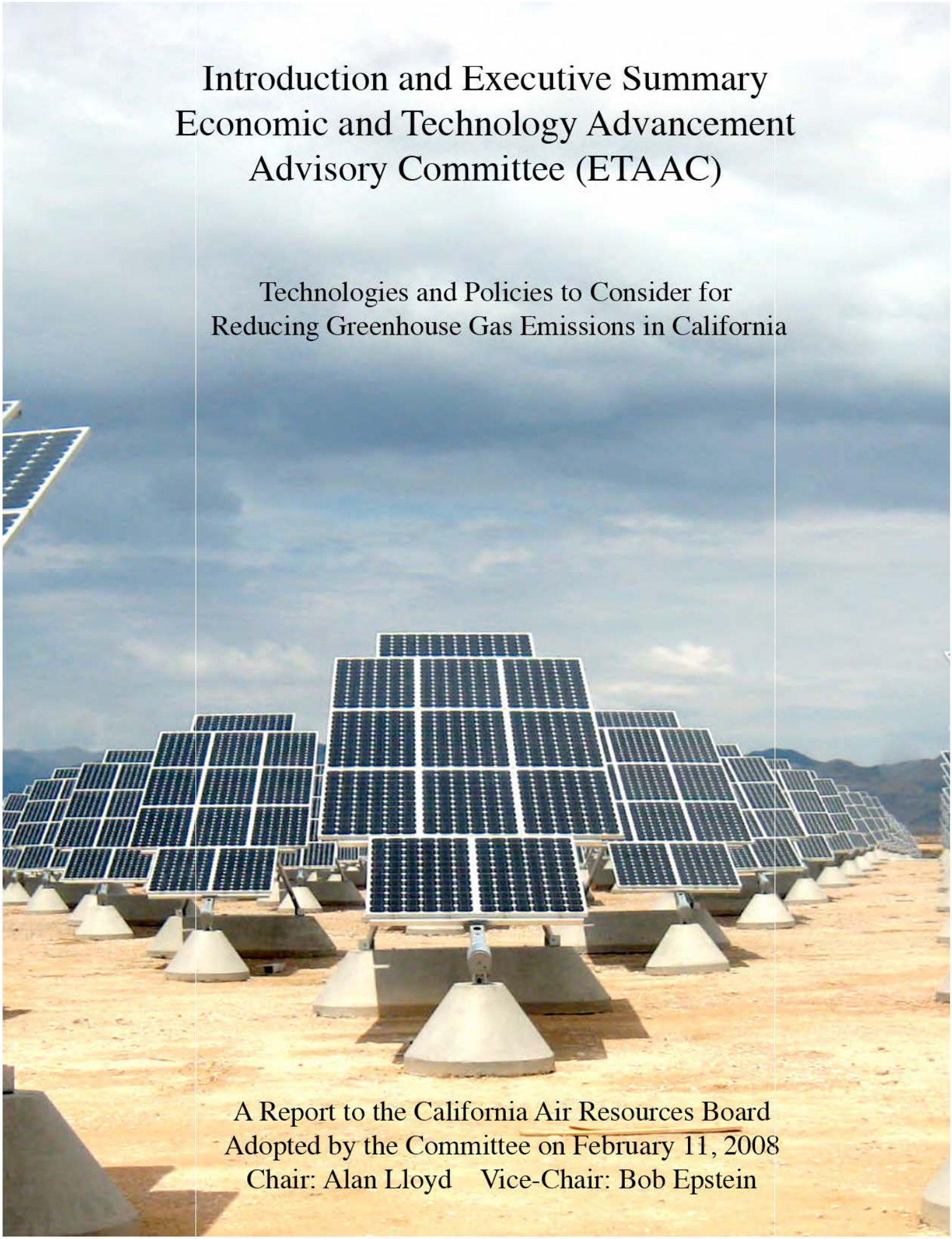
Introduction and Executive Summary Economic and Technology Advancement Advisory Committee (ETAAC)

Technologies and Policies to Consider for Reducing Greenhouse Gas Emissions in California



A Report to the California Air Resources Board
Adopted by the Committee on February 11, 2008
Chair: Alan Lloyd Vice-Chair: Bob Epstein

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Recommendation of the
Economic and Technology Advancement and Advisory Committee (ETAAC)
February 14, 2008

To: Chair Mary Nichols and
Members of the California Air Resources Board (CARB)
From: Members of the ETAAC Committee

We are very pleased to present to you our policy and technology recommendations for reducing greenhouse gas emissions in California. Our report includes 55 specific recommendations for greenhouse gas reduction strategies in the areas of finance; transportation; industrial commercial and residential end users; electricity and natural gas; agriculture; forestry; and water policy. As requested by CARB, we also examined the Market Advisory Committee's Report from the perspective of how particular market mechanisms can stimulate early action, promote innovation and establish clear price signals.

Climate change threatens California's environment and economy. We must move California from its current level of 14 tons of carbon-dioxide equivalent per person down to 10 tons/person by 2020. As requested by CARB, we also looked towards an 80 percent reduction by 2050, which would require a level of 1.5 tons/person by 2050. To achieve these significant reductions will require more efficient use of energy, the virtual elimination of all GHG emissions from the state's energy infrastructure and a substantially different mix of transportation systems and fuels. A key part of the committee's task is to expand the scope of technical and economic solutions available for consideration.

There are also opportunities for California's economy, environment and citizens. Developing cleaner energy and transportation systems will give California a chance to improve the security of fuel supplies, address stubborn air pollution concerns, and develop more livable communities. In many cases, these solutions provide important co-benefits by addressing difficult and long-standing problems, including the achievement of Environmental Justice objectives.

We hope this report provides a wide and diverse range of alternatives that will inform policymakers in their efforts to meet both the economic and environmental goals of AB 32. Our specific policy recommendations are all based on the following policy strategies and technology opportunities that are outlined in Chapter 1 of our report:

Major Strategies:
- Accelerate GHG Emission Reductions
- Balance a Portfolio of Economic and Technology Policies
- Create Innovative Public Funding to Complement Private Investment
- Foster International and Domestic Partnerships
- Leadership Across State Agencies

Major Opportunities

- Accelerate Efficiency Measures
- Remove Carbon From Energy Sources
- Rethink Transportation to Lower Demand and Carbon Emissions
- Reduce GHG Emissions from Industry, Agriculture, Forestry and Water
- Capture Cleantech Employment, Economic, Health and Environmental Justice Co-Benefits

After CARB convened ETAAC in January 2007, we conducted 9 public meetings across the state. Over 200 members of the public provided comments in writing or in person. Our committee was composed of people from a wide cross-section of California's business, academic, government and non-profit communities. As expected, members hold differing opinions and unique perspectives on the topics covered in the report. However, members are united in the effort to develop recommendations that will help meet the emission targets of AB 32 and also yield the co-benefits of cleaner air, health benefits, new industries and job growth here in California. It is our hope that the knowledge and products created in response to AB 32 can strengthen both the California economy and the state's international leadership on environmental issues.

