GLOBAL CLIMATE CHANGE

In Support of the 2005 Integrated Energy Policy Report

DRAFT STAFF PAPER

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Introduction

California has the sixth largest economy in the world.[1] The primary sources of greenhouse gases (GHG) in California are fossil fuels which are burned in motor vehicles, power plants, refineries, and industrial facilities.

Leading scientists across the country recognize the "greenhouse effect"—the existence of a layer of gases surrounding the earth that has the ability to trap heat. Overall warming occurs when concentrations of GHG increase in the atmosphere, which is referred to as climate change. While consensus has yet to emerge on the timing and magnitude of the precise greenhouse effect, most scientists now agree that climate change is occurring, is human induced, and could severely affect natural ecosystems and the world's economy.

GHG emissions in California are large and growing, mainly due to population and economic growth. From 1990 to 2001 total GHG emissions rose nearly 13 percent; they are expected to increase by 32 percent from 1990 to 2020, if current trends continue. This steady growth in GHG emissions requires policy actions at the state and regional levels to reverse this trend.

While individual states cannot combat global warming alone, by acting together, states can demonstrate global leadership on climate change and *significantly* reduce GHG emissions. State government leadership is necessary to reverse the growth in GHG emissions, and to achieve a sustainable, low-carbon future in California.

Global climate change is gaining national attention among policy makers, especially now that the Kyoto Protocol has gone into effect. This international treaty was negotiated in 1997, signed by 140 countries, and became effective on February 16, 2005. After ratification by Russia, some 35 industrial nations have set limits on their GHG emissions, pledging to reduce emission levels to 5 percent below 1990 levels by 2012.[2]

In its December 2004 Report to the Congress, the National Commission on Energy recommended that the U. S. establish a mandatory, economy-wide trading system to curb the nation's growth in GHG, and that the U. S. efforts to reduce GHG emissions should be linked to efforts by other countries.[3]

The Intergovernmental Panel on Climate Change (IPCC), an international scientific body which periodically assesses the state of the climate change science, found in 2000 that "there is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities."[4]

In May 2001, President Bush asked the National Academy of Science (NAS) to assess the veracity of the IPCC findings. According to the NAS, the IPCC assessment "accurately reflects the current thinking of the scientific community on this issue." In addition, the NAS reported that "GHG are accumulating in Earth's atmosphere as a result of human activities, causing surface air temperatures and subsurface ocean temperatures to rise. Temperatures are, in fact, rising." [5]

A 2004 study by a team of leading California scientists, *Climate Change in California: Choosing Our Future*, predicts substantial increases in temperatures in both the summer and winter months, as a result of climate change.[6] Using scenarios of lower and higher future emissions, and state-of-the-art climate models, the authors report significant changes in California's natural resources could result, including:

- Rising sea levels along the California coastline, especially in San Francisco and the San Joaquin Delta;
- Extreme-heat conditions, such as heat waves and very high temperatures, which will last longer and become more commonplace;
- An increase in heat-related human deaths, infectious diseases and a higher risk of respiratory problems caused by deteriorating air quality;
- Reduced snow pack and stream flow in the Sierra Nevada mountains, affecting winter recreation and water supplies;
- Rising temperatures that can affect California agriculture, causing variations in crop quality and yield;
- Changes in the distribution of vegetation from projected increases in temperature and high fire risk.

These changes in California's climate and ecosystems are occurring at a time when California's population is projected to grow from 34 million people today to 59 million by the year 2040. Population growth and the demand for vital natural resources will compound the effects of climate change on water resources, human health and the environment.

Purpose of the Paper

This paper builds upon prior work carried out in numerous public forums, including the *2003 Integrated Energy Policy Reports (Energy Report)* and the *2004 Energy Report Update*, the California Climate Action Registry, the California Public Utilities Commission decisions on climate change, and the California Energy Commission's (Energy Commission) Climate Change Advisory Committee. Also, the paper highlights coordinated efforts by state government agencies to address global

climate change through the Joint Agency Climate Team in California, the West Coast Governors' Global Warming Initiative, and the Regional GHG Initiative in the Northeastern and Mid-Atlantic states.

This paper provides background and context to guide the formulation of policy options for reducing GHG emissions in California. Following a summary of state legislation on global climate change, the paper discusses the science of climate change, the impacts of climate change on California, emerging trends in GHG emissions, existing state policies and programs, options for addressing climate change, and recommended next steps.

Legislative Background

In 1988, the California Legislature first recognized the potential adverse effects of climate change when it enacted a state law [AB 4420 (Sher), Chapter 1506, Statutes of 1988] directing the Energy Commission to assess the impacts of climate change as it may affect energy supply and demand as well as the state's economy, environment, agriculture, and water supplies. The law also directed the Energy Commission to identify potential GHG reducing strategies. In response, the Energy Commission published *"Global Climate Change: Potential Impacts and Policy Recommendations"* in December 1991.

Since then, numerous statutes have been enacted that at have shaped California's climate change policies and programs. These are discussed in greater detail beginning on page 8 of this report.

Climate Change Impacts to California

Climate change has the potential to significantly affect California's natural resources and every sector of the economy. This section briefly summarizes the major scientific findings of recently completed reports and peer-reviewed, published scientific papers.[7]

Since 2001, significant progress has been made in the science of climate change. New scientific studies have concluded that:

- Global warming projections may have been understated and, therefore, impacts may become more severe than previously estimated.[8]
- Global warming and other human alterations of the earth's atmosphere may increase the possibility of large, abrupt, and unwelcome regional or global climatic events.[9]

Scientific projections from existing climate models suggest that California will grow warmer, but there is not yet consensus on the timing or degree of global warming. With respect to precipitation, some models suggest substantial increases in

precipitation levels while others suggest less precipitation.[10] There is consensus, however, that the warming will result in early runoff and reduced snow levels at the end of the wet season.[11] Scientific findings conclude that climate change produces:

Coastal Impacts:

