of dollars on the high end. Examples of expensive adaptations might include significant enhancements to the state's levee system and reservoir construction to increase water storage. Some adaptive measures can generate net societal benefits regardless of mitigating climate change. Actions that increase California's ability to cope with the uncertainties of climate change can also help in dealing with existing threats to natural resource systems (e.g., frequency of droughts, fires, and floods). Implementation of appropriately designed adaptation strategies can provide greater security for the standard of living of citizens while minimizing the social, environmental, and economic disruptions likely to result from climate changes associated with past, current, and future levels of greenhouse gas emissions.

Improving the state's capacity to operate its complex water management system in the face of a more variable climate will be a key part of California's adaptation strategy to climate change. Agencies are currently investigating the implications of climate change and sea level rise for habitat restoration and levee enhancement programs. The state should produce a systematic review and evaluation of all major multi-purpose reservoirs for water supply and flood control in view of the potential effects of climate change on monthly reservoir inflows, particularly 100- and 200-year storm events. Development of more detailed hydrology and operational studies of the whole Central Valley system, including upstream reservoirs, will need to be developed for quantitative estimates of the effects of climate change.

Research efforts should concentrate on estimating the costs and benefits, as well as possible collateral effects of adaptation strategies. The state can significantly improve monitoring of hydrologic parameters, information that can document the degree and rate of change for planning purposes. Modeling and forecasting tools should be improved to better support future water management. Improvements should focus on water supply, precipitation, snow level and runoff changes, and potential impacts on the water infrastructure, as well as all beneficial uses of water in California.

The state should initiate and monitor changes in agricultural and forest management practices focused on changing the timing of planting, harvesting, and other management activities such as crop switching to reduce life-cycle greenhouse gas emissions while maintaining productivity. Efforts to improve the management of California's coastal zone should focus on preventing or minimizing development in coastal areas and incorporating adaptation options

into coastal zone management. Finally, research on the vulnerability of California's natural ecosystems to climate change and variability should be supported.

California has the potential to sequester or store additional amounts of carbon in its forests, agricultural soils, and geological formations. Carbon sequestration typically involves the capture and secure storage of greenhouse gases that would otherwise have been emitted to or remain in the atmosphere. California's farmers have the ability to store more carbon in their soils. Forest management practices can be used to consume more CO_2 and retain carbon stocks for longer periods of time. These types of activities often produce important co-benefits, such as improved soil and water quality, restoration of degraded ecosystems, increased crop productivity, and enhanced oil recovery. The West Coast Regional Carbon Sequestration Partnership has recently been formed and funded to identify new methods of storing additional carbon in terrestrial landscapes and geological formations within the region.

The Energy Commission in partnership with the Department of Forestry and Fire Protection and the Department of Food and Agriculture is working to improve methods of establishing an extensive inventory of carbon currently stored within California's landscapes. Techniques are being developed which improve the ability to quantify changes in amount of carbon stored and identify opportunities for additional carbon sequestration. This type of program should promote long-rotation silviculture on public and private forest lands and accelerate the afforestation of urban and abandoned agricultural areas. Other strategies might include aggressive reforestation of public and private lands historically burned by wildfire, and the inclusion of carbon sequestration potential as one criterion used to select acquisitions or conservation easements by government agencies. Finally, as directed by Senate Bill 812 (Chapter 423, Statutes of 2002) CCAR is developing protocols to accurately and cost-effectively measure, report, and certify sequestered carbon. These protocols could help pave the way to additional carbon sequestration as forest landowners anticipate their ability to market certified emission reductions.

Improve Ability to Predict California's Changing Climate

The ability to anticipate future changes in California's climate, model the consequences of those changes to the state's economy, environment, society and then design policies in light of expected outcomes before they occur is critical to successful adaptation. California will need an investment strategy for adaptation to climate change that evolves over time with the arrival of new information on potential risks. Choices must be made regarding the types, timing, and level of effort towards adaptive measures. Information to support these decisions requires an analytical capability that is based upon extensive observations, superior data management and quality control, and state-of-the-art modeling specific to California. Creating an improved ability to detect climatic changes is vital to predicting future changes. Western states should increase efforts to coordinate the collection and sharing of climatic data and other related information.

