Greetings! This document is a discussion draft report that includes proposals made to the Economic and Technology Advancement Advisory Committee (ETAAC) by ETAAC members or members of the public. Consideration by ETAAC does not represent an ETAAC endorsement.

This discussion draft report is intended to provide a basis for public comment and for discussion by ETAAC at its next meeting, currently scheduled for January 25, 2008 at the Cal/EPA Headquarters Building in Sacramento.

Written public comments should be submitted via email to schurch@arb.ca.gov or by surface mail to

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Written public comments should be received no later than close of business on January 18, 2008 to ensure they will be available to the Committee at the January 25, 2008 ETAAC meeting.

Further information on ETAAC, including meeting times, locations and agendas, can be found at

http://www.arb.ca.gov/cc/etaac/etaac.htm

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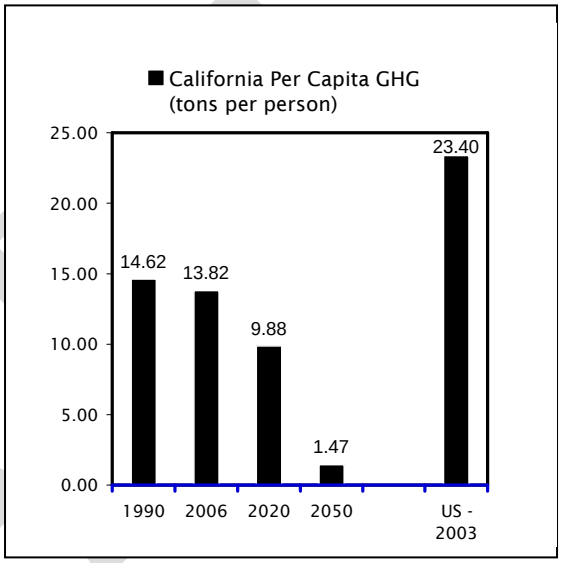
1. INTRODUCTION AND REPORT SUMMARY

I. The Challenge and The Opportunity

Global climate change presents California with serious challenges to the health of its ecosystems and the vitality of its economy. Recognizing this threat, the California Legislature and Governor Schwarzenegger approved AB 32, the California Global Warming Solutions Act of 2006. AB 32 requires that the state cut greenhouse gas (GHG) emissions such as carbon dioxide (CO_2) by 25 percent by 2020. This reduction target is calculated on a 1990 baseline of GHG emission levels and is measured against assumed business as usual economic activity.



Previous 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 percent 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 percent GHG reduction per capita. The target calls for vastly more efficient use of energy and the virtual elimination of all GHG emissions from the fuels and technologies that comprise the state's energy infrastructure.

Despite these seemingly daunting challenges, California's climate change policies also offer monumental opportunities that can benefit the state's economy, environment, and the public health of its citizens. Developing cleaner energy and transportation systems will give California the chance to improve the security of fuel supplies, address stubborn air pollution concerns, and to develop better designed urban centers. Better methods of moving people and goods throughout the state are another golden opportunity that flows from climate change response programs. 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 power and transportation infrastructure.

Continuing California's long-standing tradition of eco-innovation, AB 32 has thrust the California Air Resources Board (CARB) into a leadership role on forging new approaches to diminishing the state's carbon footprint. Significant progress has already been made in the state in cutting major sources of air pollution. For example, California's power plants now emit less than 90 percent of the fine particulates and ozone-forming nitrogen oxides than they did two decades ago. California's greenest new passenger cars emit 99 percent less Volatile Organic Compounds (VOC) and Nitrogen Oxides (NOx) than in 1970. High energy prices, a transition towards a service-oriented economy, and polices supporting aggressive energy efficiency

upgrades, 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.

The initial AB 32 target of reducing California's GHG emissions back to 1990 levels by 2020 is only the first step. The long-term reduction goals for 2050 and beyond are equally important and will require fundamental changes in consumer behavior, energy use and in the infrastructure that supports virtually all economic activity. The state will inevitably encounter tradeoffs between the actions necessary to bring about the wide scale transformation of a carbon-free economy and those that may bring about the lowest cost emissions reductions in the short term. Both near- and long-term goals are critical. Only balanced and innovative approaches will serve California's strategy to phase-in new zero carbon products and services. A chief challenge is to simultaneously address socio-economic challenges that accompany the price signals necessary to develop a more sustainable energy economy.

II. Major Strategies and Opportunities

AB 32 instructs CARB to create the Economic and Technology Advancement Advisory Committee (ETAAC). The legislation notes that ETAAC is charged 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."*

In this report, ETAAC has identified five major strategies that support five major categories of opportunities to advance cost effective GHG emission reduction technologies. A general description of each of these strategies 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

AB 32 establishes a fixed timeframe for California to achieve a 25 percent reduction in GHG emissions. This year 2020 timeframe is useful because it provides business and the rest of the state specific targets for long-term planning. However, the competing interests of many different stakeholders -- including industry, labor, environmentalists, land owners, and others -- have

helped create a regulatory system for project approval that is complex, time-consuming, costly and often litigious. Gridlock does not serve California as it looks to future solutions to the climate change conundrum. ETAAC has identified areas (for example the deployment of large scale renewables – section 5.III.C, methane digesters – section 6.II.A, etc.) where the project approval process could be streamlined without compromising environmental integrity. To competently 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.

ETAAC has observed that investments in GHG emission reductions before the AB 32 cap goes into effect in 2012 are being stymied due to lingering regulatory uncertainty. 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. As we discuss in section 5.III.A, if the value of these "early action" credits were more clearly defined, increased investment in GHG emission reduction projects would 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 and 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 that would ratchet down allowable GHG emissions over time. This declining cap would send the right price signals to shape the behavior of consumers when purchasing products and services. This declining cap 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 avoids the danger of having government or other centralized decision-makers make choices that lock-in advantages for particular 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 R&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, and address distributional impacts from the higher prices for goods and services in a carbon-constrained world. Performance standards (i.e. emissions per kilowatt or per mile traveled) have a proven history of success and need to continue to be part of California's strategy. In addition, California can consider revenue-neutral fee shifting to reward the purchase of lower GHG products (section 2.III.E).

These complementary strategies form the core of ETAAC's policy recommendations found in

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this report. Nevertheless, many of the strategies outlined in the following pages of this report would be less effective without appropriate price signals that flow from a declining cap on GHG emissions. 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.

Strategy #3 Create Innovative Pubic Funding to Complement Private Investment

One of the most important market failures resulting from not putting a price for carbon is the current inadequate level of RD&D for new low- and zero-carbon technologies. Because companies expect a high return on their capital investments – and RD&D is an inherently risky undertaking -- they invest much less in R&D than is socially optimal. 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 level of expected investment will not be enough to reach the overall GHG emission reduction goals. The ETAAC committee 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 utilize an auction for some portion of the emission allowances under the AB 32 cap, ETAAC proposes that a California Carbon Trust – discussed in greater detail in section 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 R&D funding gaps by leveraging the capabilities of universities, state agencies, non-profits and other pioneering research leaders throughout the state.

If GHG auction revenues from a "cap and trade" system are sufficiently robust in scope, they can also be used to reduce the negative impacts of California's current distorting taxation policies in addition to providing 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 has a variety of existing incentive fund programs underwriting R&D and related research activities (outlined in Appendix III). They typically serve specific functions. At present, none of them specifically target GHG emission reductions. 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

abatement (see section 2.II.B), and examine how to best integrate these GHG emission reduction priorities with existing program goals. 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 as well as 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. The state should also consider creating a new organization to house these and other programs.

Strategy #4: Create International and Domestic Partnerships

Achieving success on the climate change front domestically will require partnerships between the public and private sector, between state and local governments, 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 US states, Canadian provinces, the European Union, the United Kingdom and other countries and integrate 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 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; partnering with other states, the federal government, and other nations on low and zero tailpipe emission vehicles is another.

Strategy #5: Coordination Across State Agencies

There must be effective coordination 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 must participate in the opportunities and challenges of meeting California's GHG emission reduction goals, all state agencies must also participate with Cal/EPA in 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.

Some new technologies and practices to lower GHG emissions will have co-benefits such as less air pollution or lower water consumption. But they may 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.

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-

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front investment is rewarded with reduced future 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, technology needs to be forced into innovation to create more efficient products. In other cases, such as distributed generation technologies such as solar photovoltaic or Combined Heat and Power facilities, faster adoption of existing technology needs to be encouraged.

ETAAC believes that new types of financing will 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 sections 2.III.F, G). The potential use of auction proceeds to help finance efficiency upgrades to lower energy bills in historically disadvantaged communities is an opportunity to achieve AB 32's Environmental Justice goals.

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 recommends measures to quickly scale up renewable energy, both on-site distributed generation and central utility-scale power plants (see section 5.III.C). In the AB 32 timeframe, ETAAC believes fossil fuels, including natural gas, can play an important role for both power generation and heating if carbon can be separated and permanently stored. Biomass sources, if coupled with carbon sequestration, could produce renewable energy supplies and permanently remove carbon out of the atmosphere.

Low carbon, zero carbon and even negative carbon energy will likely require methods to permanently sequester carbon that are neither proven nor cost-effective today. California should continue to partner with other states, federal agencies and international partners to encourage RD&D to find both cost-effective and safe methods of sequestering CO_2 streams from power generation.

In order to accelerate the long-term transition to a renewable and sustainable energy economy, California will need the ability to develop new electricity storage technologies. Renewable energy sources such as wind power sometimes generate excess power during periods of low demand. If this clean and carbon-free energy could be stored, it could be used during periods of peak demand. This challenge represents an opportunity for storage systems such as flywheel batteries as well as plug-in hybrid and zero emission electric or fuel cell vehicles.

Opportunity #3: Rethink Transportation to Lower Demand and Carbon Emissions

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

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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 regulations, the Low Carbon Fuel Standard, the Low/Zero Emission Vehicle program and the Zero-Emission Bus program. The infrastructure to deploy technologies emerging from these state programs must also be based on low or zero emission fuel supplies.

California should initiate a near-term program to reduce GHG emissions from Heavy-Duty Vehicles (HDV) and continue to work with the federal government to increase national fuel efficiency standards. In addition to transportation technology itself, it is time to rethink current methods of mobility for both freight and state citizens. California's phenomenal 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 the growth in 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 due to traffic congestion and the corresponding improved quality of life. Putting a price on carbon will help reduce vehicle use and congestion. Yet these approaches are limited in scope. They must be complemented by alternative transit options, such as electric rail, and urban and suburban designs that provide better and affordable options to the internal combustion engine (see section 3.IV).

Local government land use planning decisions will need to be coordinated with state-wide priorities to encourage transit-oriented residential and commercial development. 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.

The state's coastal ports and Central Valley freeways have become increasingly congested, increasing air pollution and greatly exacerbating progress towards the goal of more efficient use of energy for transportation. 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 and Water

Greenhouse gases are also emitted from forest, agricultural and industrial practices unrelated to energy consumption. Significant opportunities exist to reduce GHG emissions through established best practices, for example the expanded use of combined heat and power in industry (see section 4.IV.I). In addition, both agriculture and forest sectors hold the long term potential to sequester carbon in soil and biomass (see soil carbon sequestration 6.II.E and forest management 7.II.B).

Water use in California is extremely energy intensive. Today, more than 19 percent of electricity, 32 percent of natural gas not used for electricity generation, and 100 million gallons of diesel fuel 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 demand will produce multiple benefits. Less demand for water resources translates into reduced

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GHG emissions and other air pollutants since energy used to pump, treat and move water is lowered.

Opportunity #5: Encourage Cleantech Manufacturing and Green-Collar 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 eco-innovation, California is well positioned to attract venture capital investments in Cleantech companies. In 2006, California led the nation in Cleantech venture capital with $1.13 billion, representing 44 percent of total U.S. Cleantech investments.

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. Cleantech is spurring new employment opportunities such as installers of solar energy and energy efficiency devices. ETAAC proposes state supported training programs to encourage the development of these kinds of green-collar jobs (2.III.D).

At present, the state 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. The state may want to 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 (2.III.C).

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 and non-energy sources.[1] 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, electricity/natural gas, agriculture and forestry. 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. In order to meet the timeframe outlined in AB 32, however, will require California to do the following:

- Continue the state's long-standing commitment to environmental policy and build on the success of existing programs and regulations;
- Attract private capital;
- Develop and retain new green collar jobs;
- Establish a clear market price on carbon to provide the incentives for business and consumers to reduce their carbon emissions efficiently;
- Adopt polices and measures that facilitate the kind of business and technology innovations that have made California world renown.
- Develop and maintain a capability to assess and adjust policies and measures over time as new conditions emerge and new technologies are developed.

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

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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. 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 in 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 GHG 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, the 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. 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.

ETAAC met several 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 125 suggestions from the general public for ways to reduce climate change emissions (a summary table of the suggestions is presented in Appendix VI). 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.

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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 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.

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V. General Principles

In chapters two through seven, ETTAC presents a variety of recommendations for reducing GHG emissions in different sectors of California's economy. All of the recommendations have been guided by the following general principles:

Address Near, Medium, and Long-Term Goals*:* ETAAC's deliberations explored the need to address near-, medium- and long-term goals. Not only is there a need to deploy innovative technology prior to 2012 to demonstrate near-term progress, but policies must also be designed to meet a 25 reduction in GHG emissions by 2020, and then also give momentum to long-term needs of California's economy and environment by 2050. Smart policies can accelerate innovation and technology diffusion, but refashioning California's energy economy to achieve zero or near-zero emissions will some take time. Therefore, California must continue to accelerate innovation to make progress in reducing GHG emissions across all sectors of the economy in the future.

Encourage Early Action: There is an urgent need for early action because some investments in particular technologies may preclude other choices rendering 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. At present, uncertainty over ownership of the benefits of early actions is not sending the right signals about the true value of early actions. An early rule making by CARB could encourage immediate investments by industries governed by the AB 32 carbon cap. This action would supplement, and could precede, resolution of complex issues surrounding the definition of obligated entities (i.e. load-based vs. first-seller approaches for a cap on electricity emissions), the ultimate approach to credit distribution (auction vs. allocation) and the scope of compliance obligations (baselines and targets). A banking system that clarifies the ownership of early GHG emission reductions will enable private entities to accept risks and act on the basis of their own assessment of the future value of carbon credits. It may also provide liquidity for any future credit markets that may emerge.

Foster Collaboration at All Levels of Government*:* Participation at all levels of government will be necessary to address global climate change. ETAAC recognizes the need for coordination across all state agencies whose programs and priorities overlap with the goals and potential programs developed in response to AB 32 and the 2050 targets established in the 2005 Executive Order. For instance, ETAAC recommends that CARB distribute lists of potential measures to other state agencies to identify areas where early coordination is needed to minimize costs and unintended consequences while also identifying opportunities to maximize co-benefits. The strategic focus provided by the Governor's Climate Action Team should be harnessed and translated into making it a priority for all state agencies to facilitate GHG emission reductions by business, government, and the public. A regular reporting structure should be developed so the Governor and the State Legislature can clearly track and identify progress being made towards complying with AB 32's reduction targets.

In order to lay the groundwork for transferring successful programs and strategies to the national stage, it is also critical that California's state government work with the federal government to achieve AB 32's goals, California's energy efficiency programs, renewable energy development

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efforts and passenger vehicle GHG emission standards can serve as models for national climate change response programs. The federal government would no doubt benefit from early adopters in California and other states with pioneering climate change response programs. Implementation of some of these programs across the country could also broaden the environmental benefits of early action and help drive down compliance costs. There are also jurisdictional matters to contend with. Only the federal government can take a leading role in coordinating certain aspects of transportation -- such as emission standards for international conveyance of consumers and freight -- that are beyond the scope of state regulatory authority.

Cooperation with city and county governments will also be necessary, particularly with regional planning and other decisions necessary to help implement GHG emission reductions in the energy, transportation and other sectors of the economy.

Encourage Public and Private Research, Demonstration & Development: There is clear need for California to support RD&D and identify the most important candidate technologies and other climate change response solutions that need to reach full commercialization status in the near future. Private sector investment plays a crucial role, and is the largest source of investment to develop innovative new technology. Public investment plays an important role, too, because many of the benefits of RD&D offer public goods that re not necessarily the priority of private sector investors. The type of specific public support varies with each developmental stage and technology type. New technologies are particularly vulnerable when making the leap from a successful technology demonstration to a bona fide commercial product. This report has identified over $700 million in state-supported RD&D funding that share at least some overlap with AB 32's GHG emission reduction goals. For example, equipment change-outs to cut criteria air pollutants often also foster the lowering of GHG emissions. It is therefore important to co-ordinate additional RD&D efforts to cut GHG emissions with existing programs and develop a consistent framework for assessing potential projects.

To broaden the resources available to develop low-carbon solutions and help spread the co-benefits, ETAAC also recommends partnerships with industry and other private organizations, other state and local governments, and the federal government. An outreach program and a clear roadmap of technology and public funding opportunities may help attract private capital. Given the global scale of the climate change challenge, and the need for international cooperation, California has also established international agreements with the United Kingdom and the European Union and should embrace similar international collaborations whenever feasible.