- Rising sea levels along the California coastline may require the construction of sea walls and other structures to protect coastal property.[12]
- Wind-induced movement of cool deep water may be enhanced by climate change and reduce summer temperatures in coastal areas.[13]

Water impacts:

- Rising sea levels may severely impact the Sacramento San Joaquin Bay Delta system that is used to transfer water from Northern to Southern California.[14]
- Reduced snow pack would reduce water availability during the dry spring and summer months.[15]
- Stream flow levels in the wintertime may substantially increase the risk of flooding.[16]

Temperature effects:

- Extreme-heat conditions, such as heat waves and very high temperatures, may last longer and become more commonplace.[17]
- Increased temperatures will make it harder to meet ambient air quality standards for ozone.[18]
- Rising temperatures could affect California agriculture and may require new farming practices and shifts in the types of crops planted in the state. If precipitation levels decrease, as suggested by some climate models, the impacts will be more severe.[19]

Changes in vegetation and fire risk:

- A changing climate will change vegetation patterns. Most ecosystems will be heavily impacted, and climate change may severely reduce their ability to cope with other stressors such as urbanization.[20]
- The risk of fire will increase under most of the projected climatic conditions in California.[21]

Energy demand and cost impacts:

- Energy demand may increase, but the degree of this increase depends on the actual level of warming. A mild warming scenario would increase net energy expenditures in the residential and commercial sectors by a small amount.
- Greater warming could increase state energy expenditures for cooling and heating by about $2 billion in 2020.[22] By comparison, Californians currently spend about $30 billion for natural gas and electric heating and cooling each year.

- Preliminary studies suggest that hydroelectric generation may increase under the wet scenarios, but generation will decrease from 10 to 30 percent if the dry scenarios materialize in the future.[23]

These climate change impacts are occurring at a time when California's population is projected to grow from 34 million people in 2004 to 59 million in 2040. Population growth and the demand for vital natural resources will compound the effects of climate change on water resources, human health, and the environment.[24]

Greenhouse Gas Emissions Trends

California's GHG emission level is already large and is increasing, due to population and economic growth. Based on 2001 data, California's emissions of carbon dioxide represent over 7 percent of the U. S. emissions and nearly 2 percent of the world's human-caused GHG emissions.

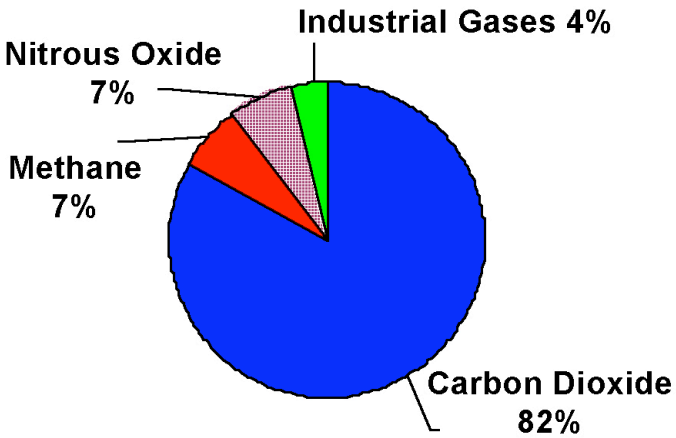
If this trend continues, total GHG emissions in California will grow 32 percent from 1990 to 2020 levels. These expected levels include the benefits from the state's renewable resources and energy efficiency programs which have already significantly reduced GHG emissions in California and will continue to be effective in keeping the rate of GHG emissions growth lower than it would otherwise be.

This section summarizes the results of staff's update to the statewide GHG emission inventory, using 2001 data. (A separate staff paper, prepared in April 2005, will include a more complete discussion of the data, methodology, and assumptions of this inventory update.)

Historical GHG Emissions

In 2001, California produced 505 million metric tons of carbon dioxide-equivalent GHG emissions, about a 13 percent increase from 1990. Figure 1 shows that carbon dioxide emissions comprised 82 percent of the total GHG emissions in 2001; methane and nitrous oxide each contributed 7 percent and industrial gases the remainder.

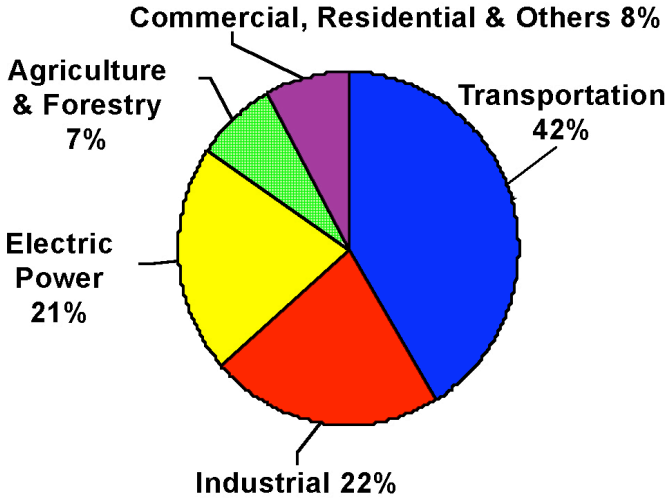
Figure 1
Composition of California's 2001 Greenhouse Gas Emissions (By Type of Gas)



Source: California Energy Commission, March 2005.

As shown in figure 2, consumption of fossil fuels in the transportation sector was the single largest source of California's GHG emissions in 2001, with the industrial sector as the second largest source, and electricity production, from both in-state and out-of-state sources, as the third largest source. Agriculture, forestry, commercial, and residential activities were the source of the balance of California's GHG emissions.