This final ETAAC report reflects consensus views when consensus was reached, and reflects a range of differing points-of-views when there was general support that fell short of a consensus. Each recommendation may not necessarily reflect the views of every ETAAC member.

Thank you for the opportunity to serve the State of California.

Respectfully submitted,

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Recommendations of the Economic & Technology Advancement Advisory Committee (ETAAC)

Introduction & Executive Summary

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Page numbering may not match the full report due to formatting differences.

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CHAPTER 1 INTRODUCTION & EXECUTIVE SUMMARY

I: The Challenge & The Opportunity

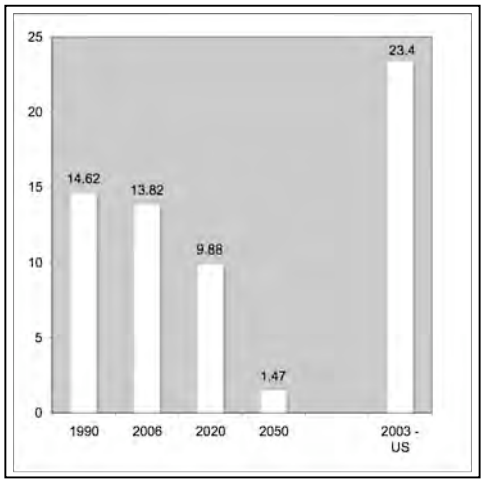

Figure 1-1: California per capita CO_2 equivalent (tons per person)

Global climate change presents California with serious challenges to the health of its people and ecosystems and the vitality of its economy. Properly implemented, the solutions to climate change can also present enormous opportunities. The California Legislature and Governor Schwarzenegger approved AB 32, the California Global Warming Solutions Act of 2006, which requires the state to cut total greenhouse gas (GHG) emissions such as carbon dioxide (CO_2) by 25% by 2020 (compared to "business as usual" economic activity.)

Prior to the passage of AB 32, Governor Schwarzenegger issued a 2005 Executive Order that set an even more ambitious climate change response program: an 80% GHG emission reduction by 2050. Other nations and states are now adopting this aggressive reduction target in light of recent scientific findings that suggest the world may soon be reaching a tipping point on climate change impacts. Given California's expected population growth, this 2050 reduction target creates great challenges for the state, as it requires a 90% per capita reduction in GHG emissions (see Figure 1-1). Meeting this target will require a sense of urgency for vastly more efficient use of energy and the virtual elimination of all GHG emissions from the state's energy infrastructure.

Despite these seemingly daunting challenges, California's climate change policies can benefit the state's economy, environment, and residents. Developing cleaner energy and transportation systems will give California a chance to improve the security of fuel supplies, address stubborn air pollution concerns, and develop better-designed communities and buildings.
The development of better methods of moving people and goods throughout the state is another opportunity to improve economic efficiency and reduce pollution and congestion in the implementation of our climate change response program. In many cases, these solutions provide important

co-benefits by addressing difficult and long-standing problems. Among them is the inequitable distribution of the environmental costs associated with California's electric power and transportation infrastructure.

Continuing California's long-standing tradition of innovation on environmental issues, AB 32 has given the California Air Resources Board (CARB) a leadership role in forging new approaches to diminishing the state's carbon footprint (while working with other state agencies). Existing California programs have demonstrated that major air pollution reductions can be achieved through economic and technological advancements. For example, new electric power plants in California now emit 90% less ozone and particulate forming Nitrogen Oxides (NOx) than they did two decades ago due to technology-forcing regulations. Strict technology-forcing standards have also resulted in California's greenest new passenger cars emitting 99% less Volatile Organic Compounds (VOC) and NOx than vehicles did in 1970. Policies supporting aggressive energy efficiency upgrades, as well as higher energy prices and a transition toward a service-oriented economy, have all helped California keep its per capita electricity consumption flat for the past few decades. California has achieved this feat, in part, through a balanced portfolio of policies, performance standards and market-based incentives. These State policies addressed important market failures: pollution externalities; market barriers to private sector Research, Development & Demonstration (RD&D); misplaced financial incentives; and imperfect information for energy consumers. As California turns its attention to combating global climate change, new State policies designed to surmount these and other market failures must expand in scope and creativity.

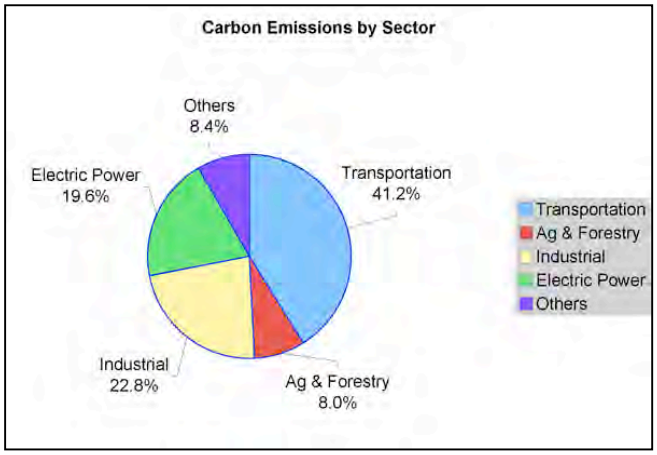

Figure 1-2: Carbon Emissions by Sector

As shown above in Figure 1-2, GHG emissions result from many activities ranging from transportation to manufacturing to agriculture.

Policies implemented under AB 32 and the Governor's Executive Order for 2050 must address all sectors of California's economy so that all significant sources of GHG emissions participate in both the challenges and opportunities afforded by this critical piece of state legislation. This broad-scaled approach is the most likely to create a level playing field, and address new alternative energy sources and fuels that could be used in multiple sectors. For example, policies need to recognize that electricity and biofuels will likely compete with more traditional transportation fuels in the future; therefore, policies that address only the electric sector or only the petroleum refining sector are unlikely to achieve the goals of AB 32.

The initial AB 32 target of reducing California's GHG emissions back to 1990 levels by 2020 is the critical first step toward reducing emissions and placing the state on a trajectory to meet long-term GHG reduction goals. The long-term reduction goals for 2050 and beyond are equally important and will require fundamental changes in consumer behavior, in energy use, and in the infrastructure that supports virtually all economic activity. In some cases, the state will encounter tradeoffs between the actions necessary to bring about the wide scale transformation of a carbon-free economy with those that may bring about the lowest cost emission reductions in the short term. This report identifies recommendations to achieve both short-term and long-term goals. Balanced and innovative approaches are clearly needed.

II: Major Strategies and Opportunities

AB 32 instructs CARB to create the Economic and Technology Advancement Advisory Committee (ETAAC) and instructs ETAAC to do the following:

> *"Advise on activities that will facilitate investment in and implementation of technological research and development opportunities including, but not limited to, identifying new technologies, research, demonstration projects, funding opportunities, developing state, national, and international partnerships and technology transfer opportunities, and identifying and assessing research and advanced technology investment and incentive opportunities that will assist in the reduction of greenhouse gas emissions. The committee may also advise the CARB on state, regional, national, and international economic and technological developments related to greenhouse gas emission reductions."*

ETAAC has identified five major strategies for promoting economic and technology advancement. The Committee believes these policy approaches are key to California's success in tackling the climate change challenge. ETAAC has also identified five key areas of opportunity, places where the state must focus its attention and resources to deliver the GHG emission reductions and ancillary benefits needed for climate success. A general description of each of these strategies and opportunities follows. A map of how each recommendation in the report reflects these major themes is included in a chart at the end of this introductory chapter.