The Energy Commission recognizes the importance of building a robust analytical framework that allows decision-makers to test proposed climate change programs and policies for both technical efficacy and cost-effectiveness. The PIER Program has developed a series of climate change research roadmaps that include efforts to improve the state's ability to analyze various strategies to mitigate greenhouse gas emissions and implement adaptive measures to lessen the adverse consequences of expected changes in climate.[38]

A majority of the state's strategic planning efforts need to consider and incorporate, where appropriate, climate change as a part of planning for the future. The state's Transportation Plan and Water Plan now consider issues related to climate change and greenhouse gas emissions. Coordination across various state agencies is essential for the effective development and implementation of a comprehensive adaptation strategy to climate change. Broad participation by potentially affected agencies is needed to build the framework for a comprehensive approach to climate change risk assessments and design of adaptive strategies that minimize impacts to current and future generations of Californians.

Develop, Commercialize, and Export Clean Energy Technologies

For nearly twenty-five years, California has been a "proving ground" for new energy technology, advances in energy efficiency, and the use of renewable energy resources. California's energy policies, energy efficiency standards, economic incentives and research investments established the foundation for technology leadership and the practical installation of clean energy projects in the marketplace. As a result of California's clean energy accomplishments, the state enjoys direct economic and environmental benefits. Over this quarter century timeframe, a significant new energy industry has emerged. This industry is comprised of equipment manufacturers, project developers, engineering firms and energy consultants involved in wind power, geothermal, solar and biomass energy technology, energy efficiency projects, cogeneration and combined heat and power systems, as well as non-petroleum transportation fuels and technologies. California now represents between 20 percent and 80 percent of the U. S. industry for these categories of energy technology.

Clean energy technologies have a common attribute in that they improve air quality but also avoid or reduce greenhouse gas emissions. Consequently, the potential market for clean energy development is expected to increase as California adds greenhouse gas emission reductions to state policy objectives. Quantitative goals set for California's building and appliance efficiency standards, the renewable energy incentives and portfolio standard, and reduced dependence on petroleum in the transportation sector will stimulate domestic greenhouse gas emission reductions. Increasing demand for energy in the developing world, coupled with opportunities for countries under the Kyoto Protocol to pay for a portion of their reductions by investing in developing countries, create a rapidly growing market for emission reductions. The firm Point Carbon maintains a database of greenhouse gas emission reduction transactions that exceeded 280 trades by September of 2002.[39]

California can facilitate trade in these clean energy technologies through a variety of mechanisms. The Energy Commission's Energy Technology Export Program has stimulated approximately $500 million in California export sales of energy efficiency, renewable energy and cogeneration technology and project services in the international marketplace. Facilitating greenhouse gas emission reduction credits from these current and future international projects will increase the state's knowledge of and ability to establish greenhouse gas reduction mechanisms and secure economic value for future reductions that come from California projects. This effort can enhance the development of domestic California energy projects and help maintain the state's technology leadership. The Energy Commission can also explore new connections between state and international government policies, investment sources, and techniques that will enhance California's efforts to reduce greenhouse gas emissions and promote domestic economic activity.

Shift Demand Towards Goods and Services with Less Greenhouse Gas Emissions

The State of California has a large toolbox from which to draw upon in its effort to help consumers, including state agencies and local governments, consider the implications for greenhouse gas emissions and climate change. Many tools rely upon market mechanisms to shift demand towards processes, services and products that meet consumer and producer needs or desires but with lower greenhouse gas emissions. These mechanisms create new demand, new economic opportunities, and the potential to strengthen California's economy.