Figure 2
Sources of California's 2001 Greenhouse Gas Emissions (By End-Use Sector)



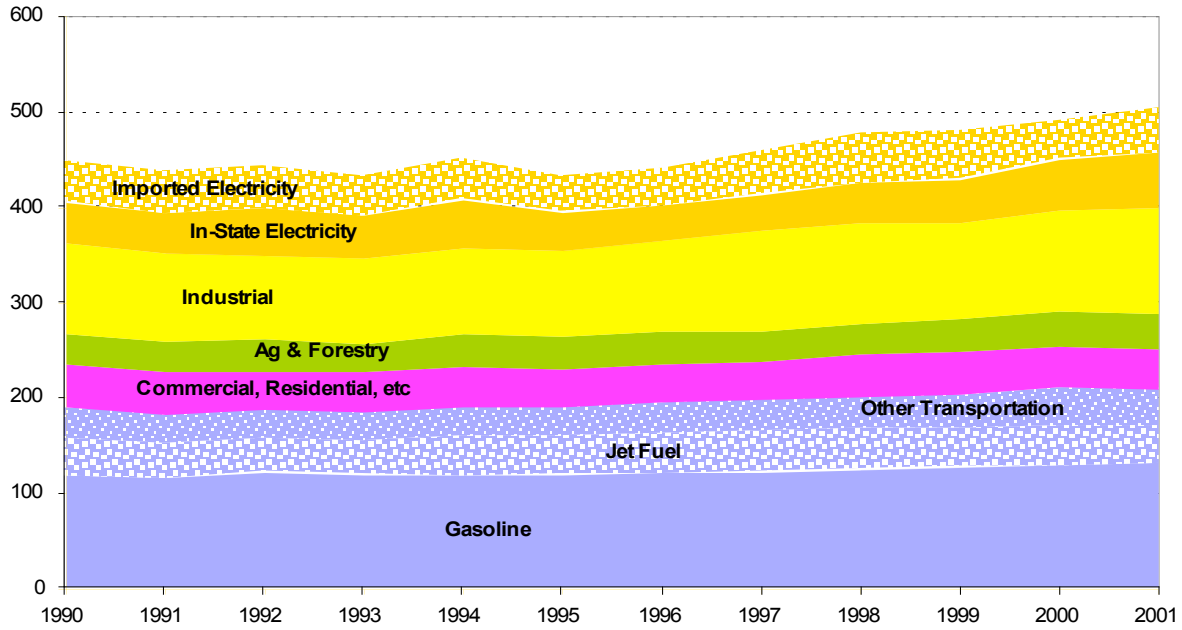
Source: California Energy Commission, March 2005.

Out-of-State Greenhouse Gas Emissions

Out-of-state electricity generation has shown higher carbon intensity than in-state generation in the past. In-state electricity produced 85 to 280 metric tons of carbon dioxide per gigawatt-hour, while imported electricity produced 660 to 1,350 metric tons of carbon dioxide per gigawatt-hour. The carbon intensity variation is affected by the availability of hydropower and other factors.

While the carbon intensity of both in-state and out-of-state electricity varied greatly, the amount of electricity California imported also varied from year to year. From 1990 to 2001, California imported 21 to 32 percent of the total electrical energy consumed in the state, depending on the year.

Figure 3-- California GHG Emissions Trends
(Million Metric Tons of Carbon Dioxide Equivalent)



Source: California Energy Commission, March 2005.

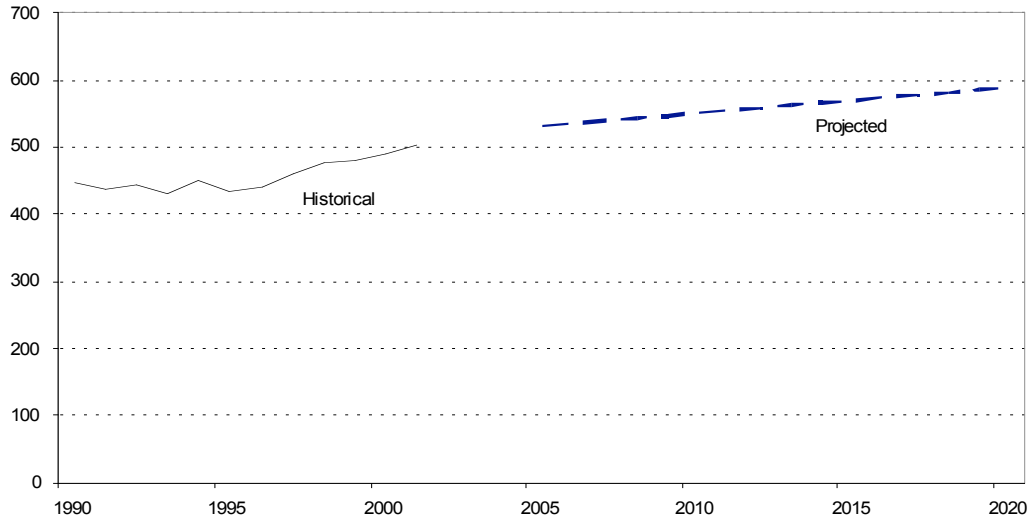
Figure 3 shows historical California GHG emissions by sector, including both in-state and imported electricity.[25] Emissions from the transportation sector, including gasoline, jet, and other transportation fuels, increased 10 percent between 1990 and 2001.[26]

Commercial and residential GHG emissions decreased 9 percent, agricultural and forestry emissions increased 16 percent, and emissions from industrial activities increased 16 percent. Lastly, emissions from electricity generation increased 24 percent, with in-state emissions producing the majority of this increase.[27]

Projected Greenhouse Gas Emissions

Figure 4 displays total historical and projected GHG emissions trends. California's GHG emissions were stable for 1990 to 1994, largely due to a stagnant economy, but increased steadily after 1995. These emissions are projected to continue to increase through 2020 unless additional policies to mitigate GHG emissions are adopted and new actions are taken to change the rate of increase. Short-term variations in future year-to-year values are likely, but are not shown.

Figure 4--California's Historical and Projected Greenhouse Gas Emissions (Million Metric Tons of Carbon Dioxide Equivalent)



Source: California Energy Commission, March 2005.

