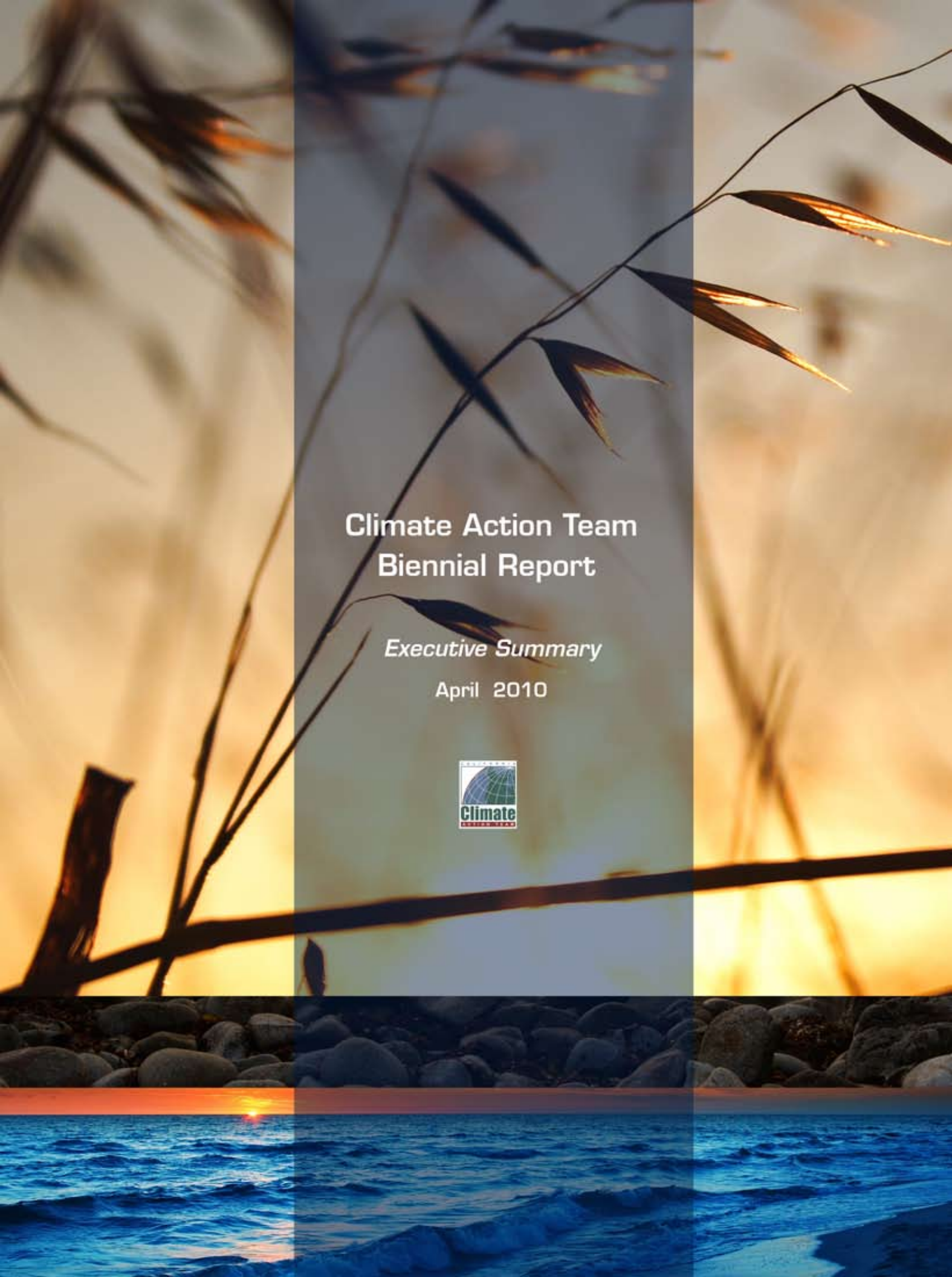

Climate Action Team Biennial Report

Executive Summary

April 2010

2009 Climate Action Team Report Executive Summary

Climate change poses serious risks to California's natural resources. California-specific impacts are expected to include changes in temperature, precipitation patterns, and water availability, as well as rising sea levels and altered coastal conditions. These physical changes will have economic repercussions across the California economy, including in agriculture, forestry, energy production and consumption, air quality, coastal infrastructure, and public health. Analyses of these potential impacts show that a high global emissions pathway is significantly more costly to the state than a low global emissions pathway: emphasizing the value of putting California and the world on the path to a low carbon future.