Climate change strategies that shift consumer demand can be designed to complement existing energy efficiency, renewable energy, and petroleum reduction measures that currently help California mitigate its emissions of greenhouse gases. Economists have long recognized that market systems do not fully incorporate external costs such as air and water pollution, traffic congestion, and greenhouse gas emissions. Several state agencies have the ability to evaluate and implement a set of new actions that lead their primary constituencies to more fully consider current and future costs likely to be imposed by climate change and variability. It is through an integrated set of measures to shift demand that the state can be most efficient in creating incentives for companies and consumers to reduce their impact on the atmosphere and take the steps necessary to adequately adapt to future climate changes.

A large body of economics research and writing exists on the subject of climate policy and the efficient use of incentives to influence consumer and producer behavior.[40] One example of a commonly used and often economically efficient tool is the application of a fee based upon the greenhouse gas contribution of a particular emissions source, such as fossil fuels. The proceeds or revenues from such fees can be returned, in part, to the energy user with a portion also used to invest in greenhouse gas reduction or adaptation measures. This type of demand shifting measure extends the logic underlying the current surcharge on electricity production and applies it to the consumption of fossil fuels that result in emissions of greenhouse gases.

A second example would be the use of rebates and fees to encourage consumer purchases of the more energy efficient vehicles within a particular vehicle class or category. Another tool being tested within the transportation sector is Pay-At-The-Pump (PATP) and Pay-As-You-Drive (PAYD) insurance. These approaches to motor vehicle insurance hold the potential to improve insurance rates and reduce greenhouse gas emissions. Both PATP and PAYD insurance convert a relatively fixed cost of insurance (i.e., a set premium for a given period of time) into a variable cost that is based upon the amount of driving. In the case of PATP, a portion of insurance would be paid through a surcharge on gasoline, while a PAYD system would charge vehicle owners a per-mile fee or a fee based on time spent driving. In either case, these approaches to insurance can provide incentives for drivers to reduce their miles traveled and thereby reduce emissions. PATP has the added benefit of making all drivers pay for some degree of insurance, compensating insured motorists for the liability created by uninsured motorists.

CHAPTER 6: STRENGTHENING THE STATE'S RESPONSE TO CLIMATE CHANGE

California has been successful in reducing its greenhouse gas intensity by combining a growing economy and population with a proportionately lower increase in greenhouse gas emissions. Several important climate change mitigation and adaptation efforts are currently underway within the state. Additional steps can be taken to promote new strategies that lead to increasingly more effective, efficient, and equitable climate change solutions for California.

The following set of recommendations is not limited to energy-related climate change issues. To date, California has not attempted to quantify the feasible range of greenhouse gas emission reductions or the reduction in risk and impacts expected to result from potential adaptation measures. Further, the state has limited information on the range of expected benefits and costs of climate policies, either in isolation or in combination. The relevant state agencies should collaborate on the quantification of feasibility, benefits, and costs associated with a set of prioritized strategies to address the challenges of climate change in California.

PURSUE OPPORTUNITIES FOR REGIONAL PARTNERSHIPS AND CLIMATE ACTION PLANNING

The governors of California, Oregon, and Washington announced the launch of a West Coast climate change initiative on September 22, 2003. Staffs of the three governors will develop new regional strategies to address the risks faced by West Coast states as a result of climate change and increased climate variability. Initial strategies are likely to focus on reducing transportation sector greenhouse gas emissions, promoting renewable sources of electricity generation, developing uniform efficiency standards to reduce emissions associated with building and appliance energy demands, as well as efforts to improve and standardize greenhouse gas accounting and methods to develop and maintain emission inventories.