Leverage California's Centers of Innovation: 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 more cost effective climate response programs. At present, there is no single source of information about what the California's centers of innovation are working on or how their research priorities are established. A coordinated effort would ensure that market and policy signals reach and influence RD&D being funded at these innovation centers. Such an effort may enable 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 carbon research efforts, or it could be accomplished by an existing private or public entity. The CPUC recently

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acknowledged a similar need and opened a proceeding to consider creating a "Climate Solutions Institute" to be housed within California universities.

Establish a Level Playing Field for Competition: 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. 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. Sometimes stubborn market failures or other barriers require on-going incentives or other forms of support for GHG emission reduction technologies beyond the point of full commercialization. If this is the case, these programs should be based on performance standards that incorporate short- and long-term GHG emission benefits and other environmental and socio-economic co-benefits or disadvantages.

For instance, full performance battery electric and fuel cell vehicles 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 electricity as part of their vehicle fuel are likely to 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.

Maximize Public Health and Socio-Economic Co-Benefits*:* Some policies designed to combat climate change can reduce pollutants affecting local public health. Ground level ozone, for example, contributes to both climate change[2] and major public health problems that exist in California.[3] Black carbon -- in particular fine particulates – is also an important public health issue. As discussed during a U.S. Senate hearing by the Committee on Government Oversight on October 12, 2007, there is increasing scientific evidence about the role black carbon plays in accelerating global climate change. 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.

Address Environmental Justice Concerns: In evaluating potential policy and technological fixes to GHG emission challenges, ETAAC recognized the need to develop solutions that do not shift burdens of compliance to disadvantaged communities suffering from historic pollution trends. Where the effects of policies and technologies can be clearly discerned, they are identified in this report. In other cases, further evaluation of any Environmental Justice effects may need to occur when specific implementation measures are developed by CARB or other agencies or organizations

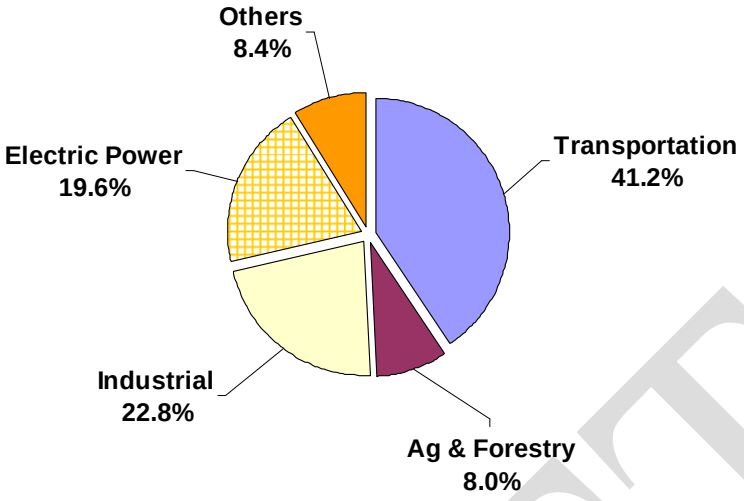

Figure 1: Carbon Emissions by Sector

Participation Across All Sectors: As shown in Figure 1, GHG emissions are a function of many activities ranging from transportation to manufacturing and agriculture. Policies implemented under AB 32 and the Governor's Executive Order for 2050 should 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 for all actors in the state economy and therefore achieve GHG emission reduction goals in a timely manner. Policies need to recognize that electricity and biofuels will likely compete with more traditional transportation fuels in the future, and policies that address only the electric sector or only the petroleum refining sector are unlikely to achieve the goals of AB 32.

Flexible Approaches: Flexibility will be necessary to minimize the negative economic impacts that might flow from AB 32 implementation and to recognize the need to phase–in new, low–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 source 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.

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VI. 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 five specific sectors analyzed from a stand-point of policy and technology strategies and opportunities (transportation, industry/commercial/residential, electricity/natural gas, agriculture, and the forestry sector). ETAAC's comments on the Market Advisory Committee report also comprise a chapter in this report. In addition, detailed information on energy and transportation technology advances is included in the Appendix V and VI, respectively.

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. 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 reductions and an expected timeframe for achieving these reductions when each policy is considered as a stand-alone option. 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. 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.

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[1] Stern Review, 2006, Cabinet Office - HM Treasury
[2] IPCC, Fourth Assessment Report (AR4), Working Group 1 Report "The Physical Science Basis," Summary for Policymakers, 2007
[3] The California Almanac of Emissions and Air Quality - 2007 Edition

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2. FINANCIAL SECTOR

I. Introduction

The ETAAC financial sector subgroup investigated several different strategies and methods to encourage financial sector innovation in the deployment and development of greenhouse gas (GHG) emission reduction technologies. The general public contributed a variety of written suggestions on financial tools to accelerate these clean technologies, which will be documented at the ETAAC web site (www.etaac.org). This financial sector chapter sums up suggestions brought forward during public meetings as well as a set of informal meetings with representatives from Cleantech companies, Cleantech investors, companies which operate in existing carbon markets and members of the greater U.S. financial community.

With billions of dollars now being invested in Cleantech companies, California has a unique opportunity to create new jobs and entire new industries right here in our own backyard. Smart economic development policies that take advantage of new financial tools and programs are needed to ensure that California realizes its full potential as a climate change pioneer and captures the job creation benefits of its environmental leadership. Many startup companies want to grow in California. They want to maintain a strong nexus between manufacturing, RD&D and proximity to major markets. Yet barriers to this potential and highly beneficial synergy remain. These barriers can result in relocation of Cleantech companies to other states and regions.

Several overriding themes emerged from the finance sector subgroup's research:

- Existing state financial incentives and grants are unlikely to be sufficient to spur the needed innovation in GHG reduction technologies to comply with AB 32. CARB staff produced a document (see Appendix III) listing the various state grants available under existing programs. While some may be beneficial, they are not yet coordinated to achieve maximum impact for AB 32's GHG emission reduction targets (see recommendation C below.) AB 32 sets the stage for a timely opportunity to rationally link the State's numerous but disparate RD&D programs to make sure they are coordinated and focused on encouraging GHG emission reductions.
- California will benefit from a significant financial incentive program to stimulate the deployment of GHG reduction technologies both inside and outside of capped economy sectors. Judging from the experience of existing "cap and trade" systems in the United States[1] it is unclear if such systems encourage or discourage innovation. Though the ETAAC financial sector subgroup does not presume that an emissions trading system will be created under AB 32, it does believe that the state needs a significant incentive system to help assure that emissions reductions are achieved at lowest possible cost. This incentive system should also encourage investments in California's disadvantaged communities to address broader Environmental Justice and economic development goals.
- Revenue neutral shifting of fees and taxes can encourage the distribution and purchase of cleaner products and fuels.
- California is well positioned to attract venture capital investments in Cleantech companies. California led the nation in Cleantech venture investments in 2006 with $1.13

billion, representing 44 percent of total Cleantech investments in the U.S. However, the amount of invested capital is not the same thing as *productive investment*. The State should encourage private investment that is informed by policy trends and technology advancements in order to generate both robust economic and environmental returns.[2]

- International Partnerships can help create export opportunities for California Cleantech companies. As California continues to transform into a greener economy, the state will need to provide a pathway for clean technology manufactured in the state to be showcased in other nations. If California is going to be a leader in developing the technologies of tomorrow, it will be important that these technologies gain traction throughout the world. There is ample opportunity for California to create this market since economies are looking for cleaner practices that will reduce their emissions. A key aspect to developing these international linkages and partnerships is by ensuring that California has an active presence in these nations. It is the state's duty to foster linkages between Cleantech businesses in California and businesses throughout the world. These linkages will not only encourage other nations to use California's home grown technologies, but it will also provide a mechanism to learn about best practices give businesses incentive to keep innovating. Existing California trade offices in other countries should showcase the state's accomplishments and have information on business opportunities and clean technologies offered in California.
- At present, the State is doing little to encourage the manufacturing of products in California. In fact, it is expected many Cleantech companies may be moving their manufacturing out-of-state while keeping their headquarters and RD&D facilities in California. The ETAAC finance subgroup did not look at the comprehensive set of issues related to attracting and keeping manufacturing in California, but rather focused on issues pertaining to AB 32 or to the manufacturing of products in California directly impacted or created by AB 32.

From these overriding themes, the finance subgroup issued two central recommendations and a set of additional policies designed to support activities in all of the subsequent ETAAC subgroup reports: transportation; industry/commercial/residential; electricity/natural gas; agriculture; and forestry. An ETAAC analysis of the Market Advisory Committee's report in chapter 8 examines how market structures will also impact early actions, innovations and price signals in each of these state economic sectors.

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II. Central Recommendations: Carbon Trust & Cleantech Commercialization

A. Create a California Carbon Trust

A new public or a public-private entity creates an incentive fund using allowance revenues to encourage carbon reductions in sectors inside and outside the cap, while also supporting environmental justice goals, actively managing the carbon market, and encouraging research, development and demonstration efforts. Activities could start prior to 2012, helping to set an early price signal for carbon and other GHG emissions.

- *Timeframe:* In place by 2012.
- *GHG Reduction Potential*: The potential for GHG emission reductions would depend on the trust's funding source (initially from early auction proceeds or some other source) and the cost of acquiring carbon rights. The Trust is likely to secure reductions at a cost equal to or slightly less than auction prices. Therefore, for every million tons of CO_2 allowance auction revenue provided to the trust about one million tons of CO_2 reductions would occur.
- *Ease of Implementation:* Moderately difficult. Barriers include the following:
  - Assumes some auction revenue.
  - Requires the creation of a new mechanism. It may make sense to house the Trust within an existing entity or create a new entity designed specifically to encourage the development and execution of GHG emission reduction projects outside the cap. This entity could be a public entity or a public/private entity.
- *Co-benefits / Mitigation Requirements*: Many co-benefits, no mitigation requirements:
  - Provides funding for carbon reductions
  - Encourages carbon reduction projects prior to 2012
  - Can direct funding towards technology demonstration and research in areas where private investment is lacking
  - Supports Environmental Justice goals of empowering communities and reducing criteria and toxic pollutants
- *Responsible Parties:* To be determined. Could be an existing agency (a combination of CARB and regional air boards, the California Treasurer's office, etc.) or could be a new entity.

Problem: California would benefit from a financial mechanism that stimulates investment in GHG reduction projects and technologies in both capped and uncapped sectors of the state's economy. This financial mechanism can address the following problems:

- Barriers and early failures in emerging markets for GHG reductions
- Lack of financial support for projects in disadvantaged communities or with other significant co-benefits
- Price spikes and instability in the carbon market

- Gaps in private sector funding for research and demonstration projects

Possible Solution: A California Carbon Trust could serve four important roles as the manager of an incentive fund for carbon and other GHG reductions in California. Its primary purpose would be to achieve GHG emission reductions beyond those coming from the AB 32 caped sectors, helping California to reach its ambitious reduction targets. The second purpose, closely linked to the first, would be to further the Environmental Justice goal of empowering communities to take part in achieving emission reductions of both carbon and other criteria and toxic pollutants. A third role for the Trust would be to serve as a market maker and price stabilizer during the early years of the carbon market. And the fourth role would be to fund University research and "first project" demonstration financing in areas where private sector funding is lacking. The Trust's activities could start prior to 2012, jump-starting emissions reductions in California, helping to establish an early price signal for carbon and other GHG emissions.

1) Achieve Additional GHG Reductions and Address Carbon Market Failures

This Trust would achieve its primary goal of reducing GHG emissions outside the cap of a cap and trade system -- reductions that cannot be claimed by regulated entities -- by offering to purchase the carbon benefits from projects that meet strict requirements of being additional, real and verifiable. Qualified projects would compete based on a project-proposed price of carbon. This process would operate in parallel with private offset investments, but would have greater flexibility to fund reductions that would achieve AB 32 goals but may not receive private sector funding. For instance, private sector investments may need to achieve rapid payback times to attract private capital, with the benefits of reductions in the future greatly discounted. By taking a long view of meeting GHG reductions in 2020 and 2050, the Trust could invest in projects that may have a greater overall GHG reduction per dollar of investment, but a longer lead time. The Trust could also address other gaps and failures in the carbon market, encouraging a variety of projects that are having trouble finding access to capital from the private sector. The Trust would not fully fund the project, but would offer enough of a financial incentive to allow the project to become financially feasible.

To ensure the integrity of the carbon reductions, the Trust should generally limit funding to projects for which clear measurement and verification standards exist. For example, project types could include those for which the California Climate Action Registry has accounting protocols or those that produce measurable and verifiable energy efficiency or low carbon energy generation. In some cases, it may be appropriate for the Trust to encourage projects for which no protocols currently exist, or projects with great potential but some uncertainty. In such situations, the price paid for carbon reductions would be reduced to account for the risk. The Trust could consider keeping some percentage of carbon reductions in reserve so that environmental integrity can be maintained in case of project failures.

The Trust's standard project selection process would be based on the relative cost-effectiveness of emissions reductions, similar to the state's successful Carl Moyer program. The Trust could issue requests for proposals periodically (quarterly or annually, for example), and applicants could include municipalities, hospitals, schools, community organizations, nonprofits, or any other project sponsor outside of the cap. An application to the Trust for funding would detail the project's plans, including the quantity of emissions to be reduced and a proposed price at which

the project will sell the emission reductions to the Trust. A "Dutch auction" or descending price auction could be used to find the lowest cost projects and determine the price at which the Trust decides to purchase carbon reductions. Because the Trust does not fund entire projects, all projects would have to be financially viable through a combination of their own economics and the additional value of selling the carbon reduction credits to the Trust.

The Trust could choose to do one of two things with the carbon it has "purchased" from emission reduction projects. Both of these mechanisms have the added benefit of ensuring that carbon reductions occur within California and that investments stay within the state.

- *The Trust can retire the carbon for public benefit.* Credits to be retired might have no real market value, or might pose double-counting concerns. For example, the Trust would retire the credits generated by an energy efficiency program that allows the associated Load Serving Entity to claim credit by reducing its own emissions. All carbon reduction projects that also value co-benefits such as abatement of air pollution would have to be retired.

- *Credits from Trust projects that value only carbon might be eligible for sale in the voluntary markets.* The revenue generated by these sales could be put back into the Trust and used to invest in further reductions. Possible buyers might include state agencies, corporations, or individuals (through an offset program) that want to offset their emissions.

Note that the Trust could potentially be designed so that some of the carbon credits it purchases could be used by capped entities as a flexible compliance mechanism in the regulated market. These credits would come from certain approved project types for which protocols exist.

2) Encourage Environmental Justice Goals and Projects with Co-Benefits

By setting aside some portion of its funds to be distributed to projects based on geographic location, demographics, and/or associated co-benefits, this Trust could also help to reach important environmental justice goals. Distributing funds based on geography or demography would ensure that disadvantaged communities receive a pre-determined amount of funding for projects that not only reduce carbon emissions, but also foster community development and protect low income consumers from rising energy prices.

In addition to (or instead of) distributing funds based on geography or demographics, the Trust could choose to favor projects with ancillary benefits, such as green collar job creation, technology demonstration, or criteria and toxic pollution clean-ups. In these cases, the Trust would pay not only for carbon reductions, but would also consider co-benefits such as local air quality benefits. For example, a project that reduced NOx in addition to CO_2 could be financially rewarded not only for the carbon reduced, but also for the NOx reduced by the project. By attaching either a time value or a monetary value to co-benefits, the Trust would create incentives for projects that not only help California reach its GHG emission reduction targets, but also achieve Environmental Justice goals such as job creation and pollution abatement.

For example, a project applicant might want to retrofit the Heating, Ventilation, and Air Conditioning (HVAC) system at a multi-family residential building. A market barrier exists because of the discrepancy between who makes the capital investment and who ultimately reaps the benefit of that investment. In this case, the building owner must front the capital while the tenants benefit from lower utility bills. The Trust creates an incentive to help overcome the market barrier by offering to purchase the project's carbon benefit from the building owner. The building owner benefits because he or she is reimbursed for the retrofit up to the value of the carbon reduced, while tenants benefit from lowered utility bills, not to mention more efficient and better quality air conditioning and heating in their homes. The State of California benefits from the reduction in carbon emissions, and capped entities such as members of the business sector benefit because California is closer to its emission reduction target at no expense to them. In this example -- as in all instances where the Trust would make this type of project investments -- it is important to note that the State would have to address any overlaps with programs eligible within the scope of a GHG cap, to avoid double counting and clarify crediting issues.

The selection process for projects with co-benefits would be similar to that for projects that involve only carbon benefits. Projects would be judged on relative cost-effectiveness, compared with other projects in the same category (based on geographic location, specific co-benefits, etc). Projects would also need to be financially viable through a combination of their own economics and the additional value of the carbon reductions, plus whatever values the Trust assigns to the co-benefits. Again, the GHG emission reduction credits could be retired for public benefit or possibly sold into voluntary markets.

3) Actively Manage the Early Carbon Market and Mitigate Price Volatility

The third role of the Trust could be as an enabler and/or "market maker" of the early carbon market in California. The Trust could purchase emission reductions that have been certified as tradable credits and sell or retire them as needed in order to help stabilize the California carbon market. The Trust could be particularly valuable in seeding the market and stabilizing it in the early years. In later years, as the California carbon market grows and matures, the role of the Trust as "market maker" would diminish.