Climate change research specific to California is continuing. Research activities are coordinated so that state-directed research complements and builds on national and international efforts. While this research proceeds, it is also recognized that past and current emissions have committed the world to some climate change. Potential economic losses, even under a scenario of reduced global emissions, highlight the need for effective adaptation policies as part of the state's response to climate change. Taking advantage of the thorough scientific analysis collected in this Climate Action Team report, a comprehensive Climate Adaptation Strategy (CAS) was subsequently released in December 2009 following extensive interagency coordination and stakeholder input.

Introduction and Background

California has a long history of studying the potential impacts of climate change on the state's natural resources and economy. In June 2005, Governor Arnold Schwarzenegger mandated the preparation of biennial science assessment reports on climate change impacts and mitigation and adaptation options for California (Executive Order S-3-05). The Climate Action Team (CAT) produced its first Assessment Report in March 2006.

In December 2008, the Air Resources Board (ARB) approved a Scoping Plan for meeting the limit required by the Global Warming Solutions Act of 2006 (AB 32, Statutes of 2006), a reduction in California's greenhouse gas (GHG) emissions to 1990 levels by 2020. The ARB worked with other members of the CAT in the development of measures for the Scoping Plan. Eight CAT Sub-groups contributed sector summaries to the ARB for inclusion in the Scoping Plan.[1] Multi-sector work on Scoping Plan measures represented much of the work of the CAT during 2007-2008. The measures proposed by the CAT sub-groups included descriptions of

[1] CAT Subgroup Reports Supporting AB 32 Scoping Plan (December 2008), http://www.climatechange.ca.gov/climate_action_team/reports/index.html

emission reduction measures, along with cost estimates whenever possible. The AB 32 Scoping Plan contains details of the results of this work[2].

The assessments in this report provide the most comprehensive review and analysis of climate change modeling for California to date. This study is also the first state-level evaluation of both the physical and economic consequences from potential future climate change. The analyses show potentially serious impacts on California's natural resources such as water and agriculture, which will in turn have severe economic repercussions. Specifically, the report 1) delves into the latest research on the impacts of climate change on California's people, natural resources and infrastructure; 2) provides detailed analyses of economic impacts of future climate change on various sectors in California; 3) assesses the research needs and opportunities for coordination on California-focused climate change; and 4) offers an introduction to coordinated efforts to adapt to current and future impacts of climate change.

Through its reliance on peer-reviewed scientific studies, this report provides strong evidence of the benefits of putting California and the world on the path to a low carbon future. The analyses show that a high emissions pathway is significantly more costly to the state than a low emissions pathway.

Scientific Research: Impacts of Climate Change in California

The scientific research on climate change, its impacts on the state, and our adaptation needs is progressing in important ways. Given California's complex climatic zones and varied geography, this research is a vital component of the decision making process in addressing the future of the state and how to respond to the climate change risks. Major scientific advances since the 2006 Assessment include:

- Downscaling of global climate model outputs to produce greater resolution and thus more realistic climate change projections for the state.
- Understanding of the climate and terrestrial influences on global sea level rise and thus improved projections for the 21st century.
- Collecting and analyzing data to better understand the state's regional and local exposure to climate change risks such as floods or extreme heat.
- Understanding the impacts of climate change on crop yields for California's important agriculture commodities.
- Providing more detailed insights into the complex challenges and costs involved in meeting future energy needs.