Existing State Policies and Programs

The State of California has been a national leader in renewable energy development and energy efficiency programs, which have important climate change benefits. However, GHG emissions in California are projected to increase steadily in the future despite the benefits of recently enacted state policies. Already enacted policies include state motor vehicle GHG emissions standards, utility resource procurement, energy efficiency, and the accelerated Renewable Portfolio Standard. Without these state policies in place, the state's GHG emissions would rise by another 40 percent above 1990 levels by 2020.[28]

The *2003 Integrated Energy Report,* the state's biennial energy policy report, recommended specific state actions to address climate change, asking state agencies to:

- Require the reporting of greenhouse gas emissions as a condition of state licensing of new electric generating facilities;

- Account for the cost of greenhouse gas emission reductions in utility resource procurement decisions;

- Use sustainable energy and environmental designs in all state buildings;

- Require all state agencies to incorporate climate change mitigation and adaptation strategies in planning and policy documents.[29]

The State of California is on track in implementing these recommendations.

State Motor Vehicle Emissions Standards

In 2002, landmark legislation [AB 1493 (Pavley), Chapter 200, Statutes of 2002] directed the California Air Resources Board (CARB) to establish motor vehicle standards to limit GHG emissions from passenger cars and light trucks, declaring that "global warming is a matter of increasing concern for public health and the environment in the state."

In September 2004, CARB unanimously approved standards to limit GHG emissions from new passenger cars and light trucks, starting with the 2009 model year. The regulations will not take effect until 2006 to allow a one year period for legislative review. Pending legislative review, the standards will be phased in during the 2009 through 2016 model years.

Based on a comprehensive assessment of emerging and existing technologies and fuels, the standards are expected to reduce GHG emissions from passenger cars and light trucks by 18 percent in 2020 and by 27 percent in 2030. In addition, the standards would cut ozone-forming pollution by about 6 tons per day in 2020 and 10 tons per day in 2030.

According to CARB, the expected cost for the added technology to meet the standards will average $325 per vehicle in 2012, and about $1,050 per vehicle in 2016. These increased costs, however, will be more than offset by operating cost savings over the life of the vehicle.

California is the first state in the nation to regulate motor vehicle GHG emissions. The States of New York, Massachusetts, and Connecticut have publicly committed to adopting the California GHG regulations. Several other states, including New Jersey, Maine, Vermont, Rhode Island, Washington and Oregon, are exploring the possibility. As expected, the automobile manufacturers filed suit in federal and state court seeking to overturn California's regulations in December 2004.

Utility Resource Procurement

In May 2003, the CPUC, the Energy Commission, and the California Power Authority jointly adopted an *Energy Action Plan*. This *Plan* recognized the need for "continuing progress in meeting the state's environmental goals and standards, including minimizing the energy sector's impact on climate change." The *Plan* also articulates the need to "encourage companies that invest in energy conservation and resource efficiency to register with the state's voluntary Climate Action Registry."[30]

In December 2004, the CPUC recognized the importance of reducing GHG emissions in its decision on utility resource procurement that directed the state's investor-owned utilities to account for climate change risk in their long-term resource procurement plans.[31] By internalizing climate change risk into the evaluation of bids for fossil-fueled generation, the utility procurement process will allow renewable and demand-side management options, which will reduce the carbon dioxide (CO2) emissions associated with producing electricity.

Under this decision, the utilities are required to use a "greenhouse adder," using a value of $8 per $25 per ton, to reflect the amount of CO2 that would be emitted by an electric generating unit under the terms of a contract. This adder represents an estimate of the likely future cost of purchasing CO2 offsets to comply with future mitigation regulations.

Other CPUC rulings require the utilities to estimate the GHG emissions reductions associated with energy efficiency programs and broaden participation in the California Climate Action Registry.[32] The CPUC is currently investigating the creation of a "carbon cap" on utility resource portfolios and an incentive framework known as the "Sky Trust" proposal to encourage the utilities to select environmentally preferred resources.

Energy Efficiency

Since the late 1970s, the Energy Commission has advocated energy efficiency through standard setting, market incentives, and utility-funded programs. Efforts to reduce energy consumption, and therefore the use of fossil fuels in California, have important climate change co-benefits.

California's building and appliance standards are internationally recognized as an example of the state's leadership in saving energy through more efficient appliances, building design, equipment, and building materials. These standards have saved individuals and businesses in California $56 billion through 2003 and are expected to save another $23 billion by 2013.

The building efficiency standards require new and remodeled buildings to incorporate cost-effective energy efficiency measures. These standards are updated every three years; the most recent, the 2005 building efficiency standards, were

adopted in November 2003.[33] Savings from the standards increase over time, as buildings are constructed or retrofitted.

California was the first state to develop and enforce efficiency standards for appliances. During 2004, the Energy Commission adopted new appliance efficiency standards for 19 appliances, including residential clothes washers. The 2004 appliance standards, to be phased over the next few years, will provide significant energy savings.[34] An important point about the appliance standards is their historic impact on appliances sold outside of California. Many manufacturers find it problematic to provide special models just for California, and therefore have sold more efficient models throughout the country.

In the early 1990s, the U. S. Department of Energy adopted the existing California appliance standards as national efficiency standards. To underscore the importance of the standards, the standards were credited with having achieved 5,380 megawatts of peak reduction during the electricity crisis of 2000-2001.

State level energy efficiency programs have contributed to California's relative low energy intensity (i.e. energy use per capita), compared to the rest of the U. S. This lower energy intensity supports the state's economic growth and provides direct savings from energy use reductions to residential and commercial customers.

Renewable Portfolio Standard

State policy has encouraged the use of renewable energy resources as a means of diversifying the electric generation mix. Today, California's Renewable Portfolio Standard (RPS) is the centerpiece of the state's strategy to diversify our electricity system and address our state's growing dependence on natural gas. State legislation [SB 1078 (Sher), Chapter 516, Statutes of 2002] currently requires that all retail suppliers of electricity in California supply at least 20 percent of their sales from renewable energy sources by 2017.