The Trust could also be designed so that some of the carbon credits it purchases from projects outside the cap could be used as a flexible compliance mechanism in the regulated market. These credits would come from certain approved project types for which protocols exist, and would only be sold into the compliance market as needed to alleviate price spikes. The Trust would thus act as a "shock absorber" – buying credits from capped entities when demand for carbon is weak in order to support higher prices needed for investment and innovation, and selling credits when demand is high and supply is low.

By stabilizing the price of carbon (when necessary) and providing a sense of certainty over time, the Trust would be managing carbon the way that the Federal Reserve Bank manages interest rates. This active management should decrease the likelihood of the regulatory process overreacting or reacting too slowly to volatile carbon prices. As a dynamic manager of the price of carbon with a long-range view, the Trust would perform the role of a market oriented safety valve and obviate the need for static regulations such as price floors or ceilings.

Specific rules for intervention in the market would have to be developed in advance. The market regulating role of the Trust would be carried out by an independent body of experts. This would be a preeminent group, comparable to the Federal Reserve board or the California Independent System Operator, which currently manages the majority of transmission resources for the state's electricity grid.

Considerable public comments were received both in favor and against the role of the California Carbon Trust as an active market maker. The potential effectiveness of this role will depend on the overall design of both the regulations and the structure of the California Carbon Trust.

4) Encourage Research, Development, and Demonstration

A fourth role for the Trust would be to fund University research and development, as well as demonstration projects and first production facilities. These are areas that lack adequate private funding but can produce valuable technology advancement, accelerating GHG reductions and supporting economic growth. The Trust could set aside some percentage of the allowance revenues to be spent in these areas, with funds to be distributed based on judgments of the relative promise, reliability, and cost-effectiveness of projects in various categories. This really encompasses two related, but separate, uses of Carbon Trust funds:

- *University Research and Development:* The Trust would provide funds for research and development of the technologies needed for a low carbon future. The role of the Trust in funding University R&D should be considered alongside the proposed California Institute for Climate Solutions currently under consideration by the CPUC so as to prevent overlap and duplication of efforts. The Trust could possibly serve as a source of funds for the Institute.
- *Demonstration and First Production Facilities*: By supporting demonstration and first production facilities, the Trust could bridge an important gap in the financing of new technologies. Public sector managers generally treat demonstration, first project financing, and commercialization as the responsibility of the private sector, while most private sector financiers are unwilling to invest at these early stages due to the high level of risk. This dilemma creates a financing gap that requires a novel solution. The Trust could provide the financing and capital necessary to address this problem and encourage the commercialization of clean energy technologies. This could be done in many different ways. See "Support Demonstration Finance" - Finance Sector Section II, C, below.

Funding Sources for the Carbon Trust

Revenues for the Trust could come from the auction of allowances, from penalties or fees for non-compliance post-2012, or from another source such as the general fund or borrowing guaranteed through repayment from auction revenues. Based on historical experience, revenue from penalty fees is expected to be minimal. California Environmental Quality Act mitigation fees are another possible revenue source to consider.[3] If the Trust is set up as a public-private partnership, private sector businesses would be another potential source of funding. If the Trust

is designed to be a market maker and has the authority to purchase and sell carbon credits, an additional source of funding would be the sale of certified, tradable carbon credits. Finally, another source of funding could be the sale of carbon reduction credits into the voluntary market.

The State might consider offering one or more early auctions of a small percentage of the 2012 allocations. This early auction proposal presupposes that the state has decided not to grandfather all allocations based on historic emissions and has established a minimum percentage of allowances to be auctioned in 2012. One or more early auctions would help to set an early price signal and would remove some of the uncertainty about rule-making, jump-starting the market for carbon in advance of 2012. A price discovery period would probably reveal a price lower than expected; this is what has happened historically in other similar schemes. Early auctions would allow the state to "learn by doing," essentially serving as a trial period. The State would have the opportunity to learn and make adjustments before 2012. If the State decides against an early auction, the Trust could be funded initially through the state's general fund or through a loan, or through other sources.

Any auction revenues are legally a fee and thus must meet the legal standard established by the Sinclair Paint court decision. A "Sinclair Test" requirement means that the fee must be reasonable and there must be a nexus between the purpose of the fee and the use of its revenues. The Trust passes the Sinclair test because both the fee and the Trust's expenditures are intended to reduce carbon emissions in California.

Consideration should be given to designing the Trust as a public/private partnership in order to leverage private capital in addition to the public money used to purchase credits. Involving private capital could provide access to resources that should help improve the economics of the Trust, particularly in the earlier years of operation before 2012. Another possible benefit of involving the private sector would be a contract guarantee that Trust revenues would be restricted to the purpose of reducing GHG emissions.

Models for the California Carbon Trust

The **Carbon Trust (UK)** is an independent government-funded company created in 2001. Its mission is to accelerate the country's move towards a low-carbon economy by developing commercial low-carbon technologies and working with business and the public sector to reduce emissions. The Carbon Trust carries out five different functions: (1) information and education; (2) practical solutions, knowledge, and resources for businesses and public sector entities that wish to reduce energy use and emissions; (3) funding, advice, and demonstration for low carbon technologies; (4) developing new, low carbon businesses; and (5) investing in clean energy technologies with commercial potential.

The **Climate Trust** is a non-profit formed in 1997 in response to an Oregon law that requires new fossil fueled power plants to offset a portion of their CO_2 emissions. The Climate Trust provides high-quality offset projects for power plants, regulators, businesses, and individuals. The Climate Trust is one of the largest buyers of offsets in the United States, with a portfolio of sixteen projects that are anticipated to offset 2.6 million metric tons of CO_2 over their lifetimes.

The **Carbon Market Efficiency Board** is a market-regulating body proposed in the Warner-Lieberman "America's Climate Security Act" (S. 2191). The Board would be authorized to trigger relief remedies to protect the economy in case of volatile prices or unpredictable market events. Operating under the oversight of the US Department of Treasury, the Board would be authorized to allow increased borrowing of allowances or to temporarily expand the National Emission Allowance Account, so long as the cap in future years is tightened enough that cumulative emissions reductions remain unchanged.

The **Climate Change Credit Corporation** is a nonprofit corporation proposed in the Warner-Lieberman Bill. The Corporation would receive and auction allowances and distribute the proceeds. Auction revenues would be distributed among seven clearly delineated categories. Examples include 20 percent for a public-private partnership to commercialize low and zero-emissions transportation sector technologies and reducing vehicle miles traveled, 10 percent for air quality improvements, and 10 percent for mitigating impacts in disadvantaged areas.

B. Promote Clean Energy Innovation and Commercialization

Support California RD&D and commercialization efforts *today* to ensure that critical innovations are available to contribute to GHG reductions in future years. Optimize current programs toward the climate change goal and consider new programs to accomplish objective. Consider creating a new entity to coordinate these efforts.

- *Timeframe:* Programs in place by 2012.
- *GHG Reduction Potential:* Cannot quantify.
- *Ease of Implementation*: Moderate. Barriers include:
  - Recalibrating current subsidy programs that are not structured to measure GHG reductions could be politically challenging.
  - Some current subsidy programs calculate avoided costs differently so it may be difficult to compare or measure real program value or comparative potential for GHG emission reductions.
  - The state currently has no scale-relevant program in place to support demonstration projects for emerging technologies. A new financial vehicle may need to be created to fill this gap by sharing risk between public and private sectors.
  - Complicated state programs make it difficult for the private companies to identify opportunities for them to participate.
- *Co-Benefits / Mitigation Requirements:* Many benefits, no mitigation requirements:
  - Would fill the “innovation pipeline” with promising new technologies that may contribute substantially to carbon and GHG emission reductions.

- Would orient disparate clean energy programs toward the unifying goal of decreasing GHG emissions without decreasing the importance of other public policy goals.
- Would better ensure that public and private RD&D efforts are informed by public policy objectives.
- Would close a critical gap in the clean energy investment ecosystem by supporting demonstration projects.
- Would ensure greater linkage and enable more effective comparison across current programs by creating consistent calculation of avoided costs.
- Would support California's culture of entrepreneurship and support economic development objectives.

- *Responsible Parties*: CEC ; CPUC ; CARB. Could involve the creation of the new organization referenced below.

Problem: The technologies needed to support GHG reductions beyond 2020 do not yet exist. While the State of California currently funds a variety of RD&D programs, these programs are not necessarily geared strictly toward measuring GHG reductions. Moreover, in most cases, the state's individual subsidy programs are not optimally coordinated in pursuit of the principal current objective of AB 32 -- GHG emissions reduction -- causing inefficiencies and missed opportunities for improved performance. On top of that, other states are implementing programs and incentives to attract Cleantech companies as part of their economic development strategies.

Possible Solution: The State of California should make an affirmative commitment to RD&D programs geared toward GHG abatement. By not just supporting but actively promoting clean energy innovation, the state has the opportunity to seed the California marketplace with promising new technologies that may aid in achieving GHG abatement goals -- particularly for the beyond 2020 goals,. 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. The state should also consider creating a new organization to house these and other programs.

What is "Cleantech"?

The Cleantech industry encompasses a broad range of products and services, from alternative energy generation to wastewater treatment to more resource-efficient industrial processes. Although some of these industries are very different, all share a common thread: they use new, innovative technology to create products and services that compete favorably on price and performance while reducing humankind's impact on the environment.

According to categories established by the Cleantech Capital Group, total U.S. venture investment in Cleantech was $2.54 billion in 2006. California received $1.13 billion or 44 percent of the total. To be included in the Cleantech category, products and services must do the following: optimize use of natural resources; offer a cleaner or less wasteful alternative to traditional products and services; have their genesis in an innovative or novel technology or application; add economic value compared to traditional alternatives.

The eleven Cleantech categories measured are:

Energy Generation & Fuels
Energy Storage
Energy Infrastructure
Energy Efficiency
Transportation
Water & Wastewater
Air & Environment
Materials
Manufacturing/Industrial
Agriculture
Recycling & Waste

Firms in these categories may not always market themselves specifically as "Cleantech," and investors who place capital into these firms likewise may not necessarily consider themselves to be "Cleantech" investors.

The ETAAC financial sector subgroup offers these suggestions to foster clean energy innovation:

Support Demonstration Finance: Create a single or a series of financial vehicles to support demonstration finance for projects that have particularly high GHG abatement potential. This may include but is not limited to clean generation technologies, energy efficiency industrial applications and vehicle demonstrations of new low and zero tailpipe transportation options. The absence of funding for project demonstrations is a significant impediment to the maturation of new technologies and is consistently identified by thought leaders as a major gap in the financial architecture of clean energy. Public sector managers view demonstration as the responsibility of the private sector, while private sector investors view it as too risky. The demonstration finance fund could be structured to leverage a combination of public funds already nominally dedicated to such efforts and private funding, and/or it could be funded by royalties, shared savings or shared carbon credits banked for future use. The proposed California Carbon Trust (Finance Sector Section II, B) is one option to consider for this role. Organizing principles for a demonstration finance effort could include:

- *Establish Public Sector Tenants*. Where possible, use the State of California, counties and cities and/or other large scale public sector customers as "anchor tenants" for demonstration projects.
- *Support Specific Projects with the Highest Likelihood of Return*. A process should be established whereby projects that have the highest likelihood of making a major contribution to GHG reductions but are too speculative for the private markets are given first priority.
- *Enable Market/Consumer Choice*. In addition to some technology specific demonstration projects, support a more broad set of investments in infrastructure for competitive

demonstration projects where technologies can demonstrate their virtues against one another, such as biofuels infrastructure and transmission infrastructure development for renewables.

- *Encourage Broader Participation in Procurement Processes*. Consider using a demonstration fund to allow pre-competitive technologies to participate in electricity and fuels procurement by funding their above-market cost component.
- *Partner Where Possible*. Because demonstration projects come in all shapes and sizes, it would be optimal to allow the private sector to participate. Debt and high risk equity from the private sector at market rates could be coupled with contributions from the public sector in the form of serving as a backstop to mitigate against above-market costs and risks.
- *Link Current Demonstration Efforts*. The Public Interest Energy Research Program (PIER) and the Emerging Technologies Coordinating Council (ETCC), both funded by investor-owned utility (IOU) ratepayers, have funds available and actively pursue demonstration projects. In addition, the CPUC is considering a proposal by PG&E and Sempra Energy to create an analogue to the ETCC specifically for renewable resource demonstration projects. These efforts, while very important, are all immature, not coordinated and not geared to address the new mandates of AB 32. At some point it may be useful to link all demonstration project funds and to consider a broader funding source than just IOU ratepayers.

Specific technology areas that merit attention from a demonstration finance program include:

- *Clean Generation*. Support initial megawatt-scale installations that prove technical feasibility and enable project financing for emerging technologies.
- *Energy Efficiency Technologies*. Support demonstration projects for industrial equipment to accelerate the adoption of emerging technically proven energy efficiency technologies[4].
- *Clean Transportation*. Support vehicle demonstrations of low and zero emission transportation options including light, medium and heavy duty plug-in hybrids, dedicated electric vehicles, and hydrogen or other advanced fuels[5].

Target RD&D Funding for GHG Reduction: Promote the use of public funds to support research specifically for technologies with potentially high GHG abatement value. Consider linking the current individual subsidy programs into a unifying framework with a common set of reduction objectives, possibly including a consistent approach to state-calculated avoided costs. Accurate and consistent calculation of avoided costs would help identify the most cost-effective technology options and better ensure that RD&D funding is efficient and attuned to commercialization.

Leverage California's Centers of Innovation: Leverage and provide coordination among the existing RD&D efforts of state and federal labs, private research institutes and universities. Currently there is no single source of information about what the referenced centers of innovation are working on or how their research priorities are established. A coordinated effort would ensure that market and policy signals reach and influence innovation centers. Such an

effort may enable policy initiatives that reflect real technological progress and may help individual innovations achieve scale more quickly. This could be accomplished by a new entity charged with coordinating low 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 "Climate Solutions Institute" to be housed within California universities.

Engage the Private Sector: Create visible onramps for private sector support for early stage clean energy innovation. Create a roadmap of the state's technology priorities citing public funding of certain sectors where applicable (i.e. where funding starts and where it stops). Where it makes sense, create financial vehicles that leverage both the public and private sectors. Develop a program including an outreach campaign that enables our state to more effectively attract and nurture the most attractive low carbon start up entrepreneurs. Create industry specific public private partnerships in support of low carbon objectives to ensure private sector knowledge, engagement and support.

Consider Creating a New Entity to Coordinate These Efforts: A single focused entity may be well positioned to act as a coordinator of policy-motivated technology innovation, for example by administering targeted state grant funds for specific technology challenges – i.e. the "golden carrot" approach to goal-setting and reward. Such an entity could also enable the multiple public and private centers of innovation in California clean energy to communicate, share research, seek private funding, and move mature technologies through the procurement processes of the major state energy providers. The organization could also act as the principal agent for external market development and technology transfer to demand centers outside of California. Finally, such an entity could play a valuable "connective tissue: role in helping to coordinate state incentive programs toward the AB 32 reduction goals, and in providing the private sector with insight into the structure and availability of incentive funding.

The organizational form and supporting revenue structure of a new entity would be dependent on the objective. A variety of organizational models could be considered including:

- Create a new State program authority within an existing state agency;
- Create a private nonprofit entity via statute similar to the creation of the California Climate Registry;
- Create a private vehicle that manages public fees and funds to accomplish public objectives similar to the Carbon Trust;
- Create a private nonprofit organization that does not manage public fees.

In response to public comment on this issue, the Committee recognizes the potential value of initiating this coordinated process via the creation of a statewide "Action Plan" that would "enable California's agencies and institutions to avoid duplication, maximize coordination, leverage resources, ensure cost-effective results, and identify gaps in necessary efforts."[6]

III. Additional Organizational and Policy Recommendations

C. Leveraging AB 32 to Spur California Job Creation and Manufacturing

A five-year "Buy California" incentive program could boost in-state Cleantech manufacturing and take advantage of the lower embedded carbon content of California-manufactured products. Amending current disincentives in the state's income tax and sales tax codes would help ensure that California is competitive with other states in attracting Cleantech capital investment. A Cleantech manufacturing attraction initiative could help the state proactively attract and grow companies here.

- *Timeframe:* In place by 2012
- *GHG Reduction Potential:* Significant, but difficult to quantify. Potential reductions depend upon the type of manufacturing established in California and the proximity of where goods are produced to where they are sold and used. The manufacture and transportation of products manufactured in California for use in California is likely to generate fewer GHG emissions than those resulting when manufactured elsewhere.
- *Ease of implementation:* Moderate.
- *Co-benefits /Mitigation Requirements*: Many benefits, no mitigation requirements:
    - Reduced GHG emissions due to California's lower carbon energy supply (relative to other states and countries with Cleantech manufacturing);
    - "Multiplier effect:" additional jobs and economic activity generated through the close proximity of suppliers, installers and other ancillary businesses;
    - To the extent that this encourages the adoption of clean energy technologies, California residents can expect improvements in air quality.
- *Responsible parties:* CPUC; State Legislature; California Business Transportation and Housing Agency.