Strategy 1: Accelerate GHG Emission Reductions

Collecting solar energy

AB 32 establishes a fixed timeframe for California to achieve a 25% reduction in GHG emissions relative to current levels. This 2020 timeframe is useful because it provides business and policy-makers specific targets for long-term planning. However, the competing interests of many different stakeholders – including industry, labor, environmentalists, land owners, and others – has led to a regulatory system for project approval that can be complex, time-consuming, costly, and often litigious. Gridlock would not serve California identified areas (for example the deployment of advanced large scale renewable energy – section 5.III.D and methane digesters – Chapter 6.II.A, etc.) where the project approval process could be improved without compromising environmental integrity. To successfully complete this task, however, will require addressing the special interests that created the existing system to begin with. Leadership and skill to help design politically acceptable compromises will be needed.

There is an urgent need for investments in GHG emission reductions before the AB32 implementing regulations begin taking effect in 2012 because some investments in particular technologies may preclude other choices that would lead to even greater GHG emission reductions. In many cases, delaying these

investments will also delay the total benefit of actions that could be taken today to reduce GHG emissions.

Lingering regulatory uncertainty has stymied some potential investments. These "early actions" by the private sector could proceed at a faster pace if the potential economic benefits of early actions were made explicit. The actual economic value of "credits" for early action depends on market and regulatory decisions that may not occur immediately. If ownership and quantification of these "early action" credits were more clearly defined, increased investment in GHG emission reduction projects could begin to flow, leaving California in a much better position to cost effectively meet the AB 32 GHG emission reduction targets.

Strategy 2: Balance a Portfolio of Economic & Technology Policies

Placing a price on carbon and other GHG emissions is a critical step towards responding to the climate change threat as it allows private markets to incorporate the value of reducing these emissions into their everyday business decisions. One potential option is a market based "cap and trade" system which establishes a cap on allowable GHG emissions that would ratchet down over time. A declining cap can send the right price signals to shape the behavior of consumers when purchasing products and services. It would also shape business decisions on what products to manufacture and how to manufacture them. Establishing a price for carbon and other GHG emissions can efficiently tilt decision-making toward cleaner alternatives. This cap and trade approach (complemented by technology-forcing performance standards) avoids the danger of having government or other centralized decision-makers choose specific technologies, thereby limiting the flexibility to allow other options to emerge on a level playing field.

If markets were perfect, such a cap and trade system would bring enough new technologies into the market and stimulate the necessary industrial RD&D to solve the climate change challenge in a cost effective manner. As the Market Advisory Committee notes, however, placing a price on GHG emissions addresses only one of many market failures that impede solutions to climate change. Additional market barriers and co-benefits would not be addressed if a cap and trade system were the only state policy employed to implement AB 32. Complementary policies will be needed to spur innovation, overcome traditional market barriers (e.g., lack of information available to energy consumers, different incentives for landlords and tenants to conserve

energy, different costs of investment financing between individuals, corporations and the state government, etc.) and address distributional impacts from possible higher prices for goods and services in a carbon-constrained world. Investing revenues from any allowance auctions in low and zero carbon technology development and deployment will greatly increase the benefit of putting a price on carbon. Performance standards (i.e. emissions per kilowatt-hour, per mile traveled, per units produced, etc.) also have a proven history of success and need to continue to be part of California's strategy. In complying with a performance standard, a regulated entity should have the choice to use a mix of technologies that brings the entity into compliance on an equivalent basis with a particular performance standard. In addition, California can consider revenue-neutral fee shifting to reward the purchase of lower carbon products (see Chapters 2.III.E and 3.IV.G).

These complementary economic and technology development strategies form the core of ETAAC's policy recommendations found in this report. Many of the strategies outlined in the following pages of this report would be much more effective with appropriate price signals that flow from a declining cap on GHG emissions combined with near and long-term development of low and zero carbon alternatives. A well-conceived diverse portfolio featuring both market-based policies and regulatory measures will be more efficient and less costly than relying exclusively on options from either category of potential solutions on their own.

Government policy should not attempt to pick technology winners. Rather, performance-based programs—whether market-based, command-and-control, or incentive oriented—should be the normal course of business. ETAAC makes a number of recommendations based on the need to help emerging technologies move through demonstration phases to achieve full commercial viability (see Chapters 2.II.B and 4.III.I). For instance, policies shaping development and demonstration of innovative technologies may differ from those focused on introducing technologies into the marketplace on a commercial scale. The best approach may be to support new technologies to the point where they can stand-alone within a market structure characterized by performance standards and carbon prices that become a part of everyday decision-making by consumers and businesses. Full performance battery electric and fuel cell vehicles, for example, are two major zero tailpipe emission technologies currently under development. While both technologies will require significant government involvement to become fully

commercialized, ETAAC does not advise selecting one or the other as the preferred future technology. In the shorter term, plug-in hybrids using clean electricity as part of their vehicle fuel may compete with other vehicle technologies using lower carbon advanced vehicle fuels. Thus, standards, policies, and incentives should be aimed towards establishing a level playing field and lowering barriers to technologies that can then compete based on price, efficiency, emissions, convenience, and other factors.

Flexibility in program design and implementation will be necessary to minimize the negative economic impacts that might result from AB 32 implementation and to recognize the need to phase-in new, low-and zero carbon technologies into the state's economy. Preserving flexibility for changing circumstances in the future is yet another important goal embedded in the work of ETAAC. Electric power generation stations and other forms of capital-intensive infrastructure being planned today may become the primary energy sources for advanced vehicles of the future. The crossover and spillover effects of today's investment decisions will present significant challenges and opportunities for both energy and transportation sectors.

Strategy 3: Create Innovative Public Funding to Complement Private Investment

Bio energy research at Stanford University's Global Climate and Energy Project

One result of the lack of a clear price for GHG emissions today is the inadequate level of RD&D for new low and zero carbon technologies. Companies invest much less in RD&D than is socially optimal because they expect a high return on their capital investments, they may not capture all the benefits of RD&D investments, and because RD&D is an inherently risky undertaking. Stimulating innovation in new technologies is the goal of RD&D. Broadly speaking, there are two ways to foster innovation: by funding RD&D directly or by requiring improved performance in the marketplace. In the energy sector, where new technologies are often very capital intensive and integrated into complex

production systems, a balanced approach that uses both methods is clearly desirable.