Approach to Climate Scenarios

The climate scenarios for this assessment were developed by scaling down six global climate models to grid sizes of about 7.5 by 7.5 miles to determine probable impacts on distinct climatological regions within California. Overlaid on these models were two plausible scenarios

[2] AB 32 Climate Change Scoping Plan Document, http://www.arb.ca.gov/cc/scopingplan/document/scopingplandocument.htm

for 21st century trends in social and economic development around the world. Each of these scenarios is drawn from the Intergovernmental Panel on Climate Change's (IPCC) Special Report on Emissions Scenarios:

- A2: referred to as the "higher" emissions pathway; and
- B1: referred to as the "lower" emissions pathway.

Key Research Findings

The climate change scenarios describe changes in temperature, changes in precipitation patterns and water availability, and rising sea levels and altered coastal conditions. Each of these basic climatological changes in turn drives changes in natural and human systems that have the potential to alter the future of the state. Specific research highlights include:

- **Agriculture.** Since 1980, nighttime temperature has increased about three times as much as daytime temperature, and in some areas there has been a reduction in yield for wheat, maize and barley. By the end of the century modeling predicts that yields of almost all high value crops studied will decrease, although there were pronounced differences between high- and low-emissions scenarios.
- **Forestry.** Although preliminary results projected increases in yield as measured in total tree volume, model results also suggest increases in wildfires. The long-term increase in fire occurrence associated with the higher GHG emissions pathway is substantial, with increases in wildfire occurrence statewide ranging from 58 percent to 128 percent by 2085. Likewise, estimated burned area increased 57 percent to 169 percent under the higher emissions pathway.
- **Water Resources.** The reliability of the State Water Project (SWP) and federal Central Valley Project (CVP) water supply systems are expected to be reduced for the range of future climate projections studies. Without changes in operating rules, gains in efficiency, and expanded infrastructure, the reliability of statewide water supply systems could be severely affected.
- **Coastal Areas.** Many of the areas indicated as vulnerable to sea water inundation are presently behind levees and would be inundated if those levees breached or were overtopped. Other areas with critical infrastructure, such as the San Francisco and Oakland airports, would need levee protection.
- **Energy.** On average, statewide electricity demand in the residential sector may increase by about 7 percent in the next few decades solely due to increases in mean temperature and frequency of extreme heat events from climate change. By the end of this century, residential demand may increase by 20 percent in the lower GHG emissions scenario and by 50 percent in the higher emissions scenario.
- **Air Quality.** By 2050, the effects of climate change may partially or completely offset the benefits of emission control programs on ambient levels of ozone. Additional reductions of 900 tons per day of reactive organic gases (ROG) emissions and 500 tons per day of nitrogen oxides (NO_X) emissions, in excess of the 2007 State Implementation Plan (SIP) requirements, would be needed in the four heavily populated regions of the state.
- **Public Health.** Increased frequency of extreme conditions, such as more frequent, longer and more intense heat waves, are likely to lead to the most serious effects of

climate change on public health. Climate change also has the potential to influence asthma symptoms, the incidence of infectious disease, has and the potential to affect humans indirectly through impacts on food and water supplies and quality.

Economic Analysis: Consequences of Future Climate Change on California

By putting a dollar value on the physical impacts of climate change, this study examines in economic terms the cost associated with climate change if no corrective actions are taken. These assessments are in the early stages of development and are expected to evolve as improved data and methods are developed. This current assessment demonstrates that climate change poses significant financial risks for California, indicating that the value of reducing global emissions is substantial. Moreover, past and current emissions of GHGs have already committed the world to certain levels of climate change. Therefore, the potential economic losses even under scenario B1 highlight the need for effective adaptation policies as part of the state's response to climate change.