Problem: California currently faces stiff barriers to developing a strong Cleantech manufacturing sector. Nearly 340,000 manufacturing jobs were lost in a recent five year period. Cleantech manufacturing could help create new jobs to replace these employment losses and create a substantial multiplier effect with suppliers and the transportation and financial sectors, while reducing GHG emissions.

Companies contemplating moving products from the laboratory to full-scale manufacturing are under strong economic pressures to locate out of state. While many states provide incentives to attract Cleantech investment, California's corporate income tax apportionment formula imposes a higher tax burden on those hiring and investing within the state's borders. Imposition of a sales tax on manufacturing equipment installed for in-state use makes capital-intensive expansion in California significantly more expensive than in almost any other state. Out-of-state manufacturing results in increased emissions of carbon being released into the atmosphere due to less efficient and higher carbon content energy supplies. Encouraging in-state manufacturing would therefore result in both lower GHG emissions and significant economic benefits.

Possible Solution: California can benefit from a time-limited incentive program that promotes the growth of in-state Cleantech manufacturing. The goal of a "Buy California" campaign should be to get a new market started, rather than to create corporate dependence on another entitlement program. California cannot match the incentives offered by every other state. But California could act to remove the current disincentives in the state's income tax code that reduce a company's tax bill when it decides to grow outside of California. State policy makers should also take action to ensure that available capital resources in California are competitive with other states.

California should examine state policies from Massachusetts, Washington, Oregon, and New York, which are moving aggressively to promote Cleantech manufacturing. These states offer a combination of grants, tax incentives and credits, loans and guarantees, and seed capital to promote local jobs and the adoption of technologies developed and/or manufactured in those states. These efforts often dramatically lower the capital costs for companies that locate in those states. If California takes its leadership for granted, we will lose high quality jobs, significant tax revenues and other benefits of having a thriving Cleantech sector.

Here are a few examples of what these other states are doing. Oregon, which does not have a state sales tax, approved House Bill 3201 recently to provide a 50 percent income tax credit up to $20 million (up to ten percent of the cost of the facility for each year over five years, for the construction of facilities to manufacture renewable energy systems and components in state.) California provides no comparable investment credit and subjects new manufacturing equipment to a sales tax that generally exceeds eight percent. So a company contemplating a $40 million capital investment could face a final net projected cost for that facility of approximately $23 million in Oregon – or close to $43 million for an identical facility in California.

An example of what California might emulate is the Massachusetts's Technology Collaborative (MTC), which offers Renewable Initiative Rebates similar to California's Self Generation Incentive Program (SGIP). The difference is that Massachusetts offers an additional incentive (an extra $0.25/watt for solar and an extra $2.00/watt for fuel cells) if Massachusetts-manufactured components are used. Similarly, Washington enacted Senate Bill 5101 in May 2005, establishing production incentives for individuals, businesses, or local governments that generate electricity from solar power, wind power or anaerobic digesters. The incentives range from $0.12/kilowatt hour (kWh) - $0.54/kWh, depending on technology type and where the equipment is manufactured. One example of how to address California's competitive disadvantage is found in SB 1012 (Kehoe), which extends California's self generation incentive program to combined heat and power projects and requires the CPUC to, "provide an additional incentive of $0.50 per kilo watt hour from existing program funds for the installation of qualifying technologies that are manufactured in California by companies that maintain their principal place of business in California."

Because fuel cell systems and solar panels are large durable goods, it makes sense from an environmental standpoint for them to be manufactured domestically. These technologies offer direct carbon reductions by producing clean electricity. Locally produced clean energy technologies will reduce the GHG emission impact of importing large heavy equipment from

across the country or the world. Early actions to reduce the California's CO_2 levels should not only consider end-use applications, but lifecycle product transportation impacts.

Along with GHG emission reductions, fuel cells, solar and wind technologies generate virtually no NOx, SOx, or other harmful particulates. Accelerating the adoption of these technologies in California will also improve overall air quality and state living standards. On top of the environmental benefits, AB 32 could also work wonders for the state economy. There will be an estimated $14 to $19 billion of additional U.S. Cleantech investment between 2007 and 2010, resulting in 40,000 to 50,000 new jobs.[7] State Cleantech retention and attraction policies will help ensure that California benefits from the job creation and economic development spurred on by its environmental leadership and the passage of AB 32.

In addition to the direct "green collar" job creation that can come from promoting in-state manufacturing of clean energy technologies, a beneficial "multiplier effect" can occur. The multiplier effect of a successful manufacturing facility will generate additional jobs and economic activity through the close proximity of suppliers, installers and other ancillary businesses.

A five-year "Buy California" incentive program could boost Cleantech manufacturing through 2013. Building high production volumes should help drive down production costs, enabling the industry to contribute significantly to achievement of the 2020 targets contained in AB 32 with progressively fewer incentives going forward.

As part of this effort, California should also develop an aggressive Cleantech manufacturing attraction program that proactively identifies key incentives and reaches out to Cleantech manufacturers interested in siting, remaining, or expanding in California. Through this program, the California Business Transportation and Housing Agency would:

- Coordinate with relevant public and private sector parties including the California Labor Federation, the California Manufacturers and Technology Association and TechNet.
- Identify additional barriers to in-state manufacturing and in-state business attraction and retention with strategies for removing them.
- Develop additional recommendations that may include tax incentives for up-front capital costs, State tax credits for businesses that use clean energy equipment produced in state, expedited permitting, land use, and strategies for securing them.
- Analyze effectiveness of other state policies to increase in-state manufacturing.
- Develop a comprehensive list of California's existing incentives and educate Cleantech companies and investors about their availability.
- Highlight benefits of green manufacturing clusters, including resource sharing, strategies for getting established through land use and permitting, publicly-funded training, economic trend information, energy efficiency strategies, information about financial services, supplier access.
- Identify existing manufacturing in California that has the potential to take companies to the next level and offer the necessary support mechanisms.

D. Cleantech Workforce Training Program

A program to address workforce needs in new skill and occupational demands across industries that are developing and deploying advanced clean technologies in California.

- *Timeframe:* In place before 2012.
- *GHG Reduction Potential:* Difficult to estimate.
- *Ease of Implementation:* Straightforward. Models for successful workforce training programs exist.
- *Co-benefits / Mitigation Requirements:* Many benefits, no mitigation requirements:
    - Increased competitiveness for companies due to lower training costs incurred by businesses; Cleantech business growth and retention, higher profits.
    - Skilled and available labor pools to attract new businesses to CA, lower turnover with skilled workforce
    - Apprenticeship opportunities, new curriculum for academic institutions in modern energy sectors
    - Increased coordination between community-based workforce training programs, union apprenticeship programs and community college programs
    - Labor-management training partnerships in Cleantech sectors
    - Expansion of high-quality, career oriented employment
    - Increased tax base
- *Responsible Parties:* the CA Labor and Workforce Development Agency would administer. The Employment Development Department (EDD) would develop and manage the RFP process and track performance. In coordination with the State Workforce Investment Board (WIB), a panel of experts would develop priorities, principles and criteria, and require accountability. Panel makeup would include employers, labor representatives, and training program providers including community college district representatives and workforce and economic development agencies.

Problem: California's initiatives to reduce GHG emissions boost demand for a skilled and trained workforce. Already, workforce shortages are being reported in areas such as heating, ventilation and air conditioning. A technically educated workforce is vital for California's emerging energy sectors to be competitive and for the state to attract service and supply-side businesses to the area.

Possible Solution: Establish a "Cleantech Workforce Training Program" that could effectively equip workers with skills in advanced energy technologies at a cost of $3,000-$6,000 per trainee annually. The Cleantech Workforce Training Program would leverage this funding by 50 percent through additional public and private funds and, to the greatest degree possible, utilize existing program infrastructure, such as the California State Advanced Transportation

Technology and Energy program within the community college system and the related Union Apprenticeship training programs within the Building Trades.

This program would support, create and coordinate training efforts tailored to the needs of new and existing Cleantech businesses by sector. Training programs must be employer-driven and reflect true workplace needs.

A properly designed and executed Cleantech Workforce Training Program would lead to business-government-labor partnerships that support ongoing skill development and quality employment opportunities to meet workplace needs and keep companies competitive. In addition, curriculum development in related fields would prepare students and working people to serve the growing labor market in emerging energy sectors, and steer them to meaningful, career oriented jobs. Finally, this kind of program could create skilled and available labor pools to attract new businesses.

The Cleantech Workforce Training Program would coordinate appropriate state agencies and departments, private and non-profit entities to:

- Assess anticipated technological changes and workforce and training needs in advanced energy-related fields at all skill levels;
- Coordinate with relevant workforce agencies to prioritize public and private training funding in high-growth sectors;
- Identify gaps for training in emerging Cleantech sectors and existing training funding that could support Cleantech workforce development;
- Promote skilled trades in construction, manufacturing and utilities to serve needs in the new energy economy. Encourage resource-sharing and best practice models.

E. Fee and Tax Shifting (Feebates)

Adjust specific state fees and taxes in a revenue neutral manner that reduces the cost and encourages the distribution of low carbon products.

- *Timeframe:* In place by 2012
- *GHG Reduction Potential:* The reduction potential depends on the specific tax or fee. (See below for specific examples.) The principle benefit is to encourage innovation and to encourage consumers to purchase products with greater greenhouse gas reductions by reflecting the cost of GHG in prices that consumers pay.
- *Ease of implementation:* Relatively straightforward; requires legislative action.
- *Co-benefits /Mitigation Requirements*: None expected
- *Responsible parties:* Changes would be enacted by the State Legislature and then implemented by current State agencies.

Problem: Existing incentives and labeling schemes are not doing enough to influence consumer choices and move the state toward a low carbon economy. This is particularly true in the transportation sector, the largest source of state GHG emissions. California needs to increase the incentive for the distribution and purchase of products with significantly lower greenhouse gas emissions.

Possible Solution: Use existing tax and fee structures to encourage consumers to purchase lower emission products. The goal of fee and tax shifting is to encourage the distribution and purchase of products that either generate less GHG emissions in their lifecycle manufacturing or in their actual use. Example categories include the state excise tax on transportation fuels, car registration fees assessed with new vehicle purchases (see the Transportation Chapter for more information), and new construction.

A standard measurement of lifecycle GHG emissions for transportation fuels is instrumental to the development of the Low Carbon Fuel Standard (LCFS). The LCFS can be used to compare alternative and cleaner fuels against a gallon of petroleum-based gasoline or diesel. Fuels with significantly lower lifecycle emissions can be taxed at a lower rate. The accumulated tax revenues can be made up by a small surcharge on the high emission fuels. A proposal to do this can be found at "California Clean Fuel Incentive."[8] The surcharge is estimated to be 1/10 cent per gallon over the current tax of $0.18 per gallon, so the main benefit is to help lower the initial costs of low emission fuels and not to create a disincentive for high emission fuels. Over time, as alternative fuels are introduced, adjustments may also be needed to protect funding for public transportation and other infrastructure.

The State can also create incentives for the production and purchase of lower emission vehicles by ranking vehicles in class according to GHG emissions per mile driven. The lowest emitting motor vehicles in each class would receive an incentive from the state at the time of purchase. Highest emissions in each motor vehicle class would pay a higher initial license fee that would cover the costs of the incentives. A proposal to implement this mechanism is being considered by the legislature – AB 493 (Ruskin) - "Clean Car Discount for Families".[9]

This general "feebate" approach can be applied to any product category for where there is already well defined measurement of GHG emissions and for which there is a state tax or fee assessed at the time of purchase.

F. Municipal Assessment Districts

Municipal government sponsored financing to accelerate investments in clean energy. The investment would be paid back over time by participating property owners.

- *Timeframe:* In place by 2012
- *GHG Reduction Potential:* Would accelerate deployment of renewable energy generation.
- *Ease of implementation:* Relatively straightforward.
- *Co-benefits /Mitigation Requirements*: None expected

- *Responsible parties:* Participating municipal governments

Problem: With current State and Federal subsidies, the installation of efficiency upgrades and clean distributed generation (such as solar electric and solar thermal systems) is now much more cost effective for many residential and commercial property owners. Nonetheless, many disincentives to installation remain. A major remaining challenge is the lack of information on the part of many homeowners, residential and commercial developers, and construction companies. Perhaps the most important among the obstacles, however, is the high upfront cost of these technologies and the other financial hurdles that end-users must overcome.

Possible Solution: The City of Berkeley has proposed an innovative "Energy Assessment District" which could remedy many of the disincentives to install clean on-site distributed generation systems. It is a novel approach and has the promise to be tremendously effective if used widely throughout the state. The approach could potentially be expanded to include energy efficiency upgrades as well.

The Energy Assessment District proposed for Berkeley is modeled after existing Underground Utility Districts whereby a group of homeowners in a neighborhood work in coordination with the municipality on a plan to place utility distribution poles and wires underground. All property owners in the designated area vote on the proposal. If a sufficient majority votes in favor, the City works with the local utility to contract to have the infrastructure placed underground. The entire cost of the project is paid for with a non-tax exempt municipal bond. Homeowners repay the bond as an assessment on their property tax bills over a fixed period, typically 20 years or so. The assessment is officially in "second position" as a lien on the property – behind property tax and in front of the mortgage – giving excellent security and a corresponding low interest rate. A 20-year period fits well with the expected minimum lifetime of solar photovoltaic panels, with different periods possible should this model be adapted for other technologies.

The City of Berkeley is working to create a citywide voluntary Energy Assessment District of similar design concept. In this specific case, property owners (residential and commercial) could install solar systems and make energy efficiency improvements to their buildings and then pay for the cost as a 20-year assessment on their property tax bills. No property owner would pay an assessment unless they chose to include their property in the program. Those who do have work done on their property would pay only for the cost of their project and fees necessary to administer the program.

This program solves many of the financial hurdles facing property owners. First, it significantly reduces the upfront cost to the property owner. Second, the total cost of the system may be less when compared to a traditional equity line or mortgage refinancing. This is because the well-secured bond should provide lower interest rates than is commercially available. (Another factor is that the City would require multiple projects to be aggregated in order to reduce construction costs.) Third, the tax assessment is transferable between owners. If the property is sold prior to the repayment of the assessment, the next owner would take over the assessment as part of their property tax bill.

This kind of municipal assessment district program can support the Million Solar Roofs / SB1 legislation, can be readily applied to specific technologies (e.g. solar thermal or photovoltaic systems), or could be used more flexibly to advance a suite of designated clean-energy technologies along with major energy efficiency upgrades (e.g. tankless water heaters, heat pumps, trombe walls construction, and so forth).

G. On-Bill Financing for Small Business Energy Efficiency Projects

To overcome cash flow and capital constraints for small businesses, utilities could finance energy efficiency projects using ratepayer and/or other sources of funds, including, when appropriate, leveraging opportunities with private/public lending institutions to implement a cost effective program.

- *Timeframe:* In place for 2012 targets
- *GHG Reduction Potential:* 1-5 percent reduction of GHG emissions from small business, assuming an emissions reduction potential of 10 -30 percent with 10- 15 percent of small business participating.
- *Ease of Implementation:* Moderate to implement. This type of financing has been done before.
- *Co-benefits / Mitigation Requirements:* Electric load reduction and cost savings to the small business.
- *Responsible Parties:* Utilities as the program administrator.

Problem: Technology and products are available to reduce energy consumption in buildings and manufacturing operations that can result in net energy and cost savings for small business in the long run. The problem is that many small businesses do not have the capital to make the upfront investment needed to install the improvement.

Possible Solution: On Bill Financing (OBF) is a method where investments in energy efficiency are purchased the same way energy is purchased, by the month in installments paid via a line item on the utility bill. OBF simplifies the financing and payback for these projects, enabling small businesses to implement energy saving measures that they would otherwise be unable or hesitant to implement. The CPUC and utilities should work together to explore existing OBF programs to determine the optimum model for implementing a cost effective OBF program. In developing the program, the utilities should also weigh the overall value of ratepayer expenditure for OBF against alternative investments in energy efficiency projects, and ensure that the OBF is at least as cost effective as other successful, cost effective OBF programs. Where OBF design proposals differ from established norms and would impose unacceptable risk, appropriate means of cost recovery must also be included. San Diego Gas and Electric Company currently implements an on-bill finance program and all IOUs will have an OBF program by 2009.

[1] Taylor, Margaret, *The Dynamics of Innovation and Cap-and-Trade Programs*, (to be published)
[2] Stack, Balbach, Epstein and Hanggi, *Cleantech Venture Capital: How Public Policy has Stimulated Private Investment*, May 2007.