The policies created to support AB 32 will galvanize significant private sector investment in California, but this expected investment will not be enough to reach all areas necessary to achieve the overall GHG emission reduction goals. ETAAC reviewed areas where public financing, possibly leveraged with private capital, can stimulate innovation and accelerate adoption of cleaner products. ETAAC has identified the technology demonstration/pre-commercialization phase in a product's life cycle as a critical stage for this type of investment. If California decides to adopt a cap and trade system that includes the auction of emission allowances, ETAAC proposes that a California Carbon Trust – discussed in greater detail in Chapter 2.II.A – can direct investments in RD&D and finance technology pilot projects in disadvantaged communities and throughout the State of California. Often, these projects offer co-benefits such as improved air quality or employment. Investments from the California Carbon Trust can fill RD&D funding gaps by leveraging the capabilities of universities, State agencies, non-profits and other pioneering research leaders throughout the state.

If auction revenues from a carbon cap and trade system are large enough, they can also be used to reduce the negative impacts of some of the more distortionary elements of California's current taxation system. In addition, these revenues could provide resources for GHG emission reductions. This represents another potentially important policy option because it could improve the economic efficiency of the overall California economy. Alternatively, these revenues could address Environmental Justice issues by assisting communities or industries that are disproportionately affected by climate change or by climate change mitigation programs. Any such assistance should not eliminate the incentive created by placing a price on carbon, but instead should help with short-term transitions to a more competitive, low-carbon economy.

California does have several hundred million dollars worth of existing incentive fund programs underwriting RD&D and related research activities (outlined in Appendix III). They typically serve specific functions. At present, none of them specifically target GHG emission reductions and they also are not currently coordinated to achieve the maximum amount of co-benefits. ETAAC recommends that the State of California make an affirmative commitment to RD&D programs geared toward GHG emission abatement

(see Chapter 2.II.B), and examine how to best integrate these climate change priorities and existing State funded programs with existing environmental and energy policy goals. The State should also consider creating a new organization to house these and other programs. By not just supporting, but actively promoting clean energy innovation, California has the opportunity to seed the marketplace with promising new technologies that may provide critical tools to achieve AB 32's reduction targets. This seeding effort will also bring to market solutions necessary to meet the 2050 goal of a carbon-free economy. This will also drive new investment dollars to California and better enable our state to attract and nurture the most promising clean energy start-up businesses.

Strategy 4: Foster International and Domestic Partnerships

California should learn from the European Union and others in the international community that have already moved forward on the implementation of policies designed to respond to global climate change. California can learn from both policies that have worked and those that have not. Success on the climate change front domestically can benefit greatly from partnerships between the public and private sector (see Chapter 4.III.H), between State and local governments, between the State and Federal government, and between the State and other nations. Broad deployment of clean technology will generally drive down costs and lead to subsequent generations of innovation. California must leverage agreements with western U.S. states, Canadian provinces, the European Union, the United Kingdom and other countries and coordinate with Federal programs (such as the recently signed "Energy Independence and Security Act" – H.R. 6) if AB 32 is to accomplish its expressed intent. Achieving genuine success on climate change will also require the transfer of clean technology to developing nations, including China, India, Mexico and Latin America. Exporting both information on public policy solutions and the benefits of a strong Cleantech industry is one example recommended by ETAAC (see Chapter 2.II.B); partnering with other states, the Federal government, and other nations on low and zero tailpipe emission vehicles is another (see Chapter 3.IV.E).

Within the state, leveraging and coordinating RD&D efforts of State and Federal labs, private research institutes, universities and non-profit organizations is a major opportunity for California to garner cost-effective emissions reductions and co-benefits. CARB has initiated two projects that will offer stakeholders consolidated documents illuminating climate research

efforts and priorities in California. The California Climate Research, Development, Demonstration, and Deployment (RDD&D) catalog will present climate-related research and commercialization efforts underway in California in a publicly available, searchable database. The California Climate RDD&D Road Map will delineate each State agency's research priorities in support of AB 32's climate change response goals. The catalog and road map were initiated in October 2007 and will be completed by April 2008. A coordinated effort would ensure that market and policy signals reach and influence RDD&D being funded at these innovation centers (see Chapter 2.II.B). Such an effort may facilitate policy initiatives that reflect real technological progress and may help individual innovations achieve the necessary scale more quickly. This could be accomplished by a new entity charged with coordinating low and zero carbon research efforts, or it could be accomplished by an existing private or public entity. The CPUC recently acknowledged a similar need and opened a proceeding to consider creating a "California Institute for Climate Solutions" to be administered within California universities.

Strategy 5: Leadership Across State Agencies

There must be effective leadership across all State agencies to reduce GHG emissions from their own governmental operations and from the stakeholders they oversee and/or regulate. Just as all sectors of the state's economy need to participate in the opportunities and challenges of meeting California's GHG emission reduction goals, all State agencies must also participate (with Cal/EPA playing a key government coordination role). This sort of coordination will also be important for planning efforts to adapt to the climate change effects that could still potentially occur even if atmospheric GHG levels are stabilized to avoid the most severe negative impacts (see Chapters 3.IV.H and 5.VI.K).

Many new technologies and practices to lower GHG emissions will also have co-benefits such as less air pollution or lower water consumption. But some will also lead to higher costs and may even exacerbate other policy challenges. It will be necessary for California to identify and manage tradeoffs that will occur as it addresses climate change. Tradeoffs among different public policy objectives should be integrated across all State agency decisions – those associated directly with AB 32 as well as other air pollution regulations, infrastructure development, and so forth. Such reciprocity is needed to avoid an unbalanced set of regulatory and project decisions that

would result in missed opportunities to help meet climate change goals and integrate these goals into other State programs. SB 85, approved in August 2007, calls for an annual Report Card summarizing progress from all State agencies (section 12892). ETAAC strongly supports this Report Card as a way of providing regular feedback. If possible, these Report Cards should be strengthened with independent, third party verification.

Opportunity 1: Accelerate Efficiency Measures

The most cost-effective GHG emission reduction opportunities continue to be investments in energy efficiency. Whether it is more efficient buildings, appliances or motor vehicles, initial up-front investment is rewarded – often very quickly – with reduced energy use and lower overall costs. While California has led the nation in building and appliance efficiency, the State has significant opportunities to do much more. In some cases, further technological innovation is needed to create more efficient products. In other cases, faster adoption of existing and emerging technology needs to be encouraged (see Chapters 3.IV.E, 3.IV.F, 4.III.F;,5.II.A, 5.II.B).

ETAAC believes that new types of financing will likely increase the development and adoption of energy efficient technologies and practices. Consequently, financing policies that can be implemented through utilities or municipalities to increase efficiency are recommended (see Chapter 2.III.F, G). The potential use of auction proceeds to help finance efficiency upgrades to lower energy bills in historically disadvantaged communities is another opportunity to achieve efficiency, while also meeting AB 32's Environmental Justice goals.

Energy efficiency opportunities exist in all the sectors considered in this report. ETAAC recommends that the State, in considering these opportunities, ensure the proposed programs and measures are coordinated to avoid overlaps, duplication, and double-counting.