There are several distinct advantages of a regional approach to addressing the challenges presented by increased climate change and variability. Cooperation at the regional level has the ability to significantly increase consistency in state-level climate change policies. Greater consistency in policies is particularly of value for measures that have important ramifications beyond the border of individual states or provinces. For example, climate policy mechanisms such as combined purchasing power to improve transportation energy efficiency of member's fleets will benefit from a partnership that increases market size as a buyer. A West Coast partnership could create the first system of emission-free truck stops along the Interstate 5 corridor that spans the distance between Canada and Mexico.

Regional partnerships can produce a more coherent voice supporting air quality and climate-friendly policies at the federal level such as higher fuel economy of new motor vehicles and greater energy efficiency requirements or fewer waivers for buildings and major appliances. Cooperation at the regional level can help standardize greenhouse gas accounting protocols and the formation of regional registries can serve as the testing-ground for improved accounting procedures at the federal and international levels. Efforts such as the West Coast Regional Carbon Sequestration Partnership can draw upon the existing expertise and resources of members to significantly extend research, development, and demonstration opportunities relative to actions taken as an individual organization.

Six Northeastern U. S. states have partnered with five Eastern Canadian provinces to reduce air pollutants including greenhouse gases. Together these governments developed a regional climate change action plan in August 2001. In their plan members acknowledge the importance of reversing the global trend towards rising emissions and rapidly increasing concentrations of greenhouse gases in the atmosphere. The partners describe common goals when stating "[S]pecifically, the plan presents a set of near-term options for our region that would help protect the climate, reduce greenhouse gas emissions and other pollutants, cut energy demands, and promote future job growth by harnessing sustainable energy resources and advanced technologies."[41] More recently ten Eastern U. S. states have agreed to design and implement a regional cap-and-trade system for greenhouse gas emissions within their electricity generation sectors.

A partnership between California and its neighboring states and countries has the opportunity to create solutions to climate change that are uniquely suited to the region. Innovative approaches can be designed that tap the potential of both market-based and regulatory mechanisms to improve the efficiency and effectiveness of each member's response to climate change. Regional efforts to increase transmission efficiency throughout the western electricity grid or promote the development, transmission, and tracking of renewable energy sources are measures that address climate risks while providing an array of co-benefits such as improved grid reliability and reduced dependence upon imported fossil fuels.

ENHANCE CAPABILITY TO EVALUATE CLIMATE CHANGE STRATEGIES AND POLICIES

The ability to compare relative advantages and disadvantages of climate change policies is dependent upon a sound analytical framework for the analyses. Climate policy measures should be evaluated based upon detailed information of California's economy. The state has available to it a broad range of climate policy instruments, many of which can be used in combination to achieve overall policy objectives. Recognizing that greenhouse gases emitted outside of California's boarders contribute equally to atmospheric concentrations, evaluations of climate policy should include "life-cycle analyses" that capture all of the expected changes in greenhouse gases resulting from a particular policy or set of policies.

The Energy Commission and other state departments, boards, and commissions should work to establish a common analytical framework for the quantitative evaluation of a myriad of climate change policies, programs, and actions. New analytical tools and models need to be developed. Enhanced climate policy analysis capabilities at state agencies should complement the existing capabilities within California's universities and national laboratories.

Improve Methods to Inventory Greenhouse Gas Emissions and Reductions

The statewide greenhouse gas emissions inventory provides an essential means of monitoring progress resulting from various greenhouse gas reduction policies and programs. While California's statewide greenhouse gas inventory is a ground breaking effort, it can nonetheless be improved upon by developing new approaches to estimating several difficult to quantify greenhouse gas sources, as well as collecting new information that is currently not available for a more accurate assessment.

California should follow the federal government's example and generate an updated inventory of greenhouse gas emissions each year. Future efforts could also provide analysis and discussion of the key sources of uncertainty within the inventory and identify potential solutions to reduce the causes of uncertainty in statewide emissions estimates. The state should continue to work with various types of organizations keenly focused on sound greenhouse gas emissions accounting, including federal and state agencies, interested local governments, California businesses, and a wide spectrum of international organizations. A sound greenhouse gas accounting system is a necessary foundation for emerging greenhouse gas reduction markets that fund or trade emission reductions.