[3] While one specific project has set a precedent for CEQA mitigation fees for GHG emission impacts, the development of CEQA guidelines to respond to AB 32is still under development. The Governor's Office of Planning and Research (OPR) is in the process of developing CEQA guidelines for the mitigation of GHG emissions or the effects of GHG emissions. OPR is required to transmit the guidelines to the Resources Agency on or before July 1, 2009. The Resources Agency must certify and adopt the guidelines on or before January 1, 2010.
[4] See Industrial Sector Draft Section II. E.
[5] See Transportation Sector Draft Section III. B.
[6] Comments of the Natural Resource Defense Council on ETAAC Draft Report, submitted Dec. 10, 2007. http://www.arb.ca.gov/cc/etaac/121307pubmeet/comments_received_prior_to_12-13_meeting/wang-nrdc_etaac_comments_final.pdf
[7] Stack, Balbach, Epstein and Hanggi, *Cleantech Venture Capital: How Public Policy has Stimulated Private Investment*, May 2007
[8] http://www.e2.org/ext/doc/AB 1190 Factsheet.pdf
[9] http://www.e2.org/ext/doc/AB 493 Ruskin factsheet.pdf

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3. TRANSPORTATION SECTOR

I. Introduction

Top Priority Recommendations for Transportation Sector

Recommendation	Major Theme	Parties Responsible
Standards to dramatically reduce GHG emissions from both light and heavy duty vehicles	Opportunity #3: rethink transportation to lower demand and carbon emissions	CARB, auto industry Federal government
Low carbon fuels	Opportunity #3	CARB, Federal government, oil industry, electricity industry, auto industry, biofuel industry
Place a price on carbon through a cap or tax	Strategy #2: Balance a portfolio of economic and technology policies	CARB, Federal government
Improved land use planning	Opportunity #3	City and county governments, metropolitan planning districts

Transportation accounts for over 40 percent of all anthropogenic GHG emissions produced in California, divided among different segments of the state's transit related infrastructure as shown in the chart below. California's transportation impacts on global climate change emissions are clearly dominated by gasoline to fuel motor vehicles. These GHG emissions from various modes of travel and goods movement are a function of:

- Vehicle technologies; [1]
- Fuel carbon intensity;
- Transportation activity levels.

Achieving California's AB 32 climate change goals will require addressing all three of these aspects of the transportation system. Some policies are already in place or are being developed, as noted below. As explained under Strategy #2 of this report's Introduction, the solution will require both putting a price on carbon and technology standards. ETAAC recommends additional measures to achieve the following types of goals:

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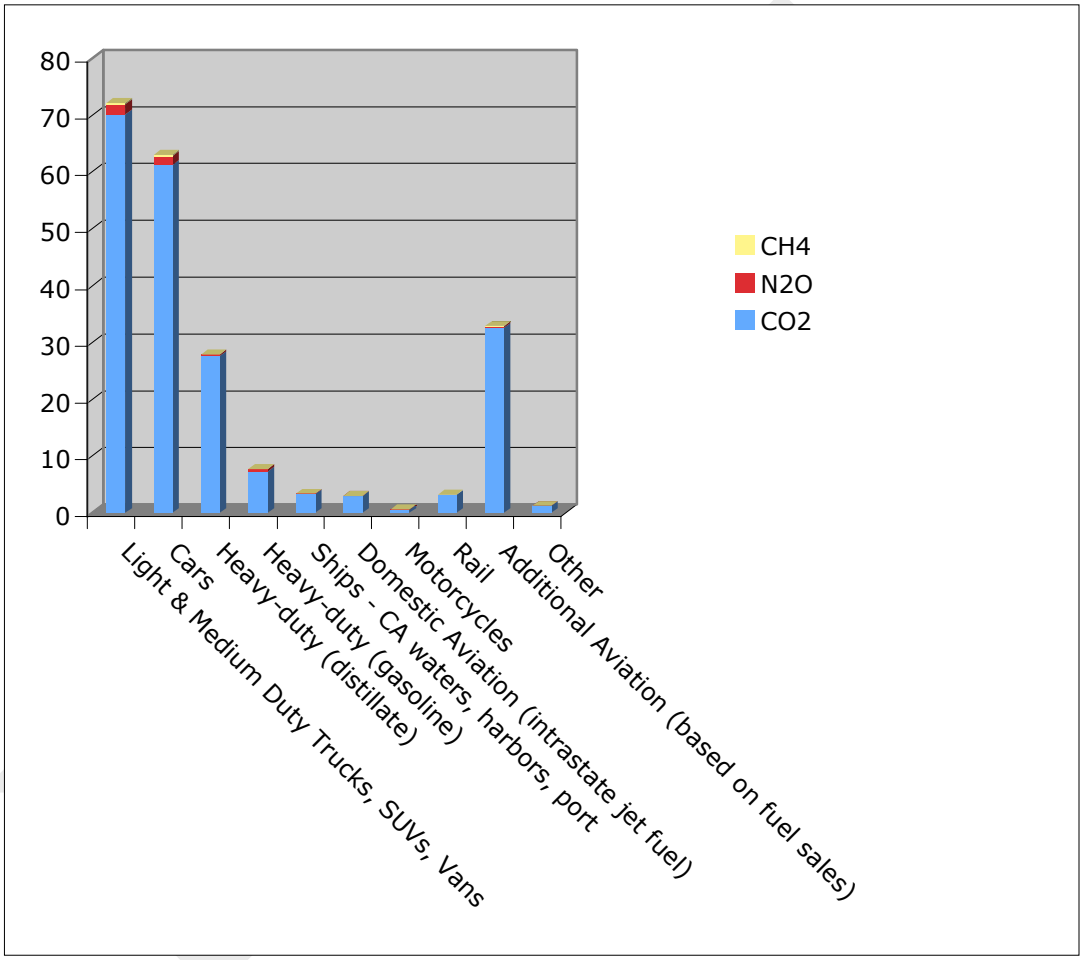
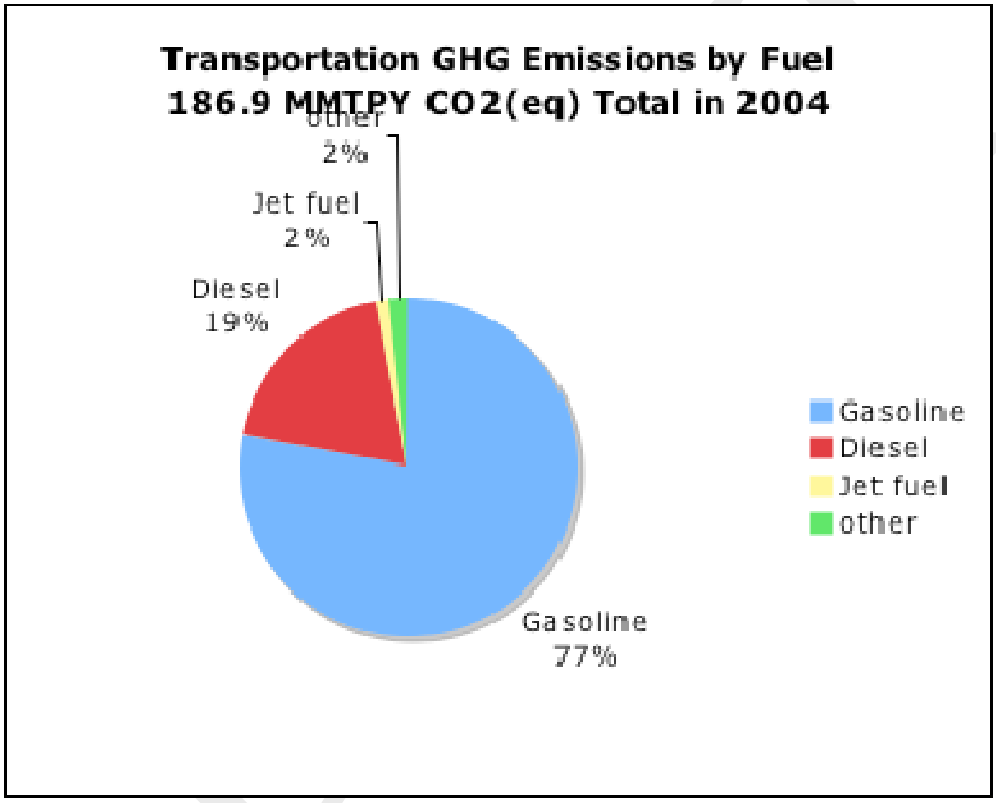
- Conserving energy by lowering passenger and freight motor vehicle miles traveled;
- Substantially lower GHG emissions released per mile traveled for each vehicle;
- Lowering the impact of transportation fuels and technologies on global climate change (see Table 1 below).

GREENHOUSE GASES BY TRANSPORTATION MODE (CARB Inventory for 2004)[2]



According to the California Department of Transportation (CalTrans), the number of vehicles in California is increasing faster than the population for many reasons. Among them are rising standards of living, which boosts vehicle ownership and global trade, increasing freight movement throughout California. The state's annual vehicle miles traveled (VMT) figures continue to rise, in part, due to longer commute distances. But expansions in non-work trips are playing an even larger role. Average on-road fuel economy has been declining, primarily because traditional family cars are being replaced with light-duty trucks and sport utility vehicles (SUVs). Levels of congestion on California's roads and highways are also up, leading to still further increases per trip in GHG emissions.

California drivers used an estimated 18.1 billion gallons of motor fuel to travel 330 billion miles in 2005 – a 15 percent increase since 1990 -- at an estimated cost of $44 billion.[3] If current growth trends continue, gasoline use and related CO_2 emissions in the state will grow by approximately 30 percent over the next 20 years. This increase has a substantial environmental price tag as well as economic penalty: a $13 billion increase in the cost of fueling the transportation system (assuming a cost of $2.40 per gallon of gasoline). Considering that over 50 percent of the petroleum consumed in California is imported, the near total reliance of transportation on petroleum exposes the state's economy to price spikes created by dynamics of national or international markets. The corresponding outflow of capital from California reduces the purchasing power and living standard of growing numbers of state citizens.



Source: California Air Resources Board, 12-21-07

However, current forecasts for California's transportation energy include a key climate change regulation, AB 1493, which will reduce the GHG emissions from new automobiles by about 30 percent by 2016.[4] With this law in place, California's gasoline consumption is expected to be essentially flat through 2025, but diesel fuel consumption is expected to approximately double over this same period.[5]

There are already several policies intended to decrease transportation GHG emissions, as well as a number of factors that can potentially increase these same emissions. It is imperative to develop and implement these existing policies while considering new policies needed to meet the goals of AB 32. Table 2 summarizes the key policies already in place or under development, and Table 3 contains relevant AB 32 Early Action measures.[6] Table 4 contains a summary of specific recommended actions to reduce GHG emissions from the transportation sector, and achieve major co-benefits (as summarized under section II of this chapter).

Table 2: Existing Policies Affecting Transportation GHG Emissions

	Standards (Regulations)	**Incentives**	**RD&D**
Mobility (personal travel)	• AB1493 • California Zero Emission Vehicle program • California Zero Emission Bus program	• HOV lane access for hybrid vehicles (limited in numbers) • Incentives for advanced vehicles • Investments in travel alternatives • Federal Tax Credit for hybrids • Moyer Program (ozone precursor and black carbon contributions to climate change)	• State and federal R&D • California Fuel Cell Partnership • Advanced Battery Consortium (DOE) • H_2 Highway (infrastructure deployment with different H_2 generation technologies)
Goods Movement	• New diesel emission requirements (small percentage increase in CO2 and major decrease in black carbon) • Diesel Risk Reduction Program (in-use vehicles via black carbon reductions) • Marine vessel speed reductions • Port expansion*	• Electrification programs for ports and truck stops (and potentially increased use of CNG) • State Emission Reduction Program • Smartway Program	• State and federal R&D
Air	• Airport expansion plans*		
Fuels	• Low Carbon Fuel Policy	• Low taxes on fuels, compared to world averages*	• State and federal R&D

* Tends to *increase* GHG emissions

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Table 3: Measures Contained in CARB's Draft Early Action Plan[7]

Name	**Summary**	**Estimated emission reduction (MMTCO2e)**
Low Carbon Fuel Standard	Require the carbon intensity of transportation fuels to decline 10 percent by 2020.	10-20 by 2020
Smartway Truck Efficiency	Require existing trucks and trailers to be retrofitted with devices that reduce aerodynamic drag.	Up to 6 by 2010 and 20 by 2020
Tire inflation	Require tune-up and oil change technicians to ensure proper tire inflation as part of overall service.	0.54) by 2010 and 0.20 by 2020
Green ports	Allow docked ships to shut off their auxiliary engines by plugging into shoreside electrical outlets or other technologies.	0.5 by 2020
New Passenger Vehicle GHG Standards	GHG Standards for post-2017 model year vehicles	4 by 2020; 27 by 2030
Heavy duty hybrid trucks	Lower GHG Emissions through heavy-duty hybrid trucks	
Air conditioning	Restrict HFC-134a sales to consumers	Options range from 0.1 to 2 MMTCO2(eq) by 2020

Table 4: Policy Recommendations for Low-Carbon Transportation Technology Advancement

	Policy Strategy		
	Standards	Incentives	RD&D
Reducing GHG rates from passenger vehicle	• AB1493 phase II (beyond 2016) • Extending ZEV requirements for all pollutants to be fully in place by 2035 • Fleet procurement requirements	• Feebates for vehicles and fuels (see Finance Sector) • Roadway Congestion pricing	• Substantial increase • Expanded national and international cooperation on electric drive and renewable energy
Shift/ Reduce Demand	• Congestion Pricing • Land Use Restrictions	• Land Use Planning • Pay-as-you go insurance • Bicycling economic incentives • Transit Funding • Additional support for public transit, including infrastructure	• Improved modeling/measurement • Evaluate personal rapid transit (PRT) demonstrations
Goods Movement	• Anti-idling enforcement • HDV retrofit requirements • Evaluation of new heavy duty vehicle standards	• Coordinating GHG reduction programs with Moyer program	• Substantial increase
Low Carbon Fuels	• Continue to develop zero and near- zero carbon energy sources and fuels	• Feebates • Green fuel labeling • Infrastructure for advanced low and zero GHG fuels	• Substantial increase • Develop infrastructure for future transportation needs

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Air transport	• Study of current and future aircraft emissions	• Evaluation of carbon-based landing fees	• Better emission factor and activity factors for existing and new aircraft

The ETAAC transportation sector subgroup focused its consideration of major recommendations on the passenger and medium and heavy duty vehicle sectors, which are currently the largest share of California's transportation GHG emission inventory. However, this is not meant to imply that other policies and technologies to reduce emissions from other sources are not important.

ETAAC collected and reviewed a substantial amount of information and technology transportation and other innovations. This material is included in Appendix V. Because RD&D for transportation technologies is advancing rapidly, a website has been established as a resource that contains or point towards many of the reports, presentations, and other documentation of these activities (www.etaac.org).

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II. General Policy Recommendations for the Transportation Sector

Enhance Research Development & Demonstration: ETAAC proposes a California Clean Transportation RD&D Program that substantially increases State investments in low-carbon and zero carbon technologies. These efforts should focus on RD&D of on-road and non-road transportation and goods movement technologies. The end goal should be to achieve greater cost-reductions in technologies that reduce GHG emissions as well as improve durability, reliability, and product life.

As vehicles are weaned off petroleum fuels, new ways of charging for the use of roadway infrastructure and operations which are currently paid for by Federal, State and local gas taxes funds will need to be developed. Many methods for supporting such research exist, including direct grants, solicitations, State procurement policies, and more. AB 118 is a constructive new tool for guiding RD&D activities, but additional funds may be needed, perhaps generated through auction revenue or other climate change related fees.

Encourage Private and Public Investment: The three key emission reduction strategies identified in the introduction – reduce or shift demand for vehicle miles traveled, boost efficiency, and expand use of low carbon intensity fuels -- could be accelerated if California created financial mechanisms to encourage investment in advanced energy and manufacturing technologies. State and local bonding authority could be used to establish investment funds that are used to encourage development of clean technology companies to build new manufacturing facilities in California and add to the state's employment base. For example, The United Kingdom's Carbon Trust is an independent, not-for-profit company set up by the U.K. Government to use government revenues to support low-carbon technologies using a private-sector approach.[8] As described in the Finance sector of this report, California could set up something similar in the spirit of the California Institute of Regenerative Medicine.

It is important to encourage private sector RD&D as well as to public sector RD&D. Private research funds are much larger than public funds and it tends to focus on innovations not being supported by the public sector. Clear and consistent public policy decisions and regulations will provide direction that encourages the private sector to make investments, and to direct their research dollars in the appropriate areas.

Coordinate Between Levels of Government and the Private Sector: The transition to a low-carbon (and for some technologies zero carbon) economy will require shifts in virtually all industries. This is particularly important in the transportation sector, where vehicle manufacturers, fuel producers and distributors must be coordinated in a way that still meets customer needs while enabling the development of many new vehicle technologies. Given the scope of the task facing California, effective collaborations will likely become increasingly important. The California Fuel Cell Partnership is just one of a number of examples.

California Fuel Cell Partnership:
Example of a Public/Private Demonstration Project

The need for coordination between auto manufacturers, energy providers, government agencies, and fuel cell technology providers is a potential barrier to commercialization of hydrogen fuel cell vehicles. The California Fuel Cell Partnership is a collaboration of 31 members to overcome barriers that would face individual members working to solve these problems alone.

Automotive members provide fuel cell passenger vehicles for demonstration programs where they are tested in real-world driving conditions (several organizations represented by ETAAC member are currently using hydrogen fuel cell vehicles in their fleets). Energy sector members work to build hydrogen infrastructure and fueling stations that are safe, convenient, and fit into the communities where they are located. Fuel cell technology members provide fuel cells for passenger vehicles and transit buses. Government members lay the groundwork for demonstration programs by facilitating the creation of a hydrogen fueling infrastructure. In addition, members collaborate on activities such as first responder training, community outreach, and agreeing on fuel cell related protocols while standards are being developed.