Both the *Energy Action Plan* and the *2003 Energy Report* recommended accelerating the 20 percent target to 2010. In the *2004 Energy Report Update,* the Energy Commission has further recommended a more ambitious post-2010 goal of 33 percent to sustain momentum and investment in renewable energy development to meet California's electricity demand.

The Energy Commission and the CPUC are collaborating to implement the state's RPS. Supplemental energy payments for RPS power costs above the CPUC-determined market prices will be offered for base load and peaking power plants, with these prices to be re-calculated for each RPS procurement cycle.

California Climate Action Registry

The Energy Commission has also supported the work of the California Climate Action Registry by providing technical guidance in the development of GHG reporting protocols. The Registry allows member companies to voluntarily report and independently verify their GHG emissions and to obtain credit for these emissions under any future federal regulatory regime.

State legislation [SB 1771 (Sher), Chapter 1018, Statutes of 2000] created the California Climate Action Registry, a non-profit organization, charged with annual voluntary reporting of GHG emissions by its member companies and agencies. The Registry was launched in September 2002 and has more than 40 participants from business, industry, government, and non-governmental organizations.

The Sacramento Municipal Utility District was the first Registry participant to complete all the necessary steps of determining their GHG emissions inventory, including independent verification, and have posted their results on the Registry's website. Pacific Gas and Electric Company and the Calpine Corporation were the next members to complete their emissions certification.

Participants are required to report entity-wide GHG emissions that must be certified as accurate and complete by third-party certifiers. To date, the Registry has issued reporting protocols for the power sector, forestry sector, and the oil and gas sector, with input from the Energy Commission and member companies. The State of California is encouraged to provide "appropriate consideration" for the emissions certified through the Registry's process under any future regulatory regime.

The Registry is seeking to harmonize its reporting protocols with those of other states and regions of the country, as a first step toward a mandatory GHG reporting system. If and when international or national requirements are instituted, these reporting protocols could become a useful model for use in enforcing voluntary goals or mandatory targets for reducing GHG emissions.

Inventory of Greenhouse Gas Emissions

In September 2000, the California Legislature passed legislation *[SB 1771 (Sher), Chapter 1018, Statutes of 2000],* requiring the Energy Commission to update the state's inventory of GHG emissions in consultation with other state agencies. The statute required the Commission to update the inventory in January 2002, and every five years after that.

The Commission prepared its first statewide inventory, *Inventory of California Greenhouse Gas Emissions and Sinks: 1990-1999*, based on the best information available at the time of publication.[35] The inventory was developed using guidelines

adopted by the Intergovernmental Panel on Climate Change, and was consistent with the methods being used by the U. S. Environmental Protection Agency.

This inventory compared California's emissions of GHG emissions with emissions of other states and nations. Limited information was available to allow a complete and thorough analysis and discussion of the impact of air quality and energy policies and programs on greenhouse gases. Energy Commission Staff are in the process of updating the statewide inventory, using 2001 data, the most recent data available, and will be issuing a staff technical paper on the inventory in mid-June 2005.

Power Plant Licensing

The West Coast states are taking different approaches to incorporating climate change considerations in the licensing of new power plants.

In California, the Energy Commission has begun to require power plant developers to report GHG emissions as an important first step in identifying mitigation opportunities. In the *2003 Integrated Energy Report*, the Energy Commission recommended that developers be required to report GHG emissions as a condition of state licensing of new electric generating facilities. A rulemaking is underway to revise current regulations for power plant licensing and compliance to incorporate these requirements.

The State of Oregon currently sets carbon dioxide emission standards for power plants, based on their electrical power output. In addition, Oregon requires that GHG emissions from power plants be mitigated through an "offsite mitigation" effort. Under the auspice of the Oregon Climate Trust, power plant developers can choose to either purchase emissions offsets from a third party or provide monetary funds to buy emissions reductions from non-power projects. Such projects can include energy conservation, transportation savings (e.g. from the purchase of hybrid vehicles), and biological sequestration projects.

The State of Washington enacted legislation in 2004 which established carbon dioxide mitigation requirements for fossil fueled thermal power plants with a generating capacity of 25 megawatts or more. Under this legislation, power plant developers must offset 20 percent of the CO2 emissions from a proposed power plant as a condition of state licensing.

State Level Coordination

An interagency committee, called the Joint Agency Climate Team, with representatives from state agencies involved in climate change activities, was established in response to state legislation[36] [SB 1771 (Sher), Chapter 1018,

Statutes of 2000]. The Team, which was originally co-chaired by the State Resources Agency and the California Environmental Protection Agency, has formulated 11 categories of recommendations to reduce GHG emissions through a combination of short-term mitigation options and longer-term adaptation measures:

- Improve the capacity to quantify GHG emissions and emission reduction measures.
- Develop, commercialize and export environmentally sound energy technologies.
- Achieve cleaner, more efficient transportation.
- Improve energy efficiency in the residential, commercial, industrial and agricultural sectors.
- Shift energy demand toward processes, services and products with low GHG emissions.
- Sequester carbon as a GHG emissions mitigation measure.
- Broaden and accelerate the use of renewable energy.
- Assess impacts and evaluate adaptive solutions.
- Enhance the capacity to project future climate changes.
- Collect better hydrologic and environmental data.
- Enhance water management planning capacity.

The Team has successfully advocated that state agencies include climate change considerations into state planning and policy documents. For example, Cal Trans and the State Department of Water Resources are including climate change considerations in their state plans.

Regional and International Partnerships

Many states are recognizing the importance of forging regional partnership to address global climate change. In September 2003, the Governors of California, Washington, and Oregon endorsed the West Coast Governors' Global Warming Initiative as a way of addressing global warming through joint regional actions. The three Governors recognized that states can act "individually and regionally to reduce GHG emissions" through strategies that "provide long-term sustainability for the environment, protect public health, consider social equity, and expand public awareness." [37]

In November 2004, the West Coast Governors asked their staffs to work together to explore more comprehensive regional measures to reduce GHG, highlighting four specific areas which hold the most promise:

- Adopt comprehensive state and regional goals for GHG emissions reductions

- Adopt standards to reduce GHG emissions from vehicles
- Develop a market-based carbon allowance program
- Expand the markets for energy efficiency, renewable resources, and alternative fuels

The Governors concluded that states can demonstrate global leadership in reducing GHG emissions, while achieving strong, long-term economic growth. When the three West Coast states are taken together, their combined GHG emissions are significant when compared to emissions from countries around the globe. Regional efforts to address global warming can, therefore, have a measurable global effect.