Plug-in vehicle

Opportunity 2: Remove Carbon from Energy Sources

California's future sources of electricity, transportation fuels and heating fuels will need to be zero or near-zero carbon by 2050. Renewable energy technologies such as wind, solar, and others offer the technical potential to

generate all of California's electricity, but there are a number of technical and implementation challenges that will not be simple to overcome. ETAAC examined the opportunity of how to quickly scale up these sources of renewable energy, (such as wind, solar, and geothermal steam) both on-site distributed generation and central utility-scale power plants. ETAAC also identified barriers that must be overcome (See Chapter 5.III.C) to achieve an increase in renewable energy or carbon-free equivalent to 33%. In addition, biomass sources, if coupled with carbon sequestration, could produce renewable energy supplies and permanently remove carbon from the atmosphere provided that there are no net adverse air quality effects from growing and using the biomass (see Chapters 6.II.A, 6.II.C, 6.II.D and 7.IV.A).

Electricity storage has the potential to enable higher penetrations of renewable energy in California's power supply portfolio. Technologies such as pumped hydro storage, compressed air, thermal storage, batteries, or hydrogen can transform intermittent renewable generation into a reliable resource for energy planning (see Chapter 5.IV.F). Electricity storage in the form of plug-in electric vehicles has the potential to both reduce reliance on fossil fuels in the transport sector and allow for even greater utilization of existing and future renewable electricity generation (see Chapter 5.IV.G).

In the AB 32 timeframe, ETAAC believes fossil fuels, including natural gas, can play an important role for both power generation and heating. Over the long term, fossil fuels such as natural gas are most likely to play a valuable role for traditional uses and as a feedstock for vehicle energy supplies if carbon can be separated and permanently stored. Large scale deployment of low carbon, zero carbon and even negative carbon biomass energy will likely require methods to permanently sequester carbon. California should continue to partner with other states, Federal agencies and international partners to encourage RD&D to find cost-effective and safe methods of sequestering CO_2 streams from power generation (see Chapters 5.V.I)

Opportunity 3: Rethink Transportation to Lower Demand & Carbon Emissions

Transportation by far accounts for the largest fraction of GHG emissions in California, roughly 40% of the state's total inventory. In order to meet 2050 GHG goals, the transportation sector will need to accomplish a dramatic transition to new low and zero carbon technologies.

ETAAC recommends that California build upon existing State programs to reduce air pollution and "decarbonize" the state's transportation system. These existing programs include the Pavley – Schwarzenegger vehicle GHG emission regulations, the Low Carbon Fuel Standard, the Low/Zero Emission Vehicle program and the Zero-Emission Bus program. California should also initiate a near-term program to reduce GHG emissions from Heavy-Duty Vehicles (HDV). The infrastructure to deploy technologies emerging from these State programs must also be based on low or zero emission fuel supplies.

Hybrid-electric hydrogen fuel cell bus

In addition to transportation technology itself, it is time to rethink current methods of mobility for both freight and people. California's growth in motor vehicle purchases and State investments in road infrastructure occurred largely during a period in time when transportation fuels were inexpensive. This is no longer the case. Decreasing Vehicle Miles Traveled (VMT) is critical to meeting AB 32 GHG emission reduction goals. Reducing this growth will also yield important co-benefits such as diminishing the time lost in traffic congestion and the corresponding improved quality of life. Putting a price on carbon is one way to help reduce vehicle use and congestion. Yet these approaches are limited in scope. They must be complemented by pricing for other currently un-priced transportation costs, alternative transit options, such as electric rail, and urban and suburban designs that provide better and affordable alternatives to the internal combustion engine (see Chapter 3.III). Local government land use planning decisions will need to be coordinated with statewide priorities to encourage transit-oriented residential and commercial development (see Chapter 3.III.A). Without such coordination, overall VMT will climb due to current population growth rates. This is just one of many ways in which local governments are a key partner with the State in complying with AB 32.

California's freight systems will need a similarly dramatic overhaul. California's coastal ports and Central Valley freeways have become

increasingly congested. Alternative modes of goods movement have become both a necessity and an opportunity to reduce GHG emissions and other criteria air pollutants.

Opportunity 4: Reduce GHG Emissions From Industry, Agriculture, Forestry & Water

Forest, agricultural and industrial practices also emit GHG emissions due to energy consumption and other activities. Significant opportunities exist to reduce these GHG emissions through established best practices such as the expanded and judicious use of combined heat and power in industry (see Chapter 4.II.C). In addition, both the agriculture and forestry sectors hold the long term potential to sequester carbon in biomass and soil (see Chapter 6.II.E, 6.II.F and Chapter 7.IV.B).

Family planting trees

Water use in California is extremely energy intensive. Today, more than 19% of electricity, 30% of natural gas not used for electricity generation, and 88 million gallons of diesel fuel per year are used to treat, deliver and heat water in California each year. Policies and technologies that increase the efficiency of the state's water delivery systems and reduce end-use will produce multiple benefits. Less demand for water resources translates into reduced emissions of CO_2 and other air pollutants since less energy is used to pump, treat and move water. Other economic and environmental benefits also flow from water efficiency (see Chapter 8.II.A and 8.II.B). There is also an opportunity to capitalize on carbon-sequestering benefits of soil and biomass and reduce end-use water demand by providing incentives for sustainable practices, including the application of compost (see Chapter 4.IV.L and 4.IV.N).

Opportunity 5: Capture Cleantech Employment, Economic, Health, & Environmental Justice Co-Benefits

Installation of solar photovoltaic panels

Many policies designed to combat climate change can also bring about substantial economic, health and environmental co-benefits for the State of California. For example, climate policies can stimulate the Cleantech industry in California providing both economic growth and jobs.

The Cleantech industry encompasses everything from alternative energy generation to wastewater treatment to more resource-efficient industrial processes. Although each of these industries is unique, they all share a common thread: they rely upon new and innovative technology to create products and services that compete favorably on price and performance while reducing our collective environmental footprint. Given its legacy of entrepreneurism and clean energy innovation, California is well positioned to attract venture capital investments in Cleantech companies. In 2007, California led the nation in Cleantech venture capital with $1.78 billion, representing 48% of total U.S. Cleantech investments of $3.67 billion. This represents a 50% growth over 2006 in venture investments in California companies.

Cleantech represents a new export opportunity, too. Cleantech products will increasingly be needed worldwide to address climate change and other challenges associated with the decreasing availability of water and other natural resources. Furthermore, Cleantech is spurring new employment opportunities in such fields as solar energy and energy efficiency device installation. ETAAC proposes State supported training programs to encourage the development of these kinds of green-collar jobs (Chapter 2.III.D).

At present, the State of California is doing little to encourage the manufacturing of Cleantech products within state borders. In fact, it is quite possible that many Cleantech companies will locate their manufacturing operations out-of-state, while keeping their corporate headquarters and RD&D facilities in California. (This trend is already underway.) The State

should consider a variety of policy recommendations to make it more economically attractive to both invent *and* manufacture solutions to climate change in California. Such incentives would allow California to more fully reap the economic benefits of the rapidly expanding Cleantech industry (Chapter 2.III.C).