Since 2000, the Partnership has placed 170 light duty vehicles in California, and fuel cell passenger cars and buses have traveled more than a million miles on California's roads and highways. There are currently 25 fueling stations, with others planned. During 2008-2012, the Partnership members will continue to improve vehicle driving range, fuel cell durability, and station access in preparation for commercialization of fuel cell technology. Other important future challenges include making the fuel infrastructure sustainable by producing hydrogen from renewable sources. Yet another challenge is maximizing efficiency through energy stations that produce stationary heat and power in addition to hydrogen vehicle fuels.

Source: http://www.fuelcellpartnership.org

Seek Domestic and International Partnerships: Opportunities to work with partners outside of California can greatly help in reducing GHG emissions from the transportation sector. Some of the most important partnerships may be in developing strategies to avoid redundant RD&D investments. Coordinating public policy strategies and creating common, robust frameworks for incentivizing and regulating GHG emissions from transportation can also create a larger international movement to commercialize and deploy new technologies.

Increase Consumer Education and Choice: Consumer education on environmentally friendly technologies or habits has worked in California; both the State *Flex Your Power* campaign and Federal *Energy Star* labeling program have proved effective in shrinking energy usage. The State should emphasize the importance of public education and outreach programs for the transportation sector similar to existing efforts like "Spare the

Air" to reduce or defer driving on bad air quality days. A much broader public outreach effort is needed, nevertheless, to address global climate change. As a greater range of choices of vehicles and fuels become available to consumers, it will become important to provide information to consumers so that they make educated choices to reduce GHG emissions. This information can complement market-based incentives. However, the evidence about the effectiveness of public education campaigns to achieve public polices is poor.[9] Thus, these programs will require monitoring, evaluation, and adjustment to make sure they are effective.

Green labeling is an important component of the transportation energy consumer education program. One form of green labeling for the transportation sector would label a fuel or vehicle, making the consumer aware of the GHG emissions associated with their purchases.[10] Consumers are then allowed to make an educated and active decision to reduce their carbon footprint if they so choose. CARB is in active discussions regarding such green labeling efforts. At present, motor vehicles sold in California already have a smog index label.[11] GHG emissions information will also become part of this label by 2009. The State Legislature may want to consider further labeling efforts referencing energy use and corresponding emissions of different fuels or the emissions that were produced in making or shipping consumer goods.

Realize Economic and Environmental Co-Benefits: It is notable that each one percent reduction in transportation energy consumption (or rate of consumption growth) could add up to $440 million in annual savings. CalTrans calculates that every one percent reduction in GHG emissions from the transportation sector (through decreased VMT, improved vehicle technology, and fuels) stops 1.81 million metric tons (MMT) of GHG emissions from being releases into the atmosphere. This one percent reduction in energy yields a total statewide GHG emission reduction of 0.5 percent.[12] The decreased cost of purchasing fuels will also result in macro-economic benefits because of a shift of consumers' dollars from purchasing imported oil to purchasing more in-state goods and services. One study of climate change policies in California found that implementing AB 1493 would lower vehicle GHG emissions by 31 million metric tons of carbon dioxide equivalent (MMTCO2e) in 2020 compared to a business-as-usual scenario. This equates to roughly 18 percent of this legislation's GHG emissions reduction goal. At the same time, the law could increase gross state product by about $50 billion (over a 2 percent increase) and the creation of about 22,000 jobs (a 0.1 percent increase) due to this macro-economic effect.[13]

In addition, lowering petroleum imports will create energy security benefits. The continued increase in petroleum imports to the State of California -- and the increasing concentration of reserves and production in unstable areas of the world -- raises concerns about both the security of supply as well as the market power of foreign oil producers. Policies that reduce petroleum consumption and imports address these related and pressing problems as well. These benefits are realized through both a reduction in transportation energy consumption and a shift away from petroleum-based fuels.

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The GHG emission reduction strategies recommended for the transportation sector are also expected, as a whole, to achieve significant public health and Environmental Justice benefits. Strategies to reduce GHG emissions in the transportation sector lower fuel consumption and generate significant air quality and other environmental benefits through reduced "upstream" emissions from oil refineries and fuel transport. Furthermore, important synergies exist between California's decades-long fight against air pollution and the current effort to respond to global climate change. Many of the state's air quality strategies (e.g., anti-idling regulations, the Zero Emission Vehicle (ZEV) and Zero Emission Bus (ZEB) programs) offer key reductions in GHG emissions. Because many criteria air pollutants such as the black carbon in particulate matter and ozone also accelerate global climate change, air quality policies yield valuable contributions to AB 32's GHG emission reduction goals.

Other co-benefits materialize from policies to decrease demand for transportation services. Such policies tend to lower traffic congestion, saving time now lost in traffic. They may also lower the number and severity of traffic accidents, reducing the associated property damage, injuries, and mortality, and water and other forms of pollution.

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III. Shifting Demand for Mobility and Goods Movement

Vehicle travel is a major contributor to global climate change. Demand for highway travel by US citizens continues to expand due to population increases and growth in per capita transport demand. Between 1980 and 1999, highway route miles increased 1.5 percent while vehicle miles of travel increased 76 percent in the US. The Texas Transportation Institute estimates that in 2003, the 85 largest metropolitan areas experienced 3.7 billion vehicle-hours of delay, resulting in 2.3 billion gallons in wasted fuel and a congestion cost of $63 billion.[14] Traffic volumes are projected to continue growing, too.[15] Convenient and efficient public transportation and transportation demand management (TDM) systems are critical measures to reduce VMT and GHG emissions.

Travel Demand Approaches to GHG Emission Reductions

It is widely accepted that the current costs of driving and road use in the United States are below the efficient levels because many important external costs are ignored.[16] Thus, there are many measures that will both reduce GHG emissions and internalize some of these costs by pricing vehicle travel per mile. Improved planning measures will also lead to reductions in these "externalities." Some travel demand strategies that are likely to have larger or more certain effects include:

- Improved planning such as Smart Growth and Transit Villages;
- Pay-As-You-Drive insurance and road pricing.

ETAAC has also evaluated employer-based commute trip reduction options. Some of these options are more likely to result in significant GHG reductions than others.

Other possible approaches to managing passenger and freight vehicle traffic were originally developed as methods to reduce congestion and improve traffic flow. They could reduce GHG emissions from the perspective of reducing time spent idling in traffic with a traditional gasoline or diesel engine (if no additional trips resulted). However, it is unclear whether strategies to reduce traffic congestion – in particular those strategies that make driving faster without providing incentives to use alternate modes of transportation -- will in fact reduce travel overall, in part due to latent travel demand (itself a controversial topic.[17]) While idling can increase GHG emissions in conventional vehicles, high vehicle speeds can also boost GHG emissions due to lower fuel efficiency.

Improving transit systems is another way to reduce GHG emissions in the transportation sector. Increased funding of public transit systems may be needed so that California residents have more travel options. These systems can be expensive if designed to provide reliable, affordable transit options to low-density neighborhoods. This chapter identifies economic and technological innovations for transit systems linked to improved transportation planning and roadway pricing, but does not rank specific transportation system technologies. The Transportation Appendix contains information on bus rapid

transit and human-powered transportation alternatives, electric rail, and personal rapid transit (PRT) systems.

A. Planning: Smart Growth and Transit Villages

Planning measures can shift investments in housing and transportation infrastructure in a way that would reduce GHG emissions over the long term by providing desirable and low-GHG transportation options, largely by replacing automobile trips. Partnerships between the State government and regional and local agencies are critical to achieving these goals

Smart growth is an urban planning and transportation strategy that emphasizes growth near city centers and transit corridors to prevent urban sprawl. This approach promotes mixed-use, infill and transit-oriented development; transit, bicycle and pedestrian-friendly infrastructure; preservation of open space; affordable housing; and other strategies to reduce traffic injuries and improve the livability of urban neighborhoods including non-residential speed limits, roundabouts, "parking maximums, shared parking, flexible zoning for increased densities and mixed uses, innovative strategies for land acquisition and development, and design emphasis on a sense of place."[18]

- *Timeframe*: Implemented by 2012. Emission benefits will continue to increase through the 2020 and 2050 timeframes as new development incorporates these concepts.
- *GHG Reduction Potential*: CalTrans estimates that the average household living in a transit village could emit 2.5 to 3.7 tons less CO_2 yearly than a traditional household.[19] This estimate is based on a CARB study estimating transit village household private vehicle mileage reductions of approximately 20 to 30 percent annually.[20]
- *Ease of Implementation:* Ease of implementing smart growth aspects will vary among regions, but ultimately will require each regional development agency to make reduction of GHG emissions a planning priority. State-level legislation requiring regional transportation agencies to address smart growth and then providing appropriate implementation incentives would enable regions to move closer to sustainability.
- *Co-benefits / Mitigation Requirements*: Smart-growth policies play a critical role in reducing GHG emissions while improving the economy. Urban in-fill housing can be an effective tool to prevent creating further suburbs from existing farmland. Proponents point out that smart growth can reduce driving, increase walking, spur transit use, curb obesity *and* promote cleaner air.[21]
- *Responsible Parties:* Land use decisions are made at multiple levels (e.g, building and urban design, local zoning and use separation, regional integration with land use patterns). It is therefore imperative that several interventions and policies are required at different institutional levels. Nonetheless, these should be consistent and complementary with smart growth priorities.

- *State Government*: In June 2007, the CEC released *The Role of Land Use in Meeting California's Energy and Climate Change Goals*, a report addressing the need for land use planning to reduce the GHG emissions from the transportation sector.[22] CalTrans has also looked at ways to reduce VMT. One of its programs is the Regional Blueprint Process, which establishes 20-year goals on reducing VMT on a regional basis. The State Resources Agency should amend CEQA guidelines to recognize transportation impact measures that are not biased towards automobiles over other modes of travel. In addition, policies and requirements relating to CEQA, the California Transportation Plan, housing element updates, the California Water Plan, and storm water plans can all affect local land use planning and development. These State agencies will be critical in providing incentives for linking ongoing State planning processes with GHG emission reduction strategies.
- *Land Use Agencies*: Implementation of Smart Growth policies by local agencies to reduce VMT will be particularly important to meet AB 32's GHG emission reductions. California local land use agencies, such as San Diego's SANDAG, provide regional plans for more efficient land use. They can play key roles in implementing smart growth policies and then monitor the progress of these planning practices over time. They can also generate funding for smart growth incentives. Smart Growth blueprints have been completed by the Sacramento, San Francisco Bay Area in Southern California and are under development in other areas including the San Joaquin Valley.
- *Land Use Advocacy*: Land use agencies such as the Smart Communities Network[23] provide information sharing and best practices for local government and regional planning agencies.
- *Regional Transportation Agencies*: The Metropolitan Transportation Commission (MTC) is an example of a regional transportation agency. MTC is the transportation planning, coordinating and financing agency for the nine-county San Francisco Bay Area. It is responsible for regularly updating the Regional Transportation Plan, a comprehensive blueprint for the development of mass transit, highway, airport, seaport, railroad, bicycle and pedestrian facilities. The latest Plan features "smart growth" development patterns. MTC has developed new policies, funding programs and technical studies to foster smart growth, including transit-oriented development, regional growth planning, station area plans, and parking policies.

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- *Developers*: Developers are the integral part of smart growth implementation. Equipped with sustainable practices, developers can build structures that generate fewer GHG emissions from both upfront construction as well as ongoing daily operations. For example, the real estate developer Thomas Properties Group (TPG) developed the headquarters building for the Cal/EPA in Sacramento as a public-private partnership with the City of Sacramento. The 25-story, 950,000 square foot office building won recognition from the Building Owners and Managers Association as an example of efficiency and sustainable development and is certified at the "Platinum" level by the US Green Building Council's Leadership in Energy & Environmental Design program (LEED).

Problem: Urban sprawl can increase and lock-in high rates of VMT, subsequently increasing GHG emissions and leading to inefficient land use practices. In addition, urban sprawl requires high rates of land consumption, which threatens farmland. Urban sprawl can also lead to inefficient spending of government funds on new infrastructure while leaving existing infrastructure unattended.[24] The low rates of physical activity associated with urban sprawl are also thought to have a negative effect on peoples' health and well-being.[25]

The current Williamson Act mechanism used to keep farmland in agricultural use and delay housing or commercial development may not provide sufficient incentives for farmland owners to prevent urban sprawl and halt the growth of VMT. A large share of Williamson Act land in San Joaquin County is in non-renewal status, for example. Other states are more proactive than California in supporting smaller family farm operations.

Possible Solutions: The most important vehicle for implementing more smart growth planning is the coordination and provision of consistent incentives in infrastructure planning and development. Tying funding for these activities to Smart Growth goals, including GHG emission reduction goals, will encourage smart growth planning.

One form of smart growth is Transit Villages, which are typically mixed-use residential and commercial areas that are designed to maximize access to mass transit systems. They are usually located within one-quarter to one-half mile (0.4 to 0.8 kilometer) of a mass transit station. Transit oriented development can reduce VMT by 20-30 percent compared to conventional lower density development. With higher densities, more consideration is needed regarding how neighborhoods share open space, bike paths, and pedestrian corridors. Other considerations include evaluating how urban dwellers travel within and between cities. Along with improved transit, pedestrian, and bicycling infrastructure, these Smart Growth housing and land use practices are critical to reducing VMT. More electrified light rail systems are also needed for intra-city travel and as collectors linked to inter-city transit systems.

Incentives to provide residential housing close to employment centers, to support transit oriented development, to expand telecommuting, and to use video-conferencing in lieu of air travel could dramatically reduce VMT. Mixed-use development where shopping and

services are within a comfortable walking distance for residents could also play a major role in cutting GHG emissions from the transportation sector.

Adding GHG emission reductions to the California Environmental Quality Act (CEQA) guidelines is yet another important complimentary policy that will encourage Smart Growth. Such a change to CEQA is already underway. By January 1, 2010, new guidelines to address global climate change will be incorporated into CEQA.[26] Though ETAAC has not been actively engaged in this rulemaking process, ETAAC endorses one specific change to the proposed CEQA guidelines on climate change to encourage Smart Growth. The use of "Level of Service" (LOS) as a measure of environmental impacts for transportation projects under CEQA[27] should be replaced with broader measure of access to goods and services and quality of life. Because the "LOS" matrix values only automobile convenience, projects that may increase access to goods and services and improved quality of life by facilitating other modes of transportation are likely to be rated unfavorably under LOS (see the Transportation Appendix for more information).

B. Pay-As-You-Drive Insurance

Pay-As-You-Drive or Pay-Per-Mile insurance assesses individualized premiums based upon miles driven instead of the calendar year, providing motorists a new option to save money by driving less and therefore minimizing insurance risk. Pay-As-You-Drive premiums incorporate traditional risk factors such as driving record and vehicle make and model. They also still reflect insurance coverage services selected by the consumer themselves.[28]

- *Timeframe:* Pay-as-you-drive insurance could be implemented quickly, either through California regulation or insurance companies' own initiatives.
- *GHG Reduction Potential*: Applying the results of studies assessing mileage changes related to fuel prices, researchers have projected that pay-as-you-drive insurance could lead to up to a 12 percent reduction in driving and energy use.[29] Even a more modest benefit of a several percent reduction in driving would achieve significant GHG emission reduction benefits.
- *Ease of Implementation:* There are a range of challenges that insurance companies face related to offering pay-as-you-drive insurance, including product start-up costs, explaining to customers the benefits of a new pricing scheme, mileage verification costs, consumer acceptance of at least some monitoring (even if only of mileage), and loss of premium dollars from existing low-mileage customers.[30]
- *Co-benefits / Mitigation Requirements*: Government incentives to promote Pay-As-You-Drive insurance appear to be very cost competitive when viewed from the vantage point of reducing air pollution and saving lives. Other government transportation-related expenditures aimed at achieving these objectives are often more costly.[31] A 1 percent reduction in VMT typically lessens total vehicle crashes by about 1.2 percent.[32] Although it is difficult to predict actual

congestion alleviation, even a small decrease in driving demand can limit congestion delays.[33]

- *Responsible Parties:* Insurance Companies; transportation agencies; CARB; State Insurance Commissioner.

Problem: At present, automobile insurance premiums do not adequately factor in the number of miles driven by consumers. This subsidy encourages more driving, leading to increased VMT, GHG emissions, and traffic accidents.

Possible Solutions: Convert insurance to a variable priced service that considers risk factors such as driving record. Several key organizations can play a major role in changing current insurance practices so that they account for climate change impacts.

- *Insurance Companies*: Insurance companies are the ultimate arbiter of products that will be offered to consumers and they face some challenges in implementing this type of insurance. But insurance companies also have the flexibility of instituting a Pay-As-You-Drive strategy and some have already put forward pilot programs based on this insurance scheme.[34] Since 2004, for example, the General Motors Acceptance Corporation (GMAC) has offered mileage-based discounts to OnStar subscribers located in certain states.[35]
- *Transportation Agencies*: CalTrans is the State agency that is pivotal to alleviating traffic congestion and implementing successful transit systems. CalTrans is likely a critical player in making Pay-As-You-Drive operations successful.
- *State Insurance Commission:* The State Insurance Commission plays a significant role in determining how insurance companies set rates for consumers. In 2006, insurance companies were ordered by this Commission to place more weight on each individual driver's record, rather than his/her zip code. The State Insurance Commission could mandate insurance companies adjust rates based on how much consumers drive. This is currently given little weight. Smog check mileage records could provide information to verify the mileage provided by consumers.