Key Economic Impacts

- **Forestry.** Climate change could result in an overall decline in the value of harvested timber, with decreases between 4.9 percent and 8.5 percent in the state. By 2085, annual damages from forest fires on housing units could be $0.7 to $14 billion in the higher emissions scenario and $0.5 to $11 billion in the lower emissions scenario.
- **Water.** Net economic loss for the water delivery system due to climate change is predicted to be between $140 and $400 million annually by the end of the century. The added risk of a major failure of the levee system in the Sacramento/San Joaquin Delta due to accelerated sea level rise could substantially increase the risk of negative economic impacts.
- **Coastal Regions.** A wide range of critical infrastructure and large areas of wetlands and other natural ecosystems will be at increased risk of inundation from sea level rise. The costs of replacing property at risk of coastal flooding or protecting vulnerable areas are estimated to be at least $100 billion and $14 billion, respectively. A socioeconomic analysis suggests that there is the likelihood of a disproportionate impact on low-income communities and those of color from sea level rise.
- **Energy.** Total incremental annual electricity expenditures in the residential sector, due solely to climate change increased by $3.5 billion by 2100 under the lower emissions scenario. For the higher emission scenario these incremental costs are estimated at $15 billion annually. For high-elevation hydropower units, up to 20 percent decreases in annual electricity generation would translate to an annual loss of about $1 billion.
- .**Ecological Services.** Economic impacts assessments on the environment under different climate scenarios are still in its infancy. For example, projected economic effects due to changes in above-ground carbon stock vary greatly, depending on many factors such as temperature increases, forest fires, development, and a future carbon price.

Table ES-1. Estimated Economic Impacts of Climate Change in California

Impact	Emissions Scenario	Cost in 2050*	Cost in 2085*	Units**
Forest Fires	Higher	0.2 to 2.3	0.7 to 14	$billion/year
	Lower	0.2 to 2.5	0.5 to 11	
Timber Revenue	Higher	-0.4 to 3.4	4.2 to 8.0	$billion, undiscounted (cumulative from 2000)
	Lower	-2.2 to -1.3	-2.2 to -1.3	
Flooding: Open coast property	Higher	***	37	$billion
	Lower	***	***	
Flooding: SF Bay property	Higher	36	62	$billion
	Lower	***	49	
Southern California Beach Recreation	Higher	< 0.08	> 0.08	$billion/year
	Lower	< 0.08	< 0.08	
Water supply	Higher	< 0.16	< 0.4	$billion/year
	Lower	***	< 0.14	
Electricity Demand	Higher	1.6	15****	$billion/year
	Lower	-0.3	3.5****	
Electricity Generation to replace Hydropower	Higher	***	0.5	$billion/year
	Lower	***	<0.5	
Carbon Stock	Higher	-2.3 to 11	-6.3 to 22	$billion/year
	Lower	-2.5 to 13	-8 to11.8	

* Negative numbers represent gains. All estimates in 2006 dollars.

** Units differ because they reflect findings from distinct studies described in the report.

*** Data unavailable

**** Estimates for electricity demand were calculated for the year 2100, not 2085

The understanding of economic valuations of potential impacts due to climate change is uncertain and continues to evolve. The analysis indicates that climate change will impose substantial costs to Californians on the order of tens of billions of dollars annually, but that costs will be substantially lower if global emissions of GHGs are curtailed to the level suggested by the lower emissions scenario. Table ES-1 summarizes the estimates of economic impacts described above. All the amounts are in 2006 dollars. In addition to these economic impacts, a study on air quality indicated that the total annual control costs of the additional reductions in criteria air pollution needed because of climate warming is estimated at about $8 billion per year by the middle of this century.

Adaptation costs have only begun to be assessed. In some sectors they are significant, even for the lower emissions scenario, and increase substantially for the higher emissions scenario. For other sectors, direct adaptation costs seem to be less costly. However, the full costs of climate change impacts and adaptation need further study.

Climate Change Research: Needs and Coordination

As described above, climate change research specific to California has great benefits to policy makers. Funding for climate research comes from a variety of sources. Federal funding comes to the state, for example, through some 40 national research laboratories based in California. Within the state, a number of state entities sponsor extramural climate research as well as maintain their own modest research programs. California-sponsored and directed climate research is designed to complement national and international efforts by focusing on regional distinctions critical to informing State climate change policy (e.g., downscaling global climate modeling outputs). Today, many state agencies conduct, support, or direct research related to climate change, and there is increased coordination among agencies in this research.