Some policies designed to combat climate change can reduce pollutants affecting local public health. Ground level ozone and black carbon (a type of fine particulate mostly from diesel combustion) contribute to both climate change[1] and major public health problems that exist in California[2]. Assessing existing regulations for public health pollutants such as ozone and fine particulate regulations were outside the scope of the ETAAC report. Nevertheless, ETAAC acknowledges the importance of existing programs to achieve public health standards and welcomes innovations that would further these goals while also meeting AB 32's GHG emission reduction targets. In addition, ETAAC has identified a number of opportunities to reduce CO_2 and other GHG emissions along with reducing ozone and fine particulates.

In evaluating potential policy and technological fixes to comply with the challenges of AB 32, ETAAC recognized the need to develop solutions that avoid imposing undue compliance or increased pollution burdens on disadvantaged communities suffering from historic pollution levels. Instead, ETAAC has explored how AB 32 could create new economic opportunity for these same communities. Many recommendations were designed in part to specifically reduce pollution burden in Environmental Justice areas (see Chapter 2.II.A). In all cases, further evaluation such as cumulative impacts assessment need to occur when specific implementation measures are developed by CARB or other agencies or organizations to ensure Environmental Justice benefits and avoid disadvantages.

III: Summary Message

California has a prime opportunity as it seeks to meet the challenges embodied in AB 32. By acting sooner rather than later, California can lower the costs of transitioning to an economy less dependent upon carbon and other GHG emitting energy sources[3]. At the same time, it can reap the rewards of a more sustainable, efficient and competitive economic system. The opportunities linked to AB 32 cut across all sectors examined in this ETAAC report: transportation; industrial/ commercial/residential energy use; electricity/natural gas; agriculture; forestry; and water. Renewable energy,

alternative fuels, and energy efficiency could create environmental benefits and jobs in all stages of economic development, ranging from RD&D to manufacturing and the rest of product and equipment lifecycles.

Policy makers, industry and consumers must bear in mind that the long-term effects of decisions made today will still be with us in 2020, and in many cases, in 2050 and beyond. Land-use decisions and choices about new electric power generation infrastructure will either help or hinder California's efforts to meet both the 2020 and 2050 GHG emission reduction targets. Development of new kinds of clean vehicles and other transportation technologies over the next decade may dictate whether the state is on a trajectory toward meeting the AB 32 mandates or falling behind the curve on achieving these critical long-range goals.

Californians are ready to respond to the climate change challenge. To meet the timeframe outlined in AB 32, however, California must do the following:

- Continue the state's long-standing commitment to environmental policy and build on the success of existing programs and regulations in order to develop low and zero carbon solutions;
- Establish a clear market price on carbon to provide the incentives for businesses and consumers to reduce their carbon emissions efficiently and California should invest the value of any resulting auction or fee revenues to achieve additional reductions;
- Attract and leverage private capital for productive investments;
- Develop and retain new green collar jobs;
- Adopt polices and measures that facilitate the kind of business and technology innovations that have made California world renowned;
- Develop and maintain a capability to assess and adjust policies and measures over time as new conditions emerge and new technologies are developed. Other parts of the U.S. and the world are also investing in Cleantech and California needs to maintain its leadership position to comply with AB 32;
- Continue partnerships at the State, national, and international level with leaders on climate change mitigation strategies.

In addition to mitigating the dire impacts of climate change, effective action on AB 32 can also yield the co-benefits of cleaner air, new industries and jobs here in California. The knowledge and products created in response to AB 32

will strengthen both the California economy and the state's international leadership on environmental issues.

IV: The Role of ETAAC

ETAAC was created to facilitate the development of new policies and technologies as quickly and economically as possible, including initiatives that reach outside of direct GHG emission regulations. The California Air Resources Board (CARB) provided several specific areas of focus for ETAAC and requested that the Committee look broadly at issues that relate to CARB, other State agencies and the State Legislature:

- Review and prioritize incentive proposals for industry compliance with AB 32, identifying potential funding sources to underwrite these fiscal incentives;
- Identify the areas where public sector investment is critical to overcoming barriers to achieving the California's climate protection objectives by 2020 and 2050 and discuss whether those investments should be at the local, State or Federal level, or some combination thereof;
- Identify advanced technologies with the greatest GHG emission reduction potential, their commercial status, and the steps necessary to accomplish significant market penetration;
- Identify export opportunities for California businesses that specialize in carbon reduction technologies and services;
- Recommend key demonstration projects for early success and assist CARB in formulating proposals for public/private partnerships and the potential involvement of national and international organizations;
- Review and comment on the findings and recommendations of the Cal/EPA Market Advisory Committee, to the extent that report affects deliberations of ETAAC.

To meet these objectives, CARB appointed members to the ETAAC in January 2007. Members were selected based on their knowledge and expertise in fields of business, technology research and development, climate change and economics. (Brief biographies of members are listed in Appendix I.)

The Committee is chaired by former CARB chairman and former Cal/EPA Secretary Alan Lloyd, Ph D. The Committee vice-Chair is Bob Epstein, Ph D., noted engineer and entrepreneur, and co-founder of Environmental Entrepreneurs.

ETAAC has endeavored to adhere to the following ten general principles while carrying out its mission and tasks:

1. Address near, medium and long-term goals
2. Encourage early action
3. Foster collaboration at all levels of government
4. Encourage public and private research, demonstration and development
5. Leverage California's centers of innovation
6. Establish a level playing field and do not pick winners and losers
7. Maximize public health and socio-economic benefits
8. Address Environmental Justice concerns
9. Participation across all sectors
10. Flexible approaches

This final ETAAC report reflects consensus views when consensus was reached, and reflects a range of differing points-of-view when there was general support that fell short of a consensus. Each recommendation may not necessarily reflect the views of every ETAAC member.

ETAAC met nine times throughout California (see Appendix II) and received presentations by members of California's technology community. Meetings were subject to the Bagley-Keene Open Meeting Act and webcast to allow significant opportunities for public comments and input. ETAAC also received numerous suggestions from the general public for ways to reduce climate change emissions (a summary table of the suggestions received prior to the final drafting of this report is presented in Appendix IV and V). ETAAC has also agreed to develop an Internet website at www.etaac.org to provide access to details of the technologies ETAAC is reviewing as mechanisms to comply with AB 32.

The work of ETAAC is designed to complement ongoing efforts to reduce GHG emissions in California. The recommendations contained in this report do not replace or supersede existing State regulatory programs, or any adopted future policies authorized under AB 32. However, the ETAAC report may facilitate the development of technologies that help meet, or even exceed, the GHG emission reduction goals outlined in AB 32. Comments received by ETAAC regarding the development of specific rules have been collated outside of this report for consideration during the appropriate regulatory development process.

V: Organization of ETAAC report

Broad participation by all sectors of California's economy will be necessary to achieve the AB 32's reduction targets. This ETAAC report contains a chapter offering economic/financial strategies for climate change solutions that stretch across sectors, followed by one chapter for each of the six specific sectors analyzed from a stand-point of policy and technology strategies and opportunities (transportation, industry/commercial/residential, electricity/natural gas, agriculture, forestry, and water). ETAAC's comments on the Market Advisory Committee report also comprise a chapter in this report. Finally, detailed information on energy and transportation technology advances is included in the Appendix IV and V, respectively.