Evaluate Past, Present, and New Climate Policies and Strategies

California has a long history of policies and programs that improve air quality and reduce greenhouse gas emissions. With the exception of energy savings that result from policies to promote efficiency, the state does not have a similar history of quantifying the greenhouse gas reductions associated with past measures. One essential building block for developing a comprehensive climate change strategy is a thorough understanding of what has already been tried and how well it worked.

Energy Efficiency Policies Reduce Greenhouse Gas Emissions

"By reducing the demand for electricity during the 1990s, these savings helped to dampen the increasing trend in California's CO_2 emissions between 1990 and 1999. Savings from energy conservation programs, including electricity savings, in 1999 relative to 1990 are estimated at about 7.1 million metric tons of CO_2 equivalent."

Inventory of California Greenhouse Gas Emissions and Sinks: 1990-1999; California Energy Commission. November 2002, page 181.

California needs to establish a consistent and scientifically rigorous analytical framework to evaluate climate policies. The impacts of greenhouse gas emissions are largely independent of either location or time emitted (their influence is global and lifespan long), so an analytical framework based upon life-cycle analysis is most appropriate for the evaluation of climate policies and programs.

The state has access to or ability to obtain the necessary tools, databases, and skilled staff to conduct in-depth evaluations of how past air quality and energy policies have contributed to cuts in greenhouse gas emissions. While challenging because often multiple factors lead to changes in emissions, performing such evaluations will assist efforts to quantify expected reductions from current and future climate change policies. U. S. EPA produced a report using a streamlined life-cycle analysis approach to quantify greenhouse gas implications of solid waste management measures that reduce waste at the source and promote recycling.[42] Consistent use of a life-cycle emissions framework (streamlined or full) is needed to effectively evaluate a range of policies that target reductions of important sources of greenhouse gas emissions in California.

PROMOTE PARTICIPATION IN EMERGING GLOBAL GREENHOUSE GAS REDUCTION MARKETS

Considering the United States withdrew from the process to ratify the Kyoto Protocol in 2001, California's success in reducing greenhouse gas emissions may in large part depend upon new state policy mechanisms and the ability of California corporations, government agencies and other entities to secure the financial asset value of those reductions. Knowledge of the financial asset value is based on quantification of the emission reductions that result from individual clean energy technology projects and other specific actions that reduce or avoid greenhouse gas emissions. Most of the existing experience in these transactions originates in Europe, although developing countries offer opportunities for cross-border emission reduction trading.

A handful of consulting firms in the United States also have developed expertise in international greenhouse gas emission trading. Furthermore, the outcomes of industry-specific protocols needed in California to quantify project-based greenhouse gas emission reductions could be enhanced and accelerated if the state explores the applicability of a variety of mechanisms that exist outside of California. The Energy Commission should expand its efforts to gather information on the economic and financial stimulus for various greenhouse gas emission reduction mechanisms such as emission offset requirements, cap-and-trade systems, permit trading, and greenhouse gas registries. One aspect of this effort should include quantification of the financial asset value of specific clean energy technologies, greenhouse gas reduction actions, and how this quantification might enhance the development of industry-specific greenhouse gas accounting protocols.

In conducting this work the Energy Commission should undertake information sharing efforts and possible alliances with other U. S. states, the federal government, foreign governments and international organizations. Pilot programs to test various mechanisms should be considered, such as exploring a cross-border emission trading system for the contiguous California – Baja Mexico region.

INCREASE PUBLIC EDUCATION AND OUTREACH EFFORTS ON CLIMATE CHANGE

One result of California's energy crisis was a dramatic illustration of how public education and outreach activities can have a significant impact on people's behavior. Continued efforts to inform consumers about the choices they can make to conserve energy and save money will also have a significant effect on greenhouse gas emission reductions. State agencies can provide valuable information that helps individuals make the connection between their consumption choices, greenhouse gas emissions, and the risks California faces with global climate change. The Energy Commission and CARB currently provide the public with information about climate change via their websites, but more can be done with this type of strategy to help Californians lessen their contribution of greenhouse gases to the atmosphere.