Climate Research by Agency:

- **Air Resources Board.** ARB's research portfolio supports AB 32 implementation and the GHG emissions inventory; probes economic, technological, and behavioral change issues related to the State's long-term goal of 80% reductions by 2050; and illuminates atmospheric science critical to air quality planning in a warming world.
- **California Coastal Commission.** Mitigation and adaptation research from the National Oceanic and Atmospheric Administration (NOAA), the Energy Commission and others provide important applications in regulatory and land use planning decisions.
- **California Coastal Conservancy.** Modeling and project design for coastal and bay wetland restoration projects, evaluating impacts on Bay Area upland habitats, and measuring carbon sequestration in tidal wetlands, all incorporate research on sea level rise and other impacts.
- **Department of Conservation.** Projects are being conducted related to geologic sequestration potential in California and impacts of recycling programs and conversion of agricultural lands on climate change.

- **California Energy Commission.** The Public Interest Energy Research (PIER) program sponsors direct climate change research in the areas of climate modeling, emissions monitoring, impacts assessment, and carbon sequestration. PEIR also conducts research in advanced generation, alternative transportation, renewables, and energy efficiency.
- **California Environmental Protection Agency.** The Agency has focused on incorporating interdisciplinary climate research to support policy decision-making, including determination of indicators of the effects of climate change on human and natural systems, and expanding capacity for analysis of environmental justice as it relates to climate change.
- **Department of Fish and Game.** The Department undertakes collaborative research efforts related to wildlife corridors and sensitive species.
- **Department of Food and Agriculture.** Research focuses on carbon sequestration in agricultural soils, emissions from dairy operations, and management practices for vineyards to reduce carbon footprint.
- **Department of Forestry and Fire Protection.** Projects have helped establish the impact of forest management practices on GHG emissions and potential for carbon storage in wild-land and urban forests. Other research is developing analytical tools to balance forest health with the removal of fuel for fire protection and bio-energy. The Department is also working with ARB on improvement to the GHG inventory and its relationship to the federal Forest Inventory Assessment.
- **California Integrated Waste Management Board.** Research projects focus on reducing GHG emissions of California's waste stream.
- **California Ocean Protection Council.** Research focuses on assessing vulnerability to sea level rise and other coastal/ocean climate change impacts and on modeling adaptation planning options.
- **California State Parks.** Projects have focused on the impact of climate change on California parks including animal and vegetation migration due to climate change, establishing resiliency through landscape linkages, and determining geographic hotspots of species evolutionary change.
- **Department of Public Health.** Studies concentrate on increases in heat-related illness and death in communities and workplaces, as well as identify vulnerabilities that need to be reduced or eliminated.
- **California Public Utilities Commission.** Under direction of the CPUC, the California Investor Owned Utilities (IOUs) operate a ratepayer-funded technology research program that directly focuses on climate change.
- **Department of Transportation.** Research related to improving transportation and transportation planning towards increased efficiency and reduced emissions. A number of additional research studies have indirect implications for climate change.
- **Department of Water Resources.** The Department provides information for understanding how climate impacts California's water resources. They also work to develop regional climate models designed to allow strategic planning for water availability and electricity supply.
- **State Water Resources Control Board.** Research projects related to the impact of climate change on coastal areas and technology for water re-use.

Future Research Needs

The CAT identified a number of research areas as important in directing future climate change research efforts. These future efforts will be crucial in providing data specific to California that can direct the state's future policy efforts.