Developing solutions of the scale required by the climate change challenge will be a complex endeavor. It is therefore important to recognize that each of the proposed policies included in this ETAAC report will inevitably interact with one another. Each recommendation put forward by each ETAAC sector subgroup contains critical information on expected GHG emission reductions and an expected timeframe for achieving these reductions when each policy is considered as a stand-alone option. The "timeframe" sections of each policy recommendation are designed to indicate which of these policies can be in place in the near term (in time for the 2012 deadline of AB 32), medium term (in time for the 2020 deadline of AB 32), or long-term (in time for the 2050 deadline under the Governor's Executive Order). ETAAC did not prepare a full scale implementation analysis for these recommendations individually, or as an integrated program (which would depend on the menu of choices selected). ETAAC did, nonetheless, identify major co-benefits and mitigation requirements when such information was known and available. ETAAC believes that the benefits, costs, risks, trade – offs and uncertainties associated with climate change response policies must

be made transparent as California moves forward with the implementation of AB 32. In the final analysis, it is vitally important to understand and fully communicate the rich diversity of information included in this ETAAC assessment so that California policy makers and the general public can identify solutions to AB 32 that are fair, balanced, and effective.

Notes

[1] IPCC, Fourth Assessment Report (AR4), Working Group 1 Report *The Physical Science Basis*, Summary for Policymakers, 2007.

[2] *The California Almanac of Emissions and Air Quality*, 2007 Edition.

[3] Stern Review, Cabinet Office - HM Treasury (2006).

VI: Mapping from Recommendation in Chapters 2-8 to Categories, Timeframes & Responsible Parties

(for the full report see www.etaac.org)

Glossary

Recommendation	Relevant Strategies and Opportunities	Time-frame	Responsible parties
Chapter 2. FINANCE			
2A - Create a California Carbon Trust	Accelerate GHG Emission Reductions; Balance a Portfolio of Economic and Technology Policies; Innovative public finance; Accelerate efficiency; International and Domestic Partnerships	By 2012	CARB Legislature Other
2B - Promote Clean Energy Innovation and Commercialization	Balance a Portfolio of Economic and Technology Policies; Innovative public finance; Capture Economic, Health, and Environmental Justice Co-benefits; International and Domestic Partnerships	By 2012	CARB CEC CPUC
2C - Leveraging AB 32 to Spur California Job Creation and Manufacturing	Capture Economic, Health, and Environmental Justice Co-benefits	By 2012	Legislature CPUC Other
2D - Clean Technology Workforce Training Program	Capture Economic, Health, and Environmental Justice Co-benefits	By 2012	Other
2E - Fee and Tax Shifting (Feebates)	Balance a Portfolio of Economic and Technology Policies; Accelerate efficiency	By 2012	Legislature Other
2F - Municipal Assessment Districts	Innovative public finance; Accelerate efficiency	By 2012	Other
2G - On-Bill Financing for Small Business Energy Efficiency Projects	Accelerate efficiency	By 2012	CPUC Other
Chapter 3. TRANSPORTATION			
3A - Planning: Smart Growth and Transit Villages	Accelerate efficiency; Rethink Transportation to Lower Demand and Carbon; Capture Economic, Health, and Environmental Justice Co-benefits	By 2012	CEC Other Cal Trans
3B - Pay-As-You-Drive Insurance	Rethink Transportation to Lower	By 2012	CARB Legislature

	Demand and Carbon		Other Cal Trans
3C - Congestion Charges	Balance a Portfolio of Economic and Technology Policies; Rethink Transportation to Lower Demand and Carbon	By 2012	Legislature Other Cal Trans
3D - Employer-Based Commute Trip Reductions	Rethink Transportation to Lower Demand and Carbon	By 2012	CARB Other
3E - New Vehicle Technology Improvements	Accelerate efficiency; Rethink Transportation to Lower Demand and Carbon; Reduce GHG - Industry, Ag, Forestry, Water	By 2020	CARB Other
3F - Low GHG Fleet Standards and Procurement Policies	Balance a Portfolio of Economic and Technology Policies; Accelerate efficiency; Rethink Transportation to Lower Demand and Carbon	By 2012 By 2020	CARB Other
3G - GHG-based Vehicle Feebates and Registration Fees and Indexed Fuel Taxes	Balance a Portfolio of Economic and Technology; Accelerate efficiency; Rethink Transportation to Lower Demand and Carbon	By 2012	Legislature Other
3H - Air Quality Incentives Programs and Standards	Balance a Portfolio of Economic and Technology Policies; Capture Economic, Health, and Environmental Justice Co-benefits	By 2012	CARB Legislature Other
3I - Create Markets for Green Fuels	Balance a Portfolio of Economic and Technology; Remove Carbon from Energy Sources; Rethink Transportation to Lower Demand and Carbon; Reduce GHG - Industry, ag, forestry, water	By 2012	CARB Other
Chapter 4. INDUSTRIAL, COMMERCIAL & RESIDENTIAL ENERGY USE			
4A - Cleantech Tax Incentives	Innovative public finance; Accelerate efficiency	By 2012	Legislature Other
4B - Rebates for Load Reduction	Accelerate efficiency; Reduce GHG - Industry, ag, forestry, water	By 2012	Other
4C - Improve Policies for Combined	Accelerate efficiency; Reduce GHG - Industry, ag, forestry,	By 2012	CEC CPUC

Heat and Power Plants	water		Other
4D - Distributed Renewable Energy Generation: Solar PV	Remove Carbon from Energy Sources	By 2020	Legislature CPUC Other
4E - Customer Choice of Electric Service Provider	Remove Carbon from Energy Sources	By 2012	Legislature CPUC
4F - Building Efficiency Programs and Incentives	Accelerate efficiency	By 2020	CEC Other
4G - Combustion Devices: Energy Efficiency	Accelerate efficiency; International and Domestic Partnerships	By 2012	CARB CEC Other
4H - Industry - Government Partnerships to Reduce Industrial Energy Intensity	International and Domestic Partnerships; Coordinate Across State Agencies	By 2012	CEC Other CalEPA
4I - A Revolving Fund for Technology Demonstration Projects	Innovative public finance; Accelerate efficiency; Reduce GHG - Industry, ag, forestry, water	By 2020	CEC Legislature
4J - Develop Suite of Emission Reduction Protocols for Recycling	Reduce GHG - Industry, ag, forestry, water	By 2012	CARB CIWMB
4K - Increase Commercial-Sector Recycling	Reduce GHG - Industry, ag, forestry, water	By 2012	CARB CIWMB
4L - Remove Barriers to Composting	Reduce GHG - Industry, ag, forestry, water	By 2012	CARB CIWMB Cal Trans
4M - Phase Out Diversion Credit for Greenwaste Alternative Daily Credit	Reduce GHG - Industry, ag, forestry, water	By 2012	CARB CIWMB
4N - Reduce Agricultural Emissions Through Composting	Reduce GHG - Industry, ag, forestry, water	By 2020	CARB CDFA CIWMB
4O - Evaluate and Improve Policies for Qualified Waste Conversion Technologies	Reduce GHG - Industry, ag, forestry, water	By 2012	Other
Chapter 5. ELECTRICITY AND NATURAL GAS			
5A - Energy Efficiency Program Coordination	Accelerate efficiency	By 2012	CARB CPUC