The Regional GHG Initiative (RGGI) is another prominent example of state government leadership in addressing global climate change. This initiative was launched in April 2003 by the Northeastern and Mid-Atlantic States under the leadership of Governor Pataki of New York. These nine states as a region represent 14 percent of U. S. GHG emissions and 3.4 percent of global emissions. Some of these same states have since announced state GHG reduction goals.

The goal of RGGI is to design a regional “cap and trade” program, which initially focuses on CO2 emissions from power plants. A model rule is being proposed for release in April 2005, for the nine participating states to use.

The Energy Commission has formed partnerships with other states and other countries who are addressing climate change. The Commission has supported the work of the Center for Clean Air Policy (CCAP), a non-profit organization established in 1988 to promote innovative solutions to energy and environmental problems. Through its membership in CCAP, the Commission has received the benefit of climate change work in other regions of the country, partnering with several U. S. states in the Northeast and with the European Union.

The Energy Commission is a charter member of the Climate Change Group, an international organization with the mission of activating new momentum in the worlds of politics, trade and finance. The Climate Group is assembling a growing, global circle of greenhouse gas reducers and supporters and pooling this group’s experience of cost-effective and profitable reduction strategies.

State-sponsored Scientific Research

While several state agencies support climate change research at some level, CARB and the Energy Commission are the most active.

CARB is funding studies to characterize black carbon and organic carbon releases, investigating emission levels from cars and trucks, improving emission inventory methods for both CO_2 and non-CO_2 gases, and evaluating the potential public health effects of climate change. CARB is also sponsoring research to determine the climate change benefits of air pollution control activities.

The Energy Commission has developed a long-term strategic research plan, which funds scientific studies that complement national and international research efforts. Core research is taking place at Scripps Institution of Oceanography and the University of California, San Diego, and the University of California, Berkeley.

Key research areas address the economic impacts from climate change, impact and adaptation analyses, regional climate modeling, and the potential for geologic and terrestrial carbon sequestration measures and techniques.

Climate Change Advisory Committee

The Energy Commission established a Climate Change Advisory Committee in July 2004 in response to state legislation [SB 1771 (Sher), Chapter 1018, Statutes of 2000]. This Advisory Committee is charged with advising the Energy Commission on "the most equitable and efficient ways to implement national and international climate change requirements."[38]

The Commission has requested the Advisory Committee to provide input on the following key policy questions:

- What strategies beyond existing state policies and programs should the State of California pursue to address global climate change?
- What criteria should be applied to develop and select recommended policy options?
- What options warrant further evaluation by the staff and their consultants?
- What business opportunities exist for California companies to become corporate leaders on climate change, while achieving operational efficiencies and cost savings?

The Committee has met quarterly since July 2004 to examine a comprehensive set of strategies for addressing climate change at the state, regional and national levels. Its membership represents key sectors of the California economy that will be affected by climate change.

Options for Addressing Climate Change

The Energy Commission has begun to identify the most promising options for reducing GHG by first identifying those end use sectors with the greatest potential for reductions. For this analysis, the Energy Commission is using the most recent update of the state's GHG inventory as a starting point to determine where the greatest opportunities to reduce emissions exist at the lowest cost.

Next, the Energy Commission will apply selection criteria to examine the relative merit of the proposed options, including technical feasibility, cost-effectiveness, political acceptability, practicality, cost or ease of implementation, timing, and the potential GHG reduction benefits. The Energy Commission will also consider the effect on international or interstate competitiveness of options employed in California.

A preliminary list of strategies, organized by end-use sectors is described below. The Energy Commission is relying on research and analysis by the Center for Clean Air Policy (CCAP), the Tellus Institute, and other consultants funded through the PIER program to evaluate and rank these potential strategies. This analysis will be available by mid-2005.

Transportation Sector Options

The transportation sector produces a significant fraction of the GHG emissions in California. The untapped potential for reducing emissions is large; however, with the exception of the state's proposed motor vehicle emission standards, appropriate policy instruments do not yet exist. In 2001, transportation sources represented approximately 42 percent of California's GHG emissions, with the largest fraction from motor gasoline in light duty vehicles.

In an August 2003 Joint Report to the California Legislature, the Energy Commission and CARB concluded that use of alternative fuels, where cost effective, should be increased as an alternative to conventional petroleum fuels. The two agencies further concluded that blending ethanol in gasoline, using Fischer-Tropsch diesel in existing diesel engines, and using propane and liquefied and compressed natural gas in heavy-duty vehicles appeared to be cost-effective options for reducing petroleum use.[39]

The Joint Report also identified expanding the existing fueling infrastructure as a key market barrier to using these fuels. Over the longer term, expanding the use of hydrogen in fuel cell vehicles has the benefit of high efficiency, zero tailpipe emissions, and reduced climate change impacts. In addition, fuel production from bio-fuels, such as ethanol produced from renewable feedstock, has the potential to produce climate change benefits.