C. Congestion Charges

Congestion pricing uses electronic transponders in the vehicle, database-linked cameras, and other barrier-free means to charge drivers as they enter heavy traffic congestion zones. This system works well in combination with public transition, and can be used as a source of funding for improved public transit. London, Norway, Rome, Singapore, and Stockholm are urban centers where such congestion pricing has already been successfully implemented.

- *Timeframe:* Initial project(s) in place by 2012; with additional potential projects feasible in time for 2020 targets.

- *GHG Reduction Potential*: Exact reductions would depend on the areas covered and specific program design. Potential GHG emissions reductions of one million tons per year or more could be achieved if applied to areas responsible for 10 percent of the state's vehicle GHG gas emissions.[36] The City of San Francisco Climate Action Plan sets a goal of reducing 165,000 tons per year of CO_2 emissions by reducing VMT.[37] The San Francisco County Transportation Authority has identified congestion pricing as a key component of that strategy.[38]
- *Ease of Implementation:* Local planning authorities need legal authority from the State to implement congestion pricing. State support for planning and/or initial set-up of congestion mitigation pricing systems would also be beneficial.
- *Co-benefits / Mitigation Requirements*: Reductions of pollutants such as fine particulates and ozone forming pollutants, and reductions in traffic deaths and injuries, are examples of major co-benefits. Revenues can be used for projects to accommodate increased demand for alternatives such as transit, walking, and bicycling. Public hearings and outreach can help focus these improvements to mitigate disadvantages and maximize improved transit and other transportation co-benefits to meet AB 32's Environmental Justice goals.
- *Responsible Parties:* The State Legislature would provide legal authority. Local transportation planning agencies would be responsible for evaluating potential projects, such as areas with existing effective transit systems or the potential for effective transit, with support and coordination from CalTrans and Regional Transportation Agencies as needed.

Problem: VMT is an important contributor to global climate change, air pollution, and other congestion-related problems.

Possible Solutions: Congestion pricing has the potential to reduce traffic jams, VMT, and GHG emissions. Under congestion pricing, drivers are charged via electronic and other barrier-free options to enter an area of heavy traffic. London reduced GHG emissions from road traffic by 16 percent within its congestion pricing area,[39] lowered congestion, and improved transit and bicycle use.[40] The City of Stockholm is estimated to have reduced CO_2 and particulate emissions by 14 percent, which equates to approximately 100 tons per weekday 24-hour period.[41] Such congestion pricing programs could offer varying fees based on different tiers that factor in co-benefits. London, for instance, offers exemptions for electric cars.[42] Other factors could be studied during the local planning process for California agencies. Revenues collected under such a program could be used for transit improvements, thus further reducing VMT and traffic congestion. Roadway improvements could also be candidates for this source of funding.

The City of San Francisco is currently seeking to move forward with a congestion charging project covering access to downtown and certain other areas of San Francisco. San Francisco is also conducting a study to be completed by summer 2008 for a possible second project that would cover traffic hotspots like the downtown area.

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The California Legislature should adopt legislation providing local governments with the authority to implement congestion pricing projects after a public process that includes a public hearing. CalTrans and Regional Transportation Agencies should examine appropriate opportunities to support and coordinate potential projects within the state.

D. Employer-based Commute Trip Reductions

Employers and their employees can reduce GHG emissions by reducing drive-alone commuting.

- *Timeframe:* Could be implemented by 2012
- *GHG Reduction Potential:* Varies based on option(s) chosen
- *Ease of Implementation:* Varies based on option(s) chosen
- *Co-benefits / Mitigation Requirements:* Varies based on option(s) chosen.
- *Responsible Parties:* CARB, employers, employees, and potentially others based on option chosen.

Problem: Just over one fifth of personal travel is for commuting. According to the 2000 US Census and National Household Travel Survey, just over three quarters of these US commuter trips are drive-alone trips. Thus, about 17 percent of personal travel is drive-alone commutes that could be addressed through employer-based policies.

Potential Solution: Several employee trip reduction policies are already in place in California, designed to lower air pollution. Existing employee-based strategies that reduce VMT will reduce more GHG emissions and other air pollutants if they are expanded to cover more employers. Other programs designed to limit or offset other air pollutants such as nitrogen oxides, volatile organic compounds, fine particulates, and carbon monoxide, from new land development (e.g. a new shopping mall) could also be expanded to require reductions of GHG emissions. Strategies such as increasing transit usage, and potentially also telecommuting and flexible work schedules, could be promoted either as expanded mandatory programs or as voluntary measures.

However, the cost-effectiveness of these programs is not clear. Policies that lower the per-mile GHG emissions of personal travel will tend to make policies to reduce VMT less cost-effective. (Of course trip reduction policies have other benefits such as lower levels of congestion.) Furthermore, placing a price on all GHG emissions may tend to reduce the need for trip reduction policies. Note that at present, there is *no* price attached to air pollutants. So if one is imposed on GHG emissions, the need for other policies like those discussed below will be less than the need to control air pollution. And in some cases, eliminating commute trips may not reduce GHG emissions as much as it might first appear since the employee who does not commute may use energy in their home office and may make other trips (e.g. for lunch) that they would not have otherwise. ETAAC recommends that the CARB study the cost-effectiveness of all policies it proposes to undertake, incorporating the factors noted below in any analysis.

- *Mandatory programs for both existing and new commute travel*: Two existing mandatory programs cover both existing employers and new land development. South Coast Rule 2202 requires employers with over 250 employees (with a few exceptions) to reduce employee trips and provides employers with a menu of options to do so. Employers can either reduce emissions, and/or purchase credits for mitigation. Similar rules could be applied to other areas where the potential to reduce drive-alone commuting exists. Parking cash-out programs are another example. Employers are required under state law to allow employees to "cash-out" the value of free parking that is provided at the employer's expense, under certain circumstances.

  Several existing California programs are aimed at reducing air pollutants for new development, including -- but not limited to -- additional employee commute trips. Developers subject to NEPA or CEQA may be required to mitigate air pollution emissions. The State is currently developing standards for addressing GHG emissions under CEQA. Many project developers are integrating evaluations of climate change impacts of their projects on a case-by-case basis. A number of Air Quality Districts have adopted "indirect source rules," which require on-site reductions of some or all of the expected emissions (such as nitrogen oxides and fine particulates) or paying a mitigation fee (for instance, San Joaquin Valley Rule 9510). These rules would also reduce GHG emissions if expanded to cover these pollutants, especially in cases where GHG emission reductions were not already required as mitigation under CEQA.

- *Shifting commute trips to other modes of travel:* Other modes of travel include ridesharing, public transit, walking, and bicycling. These modes can be promoted as a compliance option for mandatory programs. Employers can also support these options on a voluntary basis to increase employee-satisfaction and demonstrate environmental stewardship under an Environmental Management System or as a stand-alone measure. These shifts are not expected to lead to opportunities for additional personal travel by vehicle, or at-home energy use, as this strategy is not intended to affect the type of work schedule.

- *Telecommuting:* With its leading role in promoting information technology, California seems well suited to telecommuting, where employees work from a home-based office. (Telecommuting also includes satellite workplaces that are closer to home). This strategy can become a compliance option for mandatory programs. It can also be promoted on a voluntary basis for employers to increase employee-satisfaction and demonstrate environmental stewardship under an a company Environmental Management System. It can also be a stand-alone

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measure. Home energy usage could potentially offset travel-based GHG emission reductions. ETAAC did not attempt to quantify these values.

- *Compressed Work Schedules:* Under compressed work-week schedules, employees work a smaller number of longer days, such as a four-day 10 hour work week, or working seven days of 12 hours each over a two week period. Commute travel would be avoided on the day that the employee did not drive to work. Additional personal travel and at-home energy usage complicates the question of whether a net GHG emission benefit should be expected, and if so, whether a measurable effect can be determined.

  However, compressed work schedules are often not cost-effective for California employers because state law requires payment of overtime compensation for work performed by an hourly employee who works in excess of eight hours in a single day or more than 40 hours in a single work week. (This is more restrictive than federal law, and all other states, where overtime pay is required after 40 hours in a week). As a result, employers have a disincentive to schedule a four-day compressed workweek schedule because the last two hours of each 10-hour workday incur time and a half wage rates. Split shifts for 24 hour operations (12 hours on, 12 hours off) are significantly more expensive. California allows for "alternative schedules" but under very detailed Industrial Welfare Commission wage orders that are difficult to implement and rarely used. At present only 11,000 out of California's 800,000-plus employers operate under alternate rules.

  Changes to state labor law are contentious and involve issues such as safety, flexibility, cost savings, and politics. ETAAC does not have the expertise or responsibility to consider all these factors and is therefore not able to make any specific recommendations. However, it is clear that the CARB should conduct a study of the following factors for use by individuals and organizations involved in this important issue. How much wages would be decreased, and whether lowering wages for hourly workers currently earning daily overtime wages would disproportionately impact low-income communities and conflict with AB 32? Whether the measure would lead to a change in work schedules versus lowering wages without changing behavior? In addition, health and safety concerns outcomes should be quantified as well as the probable size of the expected net GHG emissions reduction.

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IV. Improving Vehicle GHG Performance

ETAAC has identified technology-forcing standards and economic incentives as key pathways to low and zero GHG emission vehicles. Like most measures that improve efficiency, these policies may pay for themselves and do not require public sector subsidies.

There are a number of successful programs that the state can build on. CARB's AB 1493 regulations establish a critical, performance-based system for driving low-carbon vehicle technology into the market through 2016. The Zero Emission Vehicle program is leading the development of zero tailpipe emission vehicles that are expected to become commercially available around the time that follow-up standards to AB1493 would take place, (see projections below). Bridge technologies like plug-in hybrids should be available even before that date. The main priorities of this section of this transportation sector chapter is to describe the development of new standards taking advantage of new technology for low and zero tailpipe emissions passenger vehicles and to expand those efforts to include the medium and heavy-duty vehicles. While these efforts are focused on cutting carbon emissions, California should also partner with the Federal government to demonstrate low and zero carbon technologies can also help form the basis for urgently needed improved fuel economy standards.

The section also describes complimentary pricing recommendations that will facilitate compliance with these standards as well as incentives to exceed them. Another key financial incentive for low and zero tailpipe emission vehicles is the "feebate" recommendation described in the Finance Chapter of this report and below. [43]

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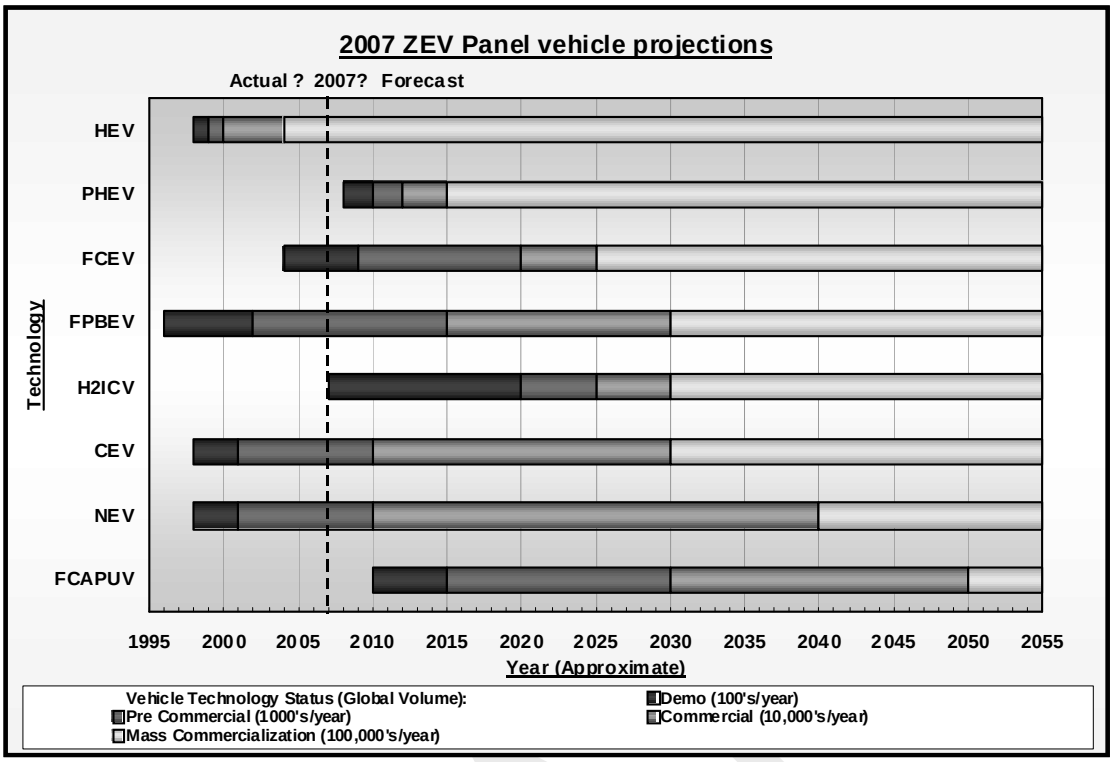

CEV city electric vehicle
FPBEV full performance battery electric vehicle
FCAPUV fuel cell auxiliary power unit vehicle
FCEV fuel cell electric vehicle
H2ICV hydrogen internal combustion vehicle
HEV hybrid electric vehicle
NEV neighborhood electric vehicle
PHEV plug-in hybrid electric vehicle [44]

E. New Vehicle Technology Improvements

While forward thinking when written -- and vitally important for near term AB 32 compliance – AB 1493 does not capture the full potential for GHG emission reductions now technically possible. For instance, the legislation covers only passenger vehicles and the cost-effectiveness analysis is based on gasoline prices ($1.75 per gallon) that are no longer realistic. A more comprehensive standard for post-2016 vehicles of all types would net even greater GHG emission reductions and can help foster partnership opportunities nationally and internationally.

- *Timeframe:* In effect by 2020.
- *GHG Reduction Potential*: 4 MMT by 2020; 27 MMT by 2030 for passenger vehicle standards. Not estimated for transport vehicles.
- *Ease of Implementation:* Changing vehicle manufacturing lines may be difficult

- *Co-benefits / Mitigation Requirements*: Very high, including reductions in up-stream refinery emissions and reduced reliance on imported petroleum. A supporting infrastructure of zero and low emission energy supplies for zero tailpipe emission vehicles will maximize benefits.
- *Responsible Parties:* CARB; auto manufacturers

Problem: Continued reductions in vehicle GHG emissions will be necessary beyond the 2016 end point of California's first round of passenger vehicle standards to account for currently available technology and future developments. The recent United Kingdom's King Review of low carbon motor vehicles found significant market barriers to deployment of new technology. These barriers include fixed capital investments in older technology, the need for economies-of-scale to make new technologies economical, and lack of high-priority given to fuel economy in consumer purchases.[45] Since vehicle manufacturing is a global industry, these same barriers affect vehicles available in California. Although the medium and heavy duty transport sector is sensitive to fuel prices, market barriers also exist to developing new technology for this sector.[46]

Possible Solutions: In September 2004, CARB approved regulations to reduce GHG emission reductions from new motor vehicles. The regulations apply to new passenger vehicles and light duty trucks phase-in from 2009 through 2016 model years. Between 2009 and 2012, these standards will cut GHG emissions by 22 percent compared to the 2002 fleet of passenger vehicles and light duty trucks. Mid-term – the 2013–2016 time frame -- standards will result in approximately a 30 percent reduction in GHG emissions.

CARB intends to present new standards to the board in the 4th quarter of 2012, which would impact the 2017 model year. ETAAC believes that follow-up technology-forcing performance standards are an immediate priority in order to accomplish the following:

- Take into account the full range of emerging vehicle technologies;
- Partner with other countries in the European Union and elsewhere that are currently developing new standards;
- Provide manufacturers with adequate lead time to introduce cleaner new vehicles.

These standards can also build on the state's Zero Emission Vehicle (ZEV) program, which is intended to help drive the development of automotive technology that will limit GHG emissions. Some of these technologies are available today (i.e. hybrids) while others will be available in the mid-term.[47] The timing of the rule adoption process should be flexible enough to accommodate acceleration if needed to provide sufficient lead time for manufacturers to bring new vehicles to market in 2017 based on new standards.

Assuming that the new standards call for about a 50 percent reduction from pre-AB1493 levels beginning in beginning in 2017, this measure would achieve about a 4 MMT reduction in 2020. The reduction achieved by this measure would significantly increase in subsequent years as clean new vehicles replace older vehicles in the fleet. CARB staff estimates a reduction potential of 27 percent[48] -- 27 MMT[49] -- in 2030.