5B - Aggressive LED Energy Efficiency Programs	Accelerate efficiency	By 2012	CARB CEC CPUC
5C - Take Steps Necessary to Achieve an Increase in Renewable Energy to 33 Percent by 2020 to Reduce GHG Emissions	Balance a Portfolio of Economic and Technology Policies; Remove Carbon from Energy Sources	By 2020	CARB CEC CPUC Other
5D - Competitive Renewable Energy Zones	Accelerate GHG Emission Reductions; Remove Carbon from Energy Sources	By 2012	CEC CPUC Other
5E - Renewable Energy Technology Assessments	Remove Carbon from Energy Sources	By 2012	CEC CPUC Other
5F - Electricity Storage as an Enabling Technology for Renewable Energy	Remove Carbon from Energy Sources; Coordinate Across State Agencies	By 2012	CEC CPUC Other
5G - Plug-in Electric Drive Vehicles as Storage Devices	Remove Carbon from Energy Sources; Rethink Transportation to Lower Demand and Carbon	By 2020	CARB
5H - Smart Grid as Enabling Technology for Renewables and Clean Vehicles	Accelerate efficiency; Remove Carbon from Energy Sources	By 2012	Legislature CPUC
5I - Carbon Capture and Sequestration in Geological Formations	Remove Carbon from Energy Sources	By 2020	Other
5J - Low and Zero Carbon Electricity Generation Plan	Balance a Portfolio of Economic and Technology Policies; Remove Carbon from Energy Sources	By 2012	CARB CEC CPUC Other
5K - Unifying Standards for Climate-Related Programs	Balance a Portfolio of Economic and Technology Policies; Coordinate Across State Agencies;	By 2020	CARB CEC CPUC
Chapter 6. AGRICULTURE			
6A - Manure to Energy Facilities	Remove Carbon from Energy Sources; Reduce GHG - Industry, ag, forestry, water	By 2012 By 2020	CARB CEC CPUC Other CDFA CalEPA
6B - Enteric Fermentation	Reduce GHG - Industry, ag, forestry, water	By 2020 By 2050	Other CDFA
6C - Agricultural Biomass Utilization	Remove Carbon from Energy Sources; Reduce GHG - Industry, ag, forestry,	By 2020 By 2050	CARB CEC

	water		CPUC CDFA CalEPA SWRCB
6D - Dedicated Bio-Fuels Crops	Remove Carbon from Energy Sources	By 2012 By 2020	CARB CEC CDFA CalEPA SWRCB
6E - Soil Carbon and Sequestration	Reduce GHG - Industry, ag, forestry, water	By 2012 By 2020 By 2050	CEC CDFA SWRCB USDA/NRCS
6F - Riparian Restoration and Farmscape Sequestration	Reduce GHG - Industry, ag, forestry, water	By 2012 By 2020 By 2050	CDFA USDA/NRCS
6G - Fertilizer Use and Water Management Efficiency	Accelerate efficiency; Reduce GHG - Industry, ag, forestry, water	By 2012 By 2020 By 2050	CEC CDFA SWRCB USDA/NRCS
Chapter 7. FORESTRY			
7A - Link Forest Fuels Management and Biomass Utilization	Remove Carbon from Energy Sources; Reduce GHG - Industry, ag, forestry, water	By 2012	CARB Other CDF
7B - Reforestation and Forest Management for Enhanced Carbon Storage	Reduce GHG - Industry, ag, forestry, water	By 2012	CARB Other CalEPA CDF
7C - Urban Forests for Climate Benefits	Remove Carbon from Energy Sources; Reduce GHG - Industry, ag, forestry, water	By 2012	Other CDF Cal Trans
7D - Endorse "California Climate Solutions" Program	Capture Economic, Health, and Environmental Justice Co-benefits	By 2012	CARB Other
Chapter 8. WATER POLICY			
8A - Establish a Loading Order for Water	Accelerate efficiency; Reduce GHG - Industry, ag, forestry, water; Coordinate Across State Agencies	By 2012	Legislature CPUC Other SWRCB DWR
8B - Establish a Public Goods Charge for Funding Water Improvements	Accelerate efficiency; Reduce GHG - Industry, ag, forest, water	By 2012	Legislature CPUC SWRCB

Glossary

AB 32	California Global Warming Solutions Act of 2006
BEV	Battery Electric Vehicle
BLM	US Bureau of Land Management
BOE	Board of Equalization
Cal-EPA	California Environmental Protection Agency
CARB	California Air Resources Board
CalISO	California Independent System Operator
CalTrans	California Department of Transportation
CCAR	California Climate Action Registry
CCS	Carbon Capture and Storage
CDF	California Department of Forestry and Fire Protection
CDFA	California Department of Food & Agriculture
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CFIP	California Forestry Improvement Program
CHP	Combined Heat & Power
CIWMB	California Integrated Waste Management Board
CO2	Carbon Dioxide
CPUC	California Public Utilities Commission
DOE	United States Department of Energy
DWR	California Department of Water Resources
Emission Allowance	Authorization to emit a given quantity of a pollutant
Emissions Cap	A limit on emissions of greenhouse gases or other pollutants, with or without a trading system
FCEV	Fuel cell electric vehicle
GHG	Greenhouse Gases
Grandfathering	Setting emission limits or baselines based on historical emissions
EJAC	Environmental Justice Advisory Committee

ETAAC	Economic and Technology Advancement Advisory Committee
IOU	Investor-Owned Utility
LCFS	Low Carbon Fuel Standard
LED	Light Emitting Diodes
MAC	Market Advisory Committee
MMTCO2E	Million Metric Tons Carbon Dioxide Equivalent
MPR	Market Price Referent
MSW	Municipal Solid Waste
MW	Megawatts
MWh (or MWhr)	Megawatt-hours
NOx	Nitrogen Oxides
NEPA	National Environmental Policy Act
NRCS	Natural Resources Conservation Service
Offset	An emission reduction that can be used to mitigate an emission increase, or in lieu of an otherwise required emission decrease.
PHEV	Plug-in Hybrid Electric Vehicle
PM10	Particulate Air Emissions less than 10-microns in diameter
PV	Photovoltaic
RD&D	Research Development & Demonstration
RECs	Renewable Energy Credits
RPS	Renewable Portfolio Standard
SOx	Sulfur Oxides
SWRCB	State Water Resources Control Board
USDA	United States Department of Agriculture
USFS	United States Forest Service
VMT	Vehicle Miles Traveled

Diesel hybrid-electric bus

(Source: The International Council on Clean Transportation)

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