Finally, a focused effort to identify and describe the expected consequences of climate change will enable Californians to better adapt by making more informed choices. There is ample opportunity to increase people's understanding of the types of climate change benefits that can be gained in aggregate by their efforts to conserve energy in the home, during commutes to and from work, or through a broad range of actions that can lead to emissions reductions. The education and outreach effort should be broad-based and multi-media. It should target numerous audiences such as the business community, school systems, local governments, and individual households.

ACRONYMS

AEP	American Electric Power Company
CARB	California Air Resources Board
CCAR	California Climate Action Registry
CCCRC	California Climate Change Research Center
CH_4	Methane
CO_2	Carbon dioxide
CO_2 Eq.	Carbon dioxide equivalent
DSM	Demand-side management
DWR	California Department of Water Resources
EU	European Union
GSP	Gross state product
HFCs	Hydroflorocarbons
IBM	International Business Machines Corporation
ICLEI	International Council for Local Environmental Initiatives
IPCC	Intergovernmental Panel on Climate Change
$MMTCO_2$	Million metric tons of carbon dioxide
MSL	Mean sea level
N_2O	Nitrous oxide
PATP	Pay-at-the-pump
PAYD	Pay-as-you-drive
PIER	Public Interest Energy Research Program
PPB	Parts per billion
PPM	Parts per million
UCOP	University of California Office of the President
UNFCCC	United Nations Framework Convention on Climate Change
U. S. EPA	United States Environmental Protection Agency
Wm^{-2}	Watts per meter squared

ENDNOTES

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[14] *Heat Death Toll Forces a Shocked France to Question Itself*. John Tagliabue, The New York Times, August 20, 2003.
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[16] "Greenhouse gas intensity" is a measure of greenhouse gas emissions per unit of some other factor. Factors commonly used include economic measures such as gross domestic product or value added, physical measures such as tons of a product produced, or per person.
[17] Bush Administration climate change policy, February 14, 2002. See: http://www.state.gov/g/oes/climate

[18] Learn more about the Prototype Carbon Fund at: http://prototypecarbonfund.org/router.cfm?Page=Home and the Global Environmental Facility at: http://gefweb.org/Projects/Focal_Areas/focal_areas.html
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[27] For more information about Climate Leaders see: http://www.epa.gov/climateleaders/ and for the Energy and Climate Project see: http://www.wbcsd.ch
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[29] Source: Inventory of California Greenhouse Gas Emissions and Sinks: 1990-1999. California Energy Commission, November 2002, Executive Summary, page 4.
[30] Sources: Fig. 4-3 - Inventory of California Greenhouse Gas Emissions and Sinks: 1990-1999. California Energy Commission, November 2002, Executive Summary, page 5; and Fig. 4-4 – staff calculations based upon 1990-1999 greenhouse gas inventory report and California Department of Finance, *Revised Historical City, County and State Population Estimates with 1990 and 2000 Census Counts,* March 2002.
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[32] Strategies to reduce California's dependence on petroleum can be found at the following location: http://www.energy.ca.gov/fuels/petroleum_dependence/documents/index.html
[33] See: *Public Interest Energy Strategies Report*. California Energy Commission, August 8, 2003, page 25.
[34] For additional information about the PIER Program's climate change research plan go to: http://www.energy.ca.gov/pier/reports/500-03-025fs.html
[35] Estimate is based upon the following assumptions: 20 lbs CO_2/gallon, 20 miles/gallon, 20,000 miles/vehicle-year. For additional information about renewables and CO_2 see: *Public Interest Energy Strategies Report*. California Energy Commission, August 8, 2003, page 96.
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