- **Regional climate modeling.** Regional climate modeling is a major focus of climate change research being sponsored by the Energy Commission. This modeling is foundational and a key to understanding the impacts of climate change on our local California environments.
- **Impact and adaptation studies.** As the state plans for adapting to current and future effects of climate change it will be necessary to understand the vulnerability of the state's natural resources, population, infrastructure and economy.
- **GHG inventory methods.** The state's ability to estimate GHG emissions has improved over time due to several factors, including improved data, identification of new emissions sources, and improvements to inventory methods and models. Research is needed in order to assure that the inventory stays up to date and accurate.
- **Emerging technologies and strategies.** A wide range of GHG mitigation strategies are essential for effective implementation of AB 32 and meeting the Governor's goal of 80 percent reductions in GHG emissions by 2050, while maintaining a robust economy.
- **Transportation.** The transportation sector's large and growing share of GHG emissions necessitates research on more effective mitigation strategies.
- **Electricity and natural gas.** Better evaluation of the performance and cost effectiveness of current and emerging energy technologies as well as improved capability to predict the effects of climate change on the supply and demand for energy services will help refine future costs assessments.
- **Low GHG technologies for other sectors.** Other sectors may offer other non-energy options for reducing GHGs and these options should be better quantified to identify potential reductions.
- **Carbon Sequestration.** Further research into both terrestrial and geologic sequestration of carbon dioxide for implementation technologies, accounting methodologies, and appropriate life cycle analysis will help to identify the future role of sequestration techniques in state climate policies.
- **Economic impacts and considerations.** The next phase of sector-specific and macroeconomic models will be crucial for guiding both GHG mitigation and climate change adaptation efforts.
- **Social science to support implementation, education, and outreach.** Further social science research, including investigation of legal and administrative structures, will be valuable in helping the State cope climate impacts, promote robust laws and institutions, and partnerships.

Climate Adaptation: Science, Strategy, Action

In order to effectively guide and coordinate California's climate change adaptation efforts, the California Natural Resources Agency, in partnership with Cal/EPA, the Climate Action Team, the Business, Transportation and Housing Agency, Department of Health and Human Services and other key stakeholders, developed a comprehensive Climate Adaptation Strategy (CAS) released in December 2009. With robust scientific analysis as the foundation, the CAS developed a comprehensive set of strategies to promote resiliency to these impacts and action plans to implement these strategies.

Climate Adaptation Strategy Components

The development process for the Climate Adaptation Strategy involved three major components: science, strategy, and action. The first key component was the collection of more detailed and comprehensive scientific data on the expected impacts of climate change to California. This strong scientific foundation continues to be crucial in understanding how climate change will affect the state and necessary to ensure appropriate adaptation efforts are undertaken. A major component of this scientific information is obtained through PIER, funded primarily through the California Energy Commission. This information will help to better assess resources in terms of their level of exposure to a climate hazard, degree of vulnerability to that hazard and ability to respond to potential impacts.

The second major component of the planning process was the development of a comprehensive set of strategies to address each of the projected climate change impacts to California. Taking into account the risks and vulnerabilities to each sector identified in the scientific analysis, the Climate Adaptation Strategy prioritizes the most important strategies to reduce future negative consequences from climate change. These strategies include a wide range of approaches, including suggestions for specific projects, new policies or updates to existing policies, necessary legislation or new regulations, and additional research needs. The CAS includes both statewide strategies and suggestions for strategies at the local level, as well arrange of strategies to account for the remaining uncertainty regarding the precise nature of climate impacts. In addition to strategies specific to sectors, the CAS also outlines cross-sector measures to reduce risk and vulnerability from climate change.

The third component of the process, action, emphasizes the need to begin implementing priority strategies as soon as possible. The nature of climate change, and the varying levels of uncertainty in many predictions of future climate change impacts, requires working within a flexible framework and often necessitates taking action before complete information is available. Policymakers and planners can no longer rely on historical records to predict the future, as climate change will introduce significant variation in future outcomes. While the scientific and economic analyses conducted to inform the Climate Adaptation Strategy will provide a solid foundation for the development of initial adaptation strategies, some uncertainty will remain about the precise magnitudes, timing, and effects of climate change impacts. Due to the very high future costs of inaction, however, risk management through effective adaptation planning will require taking action now based on probabilities and risk assessments that outline the most robust predictions for how climate change will impact California.