The Energy Commission is examining a number of options for reducing GHG emissions from the combustion of gasoline, diesel and jet fuel in cars, trucks, airplanes, and freight vehicles. Among the options under evaluation are:

- Reducing freight-sector emissions in California's ports, rail, and heavy-duty trucks
- Using alternative fuels in niche markets, including public and private fleets
- Reducing vehicle miles traveled

- Encouraging vehicle efficiency through incentives and fees
- Using bio-fuels, such as bio-diesel, or increasing the use of ethanol in gasoline
- Improving the fuel economy of light, medium, and heavy-duty vehicles

In October 2004, the CCAP presented its preliminary analysis to the Advisory Committee on Climate Change that suggested:

- Changes in the movement of freight and goods present significant opportunities to reduce GHG emissions.
- Truck traffic from over 40,000 diesel trucks operating on the state's highways is expected to triple by 2025, and cause over 6 percent of total GHG emissions.
- Use of advanced truck technologies, improvements in port equipment, and expanded use of rail could offset expansion at California's major ports.
- Use of alternative fuels in heavy-duty trucks and truck stop electrification are among the measures that show the greatest promise.[40]

California is already pursuing a combination of incentives and regulatory measures along these lines, such as the CARB truck idling regulations. In addition, the state is undertaking activities to stimulate the electrification of truck stops at key ports and along the state's highways. These pilot efforts should be expanded and funding should be secured. For example, innovative financing options, such as a port-emission reduction grant program, would allow California ports to mitigate their diesel emissions and provide climate change reduction benefits as well.

Vehicle miles traveled (VMT) in California is growing at a rate of over 1.8 percent per year, a rate lower than the national average.[41] Limiting the growth in VMT can best be achieved at the regional, state, or local level, using a combination of public transit, transit-oriented land-use development, in-fill development, and urban revitalization.

Reducing VMT has been the purview of metropolitan or regional planning agencies in San Diego, Sacramento, Los Angeles, and San Francisco. A review of five regional planning documents conducted in 2001 for the Energy Commission revealed that low-VMT policies produced a 2 to 10 percent statewide savings from "smart growth" land use planning measures at the local level.[42] Furthermore, the survey found that consistent method for reporting and monitoring GHG reductions from "smart growth" measures is needed to ensure that regional planning priorities and goals are achieved.

Moreover, the Energy Commission and CCAP are evaluating the impact of policies to reduce emissions from aircraft and airport equipment. According to the CCAP, changes in the airline industry from the added cost of homeland security concerns and airline bankruptcies make it difficult to project airport growth accurately. Nevertheless, the Federal Aviation Administration is projecting that aircraft

operations in California will grow by 54 percent by 2020, and result in growth in air taxi and commuter traffic.

One option to reduce emissions related to air travel is to shift from aircraft use to high-speed rail. Another is a regulatory approach, such as capping emissions at airports. In a preliminary analysis by CCAP concluded that GHG reductions may be possible through a combination of measures, including:

- Air traffic and communication system improvements
- Reduced intervals for aircraft maintenance
- Reduced aerodynamic deterioration
- Installation of winglets on aircraft
- Reduced weight of commercial jets and aircraft

Industrial Sector Measures

The industrial sector was the second largest source of GHG emissions in California in 2001, contributing 22 percent of the total.[43] Nearly 67 percent of direct industrial emissions are produced from fossil fuel combustion, with the largest sources of industrial emissions from petroleum refining, oil and gas extraction, and manufacturing (including the semi-conductor industry and cement industries).

Work is underway by the Energy Commission to analyze options to reduce non-carbon dioxide GHG emissions, such as methane, nitrous oxide, refrigerants, and sulfur hexafluoride. For carbon dioxide, CCAP is analyzing three primary approaches for addressing industrial GHG emissions:

- Measures to reduce CO2 emissions in petroleum refining.
- Combined heat and power options associated with power generation that can be applied in numerous industries.
- Measures to reduce CO2 emissions from the cement industry.

In addition, opportunities may exist to reduce GHG emissions involved with natural gas compressor stations and the food and semi-conductor industries.[44]

The cement industry offers potential reduction benefits through the use of “blended concrete” and through energy efficiency improvements in manufacturing cement in California, although tradeoffs between operating efficiencies and the cost of changes in the manufacturing processes need to be taken into account. Further, changes in cement performance standards over the last 20 years tend to favor “blended” cement.[45]

Petroleum refining is the largest industrial consumer of energy in California, ranking first in electricity consumption and second in natural-gas consumption. While public data on total energy consumption in California’s refining industry are not readily

available, estimates approach 500 trillion British Thermal Units (Btu).[46] Sufficient data exist on petroleum refining in California to permit only rough estimates of the potential for CO_2 emissions reduction.[47]

Refineries are highly complex and integrated industrial processes, which include hydrogen production, crude oil distillation, and hydro treating. These processes are highly energy intensive and produce both direct and indirect GHG emissions. As a result, measures to reduce CO_2 emissions from these integrated processes cannot be simply added together.[48] Data are needed to characterize the types of processes used in refineries, the estimated energy consumption of these processes, the costs of options for reducing energy consumption, and resulting CO2 emissions.

Finally, the use of combined heat and power (CHP) from a single combustion source promises to be an effective strategy to reduce GHG emissions. Installing CHP processes at facilities that purchase electricity from the grid and use significant amounts of heat or process steam is expected to produce net cost savings. To make this successful, though, new policy instruments will need to be devised to provide incentives to encourage CHP in existing industrial processes in California.

Power Sector Options

As discussed above, in-state combustion of fossil fuels in power generation exceeded 11 percent of total GHG emissions in California in 2001. While this percentage is small relative to other states, out-of-state power, especially coal imports, increases this percentage to nearly 21 percent.

CCAP is exploring several measures to address power sector GHG emissions, drawing from experience with the Northeastern States and the European Union, including:

- Regional or statewide emissions caps
- Emissions portfolio standards
- Offset requirements
- Cap on electricity production from load serving entities

Beyond existing state policies, the CCAP analysis will consider establishing a regional cap on electricity production, adding the effect of near-term measures, such as more aggressive energy efficiency programs and an expansion of the RPS. Using scenarios, the analysis will also consider the effect of a statewide cap on GHG emissions from electricity production. [49]

Other variations in setting statewide and regional caps on GHG emissions will involve modeling the effects of such caps on a variety of industry sectors, including the semi-conductor industry, cement industry, and refining industry, each of which has their own process heat, steam, and power requirements.[50]

In addition, some members of the Advisory Committee have recommended including options involving advanced power generation technologies, such as use of Integrated Gasification Combined Cycle technology.

Agriculture and Forestry Sector Measures

Opportunities for reducing GHG emissions in agriculture and forestry exist in manure management and expanding agricultural and forestry carbon sinks. Using Energy Commission data and preliminary analysis by CCAP, the Energy Commission estimates that methane emissions in California were nearly 8 percent of total in-state GHG emissions.[51] The largest sources of methane emissions include:

- Landfills
- Enteric fermentation (i.e. methane produced from livestock feeding)
- Manure management
- Petroleum and natural gas supply systems
- Wastewater plants

Of these sources, methane emissions from manure management are the fastest growing source, with a growth rate of over 5 percent a year.[52] Reducing methane from liquid livestock waste through use of biogas recovery appears to be a cost-effective option. The Energy Commission and the CCAP are exploring several implementation strategies, including economic incentives and sector-specific emission caps, to achieve the potential reductions.

California's forestry and agricultural sectors also provide a net sink for carbon in the state. In 2001, land use changes and forestry sinks offset 4 percent of the state's in-state GHG emissions in that year, including power imports.[53] Recent data indicate that the quantity of carbon sequestered is declining, however, due to land use changes and de-forestation. Specific measures being evaluated include:

- Improved forest management
- Measures to reduce de-forestation in existing forests
- Ways to keep forest land in production
- Soil erosion management
- Land conversion and restoration
- Low or no-till agriculture
- Bio-fuels production
- Crop rotation and winter cover

- Linking carbon sequestration to a broader multi-sector, emissions trading program

Adaptation Strategies

Climate change is largely due to the long atmospheric lifetime of GHG emissions (e.g., 100 years for CO2) and the high thermal inertia of the oceans. As the science of climate change demonstrates, our planet is already committed to some level of warming. For these reasons, a balanced approach, combining near-term mitigation options with longer term adaptation strategies, is the most prudent course of action.

Scientific research has identified a number of "no regrets" strategies to reduce any adverse effects of changing climate[54]:

- Increasing water use efficiency.
- Preserving vulnerable habitats, wetlands, and areas subject to fires, floods, and landslides.
- Creating nature reserves to accommodate future climate changes, range shifts and migrations of plants and animals.
- Reducing urban heat island impacts.
- Recharging groundwater systems by using pavements that are permeable to allow storm water runoff.

Additional research is being funded through both the Energy Commission's Public Interest Energy Research (PIER) program and other research efforts to identify robust adaptation strategies by:

- Developing probabilistic climate projections for the state.
- Creating a dynamic ecological model to develop biodiversity and conservation strategies.
- Demonstrating probabilistic seasonal forecasts to improve the management of water reservoirs in the state.
- Installing climate reference stations to track and detect climatic changes in the state.
- Developing a process-based shoreline model to estimate how our coastal area may change in the future with sea level rise.
- Improving a water system model to investigate potential adaptation measures under a wide variety of scenarios.

Recommended Next Steps

Analysis is underway to quantify the cost effectiveness of the selected policy options. Analytical results will be shared with the members of the Energy Commission's Climate Change Advisory Committee and other interested parties. The Advisory Committee is scheduled to meet on April 6, 2005, and July 11, 2005, and an Energy Commission hearing on climate change is scheduled for July 12, 2005, to solicit public input on specific options proposed for the transportation, power, agriculture and forestry, and industrial sectors.

Researchers from the University of California Berkeley have developed a macroeconomic model to estimate, in an integrated fashion, the overall economic impacts of efforts designed to reduce GHG emissions in the state. This work will be available in mid-2005.

The Energy Commission is updating the state's inventory of GHG emissions to reflect data available for the year 2001. This paper has drawn on the updated data, and a staff paper documenting this update will be available in April 2005.

Finally, the Energy Commission is seeking input from the Advisory Committee on key policy questions and policy recommendations from the Climate Change Advisory Committee, which will be incorporated into the *2005 Integrated Energy Plan Report.*

End Notes

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[25] Values are expressed in millions of metric tons of carbon dioxide equivalents ($MMTCO_2E$).

[26] Gasoline related GHG emissions increased from 118.3 $MMTCO_2E$ in 1990 to 131.6 $MMTCO_2E$ in 2001, an 11.2% increase. Jet fuel GHG emissions include both domestic and international fuel use. In 1990 jet fuel use GHG emissions were 38.9 $MMTCO_2E$. They peaked in 1998 at 43.2 $MMTCO_2E$ and then decreased to 39.9 $MMTCO_2E$ in 2001, for a net increase of 2.4% from 1990-2001. In 1990 diesel emissions were 32.1 $MMTCO_2E$. They increased to 40.6 $MMTCO_2E$ in 2000 and then decreased to 37.9 $MMTCO_2E$ in 2001. Total transportation GHG emissions were 189.4 $MMTCO_2E$ in 1990 and increased to 209.3 $MMTCO_2E$ in 2001, for an overall increase of 10.5%.
[27] In-state electricity GHG emissions increased from 41.5 MMTCO2E in 1990 to 57.6 MMTCO2E in 2001, a 38.9% increase since 1990. Imported power emissions increased from 43.3 MMTCO2E in 1990 to 47.4 MMTCO2E in 2001, a 9.4% increase since 1990. Taken together, electricity emissions increased from 84.8 MMTCO2E in 1990 to 105 MMTCO2E in 2001, a 23.8% increase. These emissions include the release of sulfur hexafluoride (SF6) from transmission and distribution switchyard gear.
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[33]For example, the 2005 building efficiency standards, adopted in November 2003, are expected to yield savings of 180 megawatts of electrical demand, 475 gigawatt-hours of electrical energy and 8.8 million therms of natural gas per year as buildings are constructed and remodeled.
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[42] Parsons Brinckerhoff, *California MPO Smart Growth Energy Savings MPO Survey Findings,* September 2001.
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