Additional decreases would be achieved if new vehicle standards were also applied to the heavy duty trucking sector, which accounts for nearly one-fifth of transportation sector emissions. In particular, new engine, transmission, tire, and aerodynamic designs, idle reduction, and advance auxiliary power units could ultimately reduce GHG emissions by one third to one half from new freight trucks.[50] Although the freight industry is sensitive to fuel prices, technologies that slash fuel consumption have been slow to find their way to market. Comprehensive standards should not delay the planned near-term implementation of Smart Way efficiency improvements contained in CARB's Early Action Plan, but would instead incorporate the results of those efforts in a broader look at driving innovation and the uptake of existing technologies. The Early Action Plan discussion of hybrid technology identifies a number of important Federal and private sector partners, and international coordination can also play a valuable role in this effort.

Potential Heavy Duty Vehicle Near Term and Future Technologies

- *Vehicle Technologies*

Accessory Electrification (air conditioning, etc)
Efficiency Improvements (lubricants, brake and bearing drag)
Aerodynamic Drag
Vehicle Mass Reduction
Tire Rolling Resistance
Other Factors (vehicle weight, road speed, logistics, maximum loaded weight restrictions)
Advance Auxiliary Power Units

- *Engine Technologies*

Improved Selective Catalytic Reduction
Engine Friction Reduction
Engine Controls Refinements
Improved Air Handling Efficiency
Low Temperature Combustion
Homogeneous Charge Combustion Ignition/Partial Charge Compression Ignition
Sturman Digital Engine
Post Combustion Heat Recovery
Thermal Management Engine Improvements
Fuel Cell Electrochemical Engines

- *Drive train Technologies*

Continuous Variable Transmission
Automated/Manual Transmission
Hybrid (hydraulic and/or electric)
Electric Drive

Sources: International Council on Clean Transportation; and National Academy of Sciences 21st Century Truck Partnership

F. Low GHG Fleet Standards and Procurement Policies

Performance standards and procurement policies can facilitate implementation of low and zero carbon vehicles.

- *Timeframe*: By 2012, expanding to heavy-duty vehicles by 2020.
- *GHG Reduction Potential*: This recommendation can complement the implementation of AB 1493 standards and post-2016 standards; as well as the ZEV program.
- *Ease of Implementation:* Potential barriers are the need to increase "market pull" for the continued development and implementation of low and zero emission vehicles and mitigate current price premiums for these vehicles. Companion fuel infrastructure policies will be critical to success.
- *Co-Benefits / Mitigation Requirements*: Large co-benefits will be achieved from less local air pollution and less reliance on imported petroleum. Increased clean energy supply, including renewable energy sources whenever feasible, will maximize overall emission cuts, including vehicle tailpipe and oil refinery emissions in communities concerned about Environmental Justice.
- *Responsible Parties:* CARB; State, Federal, local and other fleet owners and managers.

Problem: The efficiency benefits of new technology are not fully utilized. In addition, new technologies must be demonstrated before they are commercialized.

Possible Solutions: Many local fleets have requirements for the fuel economy of the vehicles they purchase. The first component of this suggested policy is setting standards to require certain fleets to purchase vehicles with a maximum GHG emission rate. The standard could be structured as an average over a fleet -- or even across all fleets in a given category -- with a credit trading program.

A performance standard for fleet vehicle procurement would be similar to that of AB 1493, denominated in GHG emissions per mile. However, buyers of new vehicles instead of sellers would be responsible – and would also receive the benefits of more efficient vehicles. Such a standard may be subject to less procedural or jurisdictional challenges than the AB 1493 rule impacting vehicle manufacturers. This policy should be applied to State fleets immediately, and all eventually all other public and private fleets that receive any funding through State tax or fee revenue and/or utility ratepayer revenue. In addition, EPACT now allows State and local agencies to achieve petroleum reduction goals relying on hybrids and other high-efficiency vehicles instead of purchasing lower-efficiency vehicles that could in theory burn ethanol blends such as E85 (but instead use higher levels of gasoline.) For instance, the State has recently completed a purchasing arrangement that will assist state and many local agencies to purchase gas-electric

hybrids that achieve a minimum of 42 miles per gallon, instead of the state minimum standards of 26 miles per gallons for other vehicle of similar type.

In addition to passenger vehicles, this type of standard could apply to CARB's transit bus fleet rule and could be considered for other fleet rules that would reduce GHG emissions from vehicles such as refuse trucks and port drayage trucks.

As a second step, Federal, State, regional and local government agencies -- as well as utility and other private fleets – should participate in advanced technology vehicle demonstrations. This effort should start immediately and targets should be set with the ultimate goal of implementing 100 percent Zero Emission Vehicles (ZEV) by 2035 or sooner so that vehicle fleets will be fully transitioned before California's 2050 deadline for cutting total GHG emissions by 80 percent. For instance, the State of California and several organizations represented by ETAAC members (the Bay Area Air Quality Management District, PG&E, and the University of California – Davis) are among the organizations helping to demonstrate hydrogen fuel cell cars by including them in their fleets. Procuring ZEVs and PHEVs in fleets during the demonstration and early commercialization phase will achieve several important goals: the development of advanced vehicle technology and infrastructure; enhanced air quality, and fleet managers

G. GHG-based Vehicle Feebates and Registration Fees and Indexed Fuel Taxes

Fiscal incentives to promote more fuel efficient vehicles can complement carbon standards without restricting customer access to a full range of vehicle choices. Options include a revenue-neutral vehicle "feebate" program (as described in the financial sector). Yet another potential approach would be base vehicle registration fees and fuel tax levels on GHG emissions, but indexed to match inflation and keep pace with VMT increases.

- *Timeframe*: By 2012.
- *GHG Reduction Potential*: If California cuts in half the gap between the engine size and vehicle weight of California's fleet and that of more efficient countries, AB 1493 GHG emission reductions for light-duty vehicles would increase more than a third.[51]
- *Ease of Implementation:* Potentially difficult.
- *Co-Benefits / Mitigation Requirements*: Increased gas taxes could be used in part to increase transit opportunities for low-income and other communities; changes to registration fees could be phased-in to give consumers time to adapt.
- *Responsible Parties:* State Legislature and other implementing agencies

Problem: Adjusted for inflation, fuel taxes have steadily decreased as road usage, GHG emissions, and infrastructure needs have increased. The Legislative Analyst's Office (LAO) has identified a critical need to increase fuel taxes to fund infrastructure repair. In addition, standards that are set based on different vehicle type may not completely reflect the climate change response benefits of purchasing vehicles in a class with lower GHG emissions.

Potential Solutions: Many countries create a market pull for more efficient and therefore cleaner vehicles through higher fuel taxes and registration fees levied on GHG emissions directly or on surrogate factors (vehicle weight, engine displacement). Increased fuel taxes can also provide additional support for public transit, especially in Environmental Justice areas where consumers may be most affected by increased costs. California's LAO [52] has identified a need to increase gas taxes by ten cents per mile, just to maintain infrastructure. Taxes on gasoline in Japan are approximately triple that of California's combined $0.63 per gallon for Federal and State excise taxes. Some Europe countries impose taxes as six times that level. A modest tax increase in California's fuel tax would provide critical maintenance of road infrastructure and transit while still falling well below fuel taxes imposed in most other developed countries.[53] Indexing fuel taxes to inflation and VMT (as fuel consumption per mile is likely to fall without reducing the need for infrastructure) is crucial to avoid future funding shortfalls. The State should also encourage similar policies at the Federal level.

The United Kingdom indexes vehicle registration fees according to tailpipe GHG emissions, while Germany and Japan sets those fees based upon other factors that relate to GHG emissions (engine displacement, vehicle weight). These policies affect both existing vehicles (a phase-in period for existing vehicles could be considered to facilitate a transition) as well as new vehicle purchases. They also create a clear price signal to consumers.

H. Air Quality Incentives Programs & Standards

Air quality programs such as the Carl Moyer incentive program do not include a value for diminishing GHG emissions. Coordinating GHG emission reduction programs with existing air quality improvement programs (for both vehicles and other sources) would help meet AB 32's climate change response goals. It could also improve the efficiency of incentive programs for both GHG emissions and other air pollutants.

- *Timeframe:* By 2012.
- *GHG Reduction Potential***:** To be determined, based on funding levels.
- *Ease of Implementation:* Harder initially to coordinate, but then easier to implement compared to managing separate, uncoordinated programs.
- *Co-benefits / Mitigation Requirements***:** Criteria pollutant reductions.
- *Responsible Parties:* State Legislature as needed; CARB; regional and local implementing agencies; any new organization created to administer GHG emission reduction funds.

Problem: Several types of State air quality incentive funds are available to decrease pollutants such as fine particulates and ozone that violate State and Federal standards. Many of these programs focus on vehicle retrofits. They have not traditionally reflected the need to treat GHG emissions as air pollutants. Air pollution control standards now need to recognize both GHG emissions and more traditional pollutants as high priorities.

Possible Solutions: The Carl Moyer Memorial Air Quality Standards Attainment Program provides incentive funds (currently $140 million per year) toward the incremental cost of engines and equipment that go beyond State minimum air quality requirements oxides of nitrogen (NOx), particulate matter (PM), and reactive organic gas (ROG).[54] Eligible projects include cleaner on-road, off-road, marine, locomotive and stationary agricultural pump engines. Forklifts, airport ground support equipment, and auxiliary power units are also eligible for State retrofit funds. The State, in partnership with local agencies, is also implementing a new 1B Goods Movement Program ($250 annually and total funding of $1 billion) to upgrade technology and reduce air pollution emissions and health risk from freight movement along California's trade corridors.[55]

Any incentive funds that are available for GHG emission reductions in the transportation sector are likely to substantially overlap with these existing programs. Coordination is clearly needed. A project could be funded if it meets cost-effectiveness criteria when both types of reductions – climate related and criteria pollutants -- are recognized, even if it could not qualify based on just one or the other. This would likely require the redevelopment of program guidelines for existing programs such as the Bay Area's Transportation for Clean Air program.

It is important that technology-forcing standards recognize GHG emissions just as climate change response incentives and measures must consider effects on other air pollutants. Tailpipe standards should consider less prominent GHG emissions such as N2O and CH4. Standards such as federal Clean Air Act Best Available Control Technology should evaluate GHG emissions as an environmental impact along with other air pollutant emissions. Exceptions can be rendered. (For example, the Federal Clean Air Act Lowest Achievable Emission Rate does not allow for evaluation of cost or co-benefits/dis-benefits). ETAAC encourages continued efforts by State and local agencies to coordinate and integrate GHG emissions into air quality programs.

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V. Low-Carbon Fuels

After VMT are reduced and the efficiency of motor vehicles is increased, there will still be a need for large quantities of alternative, cleaner transportation fuels. The lifecycle GHG emissions of fuels are being addressed through the Low-Carbon Fuel Standard (LCFS) mandate being developed by CARB. The ETAAC transportation subgroup notes that other fuel tax incentives to encourage low carbon fuels are covered in Chapter 2, which addresses the financial sector. Likewise, biofuels production is covered in Chapter 6, which addresses the agricultural sector. Comments on the implementation of CARB's LCFS are located in an Attachment for consideration during that regulatory process.

I. Create Markets for Green Fuels

The LCFS mandate being developed by CARB addresses the lifecycle GHG emissions of transportation fuels. However, independent incentives might expedite achieving or even exceeding that standard and creating a basis for deeper future reductions, while creating opportunities for additional in-state production.

- *Timeframe:* Could be implemented by 2010 and improved after that.
- *GHG Reduction Potential:* Unclear, but green products typically fill a few percentage points of markets for goods (e.g. renewable electricity).
- *Ease of Implementation:* Determining the lifecycle GHG emissions of biofuels is complex, but measurement systems are already being developed by CARB as part of the LCFS. However, providing the results of this analysis to consumers would require tracking of specific fuel blends down to the retail level, a level of detail not currently envisioned under the LCFS protocol. A new tracking system would therefore be required. However, significant additional technical analysis would not be required to develop such a tracking system.
- *Co-benefits / Mitigation Requirements:* Low-GHG emission fuels may have better environmental performance on other dimensions, but in some cases may create other air quality issues. Careful evaluation of these impacts is clearly needed. Policies should ensure that air and water pollution are not exacerbated by the LCFS.
- *Responsible Parties*: CARB; oil and gas industry; biofuels industry; electricity industry; possibly the auto industry.

Problem: Biofuels and other new alternative fuel products can have either a positive or negative on global climate change depending on production methods and other factors. Current corn-based ethanol production often has GHG emissions similar to, and sometimes higher than, fossil fuels once all air emissions effects are accounted for. New technologies will be needed to significantly lower the GHG emissions of biofuels and improve co-benefits.[56] The LCFS should be designed to that it encourages technologies that drive down GHG emissions. One approach might be to encourage California farmers

to collect and use agricultural waste as a bio-fuel feedstock to complement the existing CARB regulatory requirements.[57] International, Federal and State standards for sustainable low carbon bio-fuels are currently being developed. So far, however, they do not offer any environmental performance information to consumers. With additional tracking standards, these systems could be used to engage consumer demand through a green fuels labeling standard in California.

Possible Solutions: A voluntary or mandatory Green Fuels Labeling Standard could be created to guide consumer purchasing preferences. This is especially important for bio-fuels because of the potential negative environmental and social implications of different feed stocks and cropping methods. Once waste-derived bio-fuels are fully commercial, new incentives could be used to expand the blending of biomass-derived fuels with conventional fuels beyond LCFS requirements (e.g., cellulosic ethanol with gasoline, renewable diesel with petro-diesel). This information could be included on fuel content labels.

Next Generation Transportation Fuels

Many opportunities exist for development of advanced zero-emission and low GHG vehicles and fuels. An overlap between electricity generation and transportation fuels is inevitable. Electricity supply infrastructure in the planning stage today for will need to accommodate near-term deployment of Plug-in Hybrids or electric-powered transportation systems. In addition, full performance battery electric and fuel cell vehicles (which could be powered by hydrogen derived via hydrolysis) are expected to be fully commercialized by the 2025 to 2030 timeframe. Based on the CARB Zero Emission Vehicle review panel, these projections are well within the expected lifetime of electric generation, transmission and distribution systems being planned today. Careful and forward-looking planning will be necessary to capture the advantages of synergies between energy sources employed for traditional electricity use and vehicle fuels.

Key policy goals for CARB, the CEC, the CPUC, other government agencies and stakeholders include:

Enable the private sector to develop low-cost, sustainable production processes for low GHG biofuels and hydrogen fuels

Increase renewable electricity development in order to maintain renewable goals during expanded use to supply vehicle energy

Assess plug-in hybrids, full performance battery electric cars, other electric transportation vehicles and systems, and hydrogen fuel cell vehicles as energy storage devices to facilitate increased renewables with a high percentage of off-peak generation; and as a potential source of peaking power during times of highest electricity demand

Plan and implement electric metering infrastructure and tariffs that allow customers with these vehicles to access the lower cost of off-peak power and net higher prices for sale of on-peak power

Enable the private sector to develop fuel distribution and dispensing infrastructure of low and zero alternate fuels

Enable the private sector to create an overall system that optimizes energy use across both electricity and transportation sectors, creating the flexibility to adapt to future circumstances.

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VI. International GHG Emission Sources

International shipping and aviation are two sources of GHG emissions that are continuing to grow. Only international cooperation will fully address these large contributions to global climate change. ETAAC encourages State and local agencies to consider actions under their current regulatory authority to address these GHG emissions. Policy options include marine vessel speed reductions and carbon-based landing fees. Some policies designed to reduce NO_X emissions, such as speed-reduction zones for marine shipping, are expected to provide climate change response co-benefits. Some jurisdictions have used revenue-neutral incentives. Airport landing fees that vary according to the NO_X emissions of different planes is one prime example. It is also possible to lower GHG emissions from marine ports and airports through the use of cleaner energy sources to provide shore-based power for vessels, electric service vehicles, and so forth. These changes could provide important co-benefits in the form of improved air quality.

The International Marine Organization and International Civil Aviation Organization plays an important role in establishing many types of environmental requirements for these global market sectors. The Federal government will also need to play a leading role in encouraging international cooperation on broader efforts to reduce GHG emissions. Today, for example, California does not have the authority to set engine GHG emission standards for these sources. Any proposed changes to air traffic control patterns will require cooperation from the Federal Aviation Administration.

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-Cars & light duty truck emissions are almost entirely from gasoline (less than 1 MMTCO2e came from distillate)
-Ships in CA waters includes intrastate, interstate and international trip emissions out to 24 miles
-Heavy-duty includes trucks with a loaded weight over 8500 lbs, as well as buses and motorhomes
-"Other" is assumed to be proportionate to light & medium duty for split between CO2, N2O & CH4

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[4] This regulation's implementation has been the subject of litigation brought by six automakers (DamilerChrysler, Ford, General Motors, Honda, Nissan, and Toyota), and the U.S. Environmental Protection Agency has yet to issue a waiver needed under the federal Clean Air Act.

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[46]For instance, according to one delivery company, they are unwilling to bear the cost of commercializing new technology that would also benefit competitors. Business Week, Date TO BE ADDED

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[52] Legislative Analyst's Office, Addressing the State's Highway Maintenance and Rehabilitation Needs, August 21, 2007.

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4. INDUSTRIAL, COMMERCIAL & RESIDENTIAL ENERGY USE

I. Introduction

California has the largest and most diverse manufacturing and industrial sector in the country. Manufacturers in the state range from small boutique shops serving local or custom needs to large facilities that are part of global corporations. Nearly every type of manufacturing is done here, including aerospace, chemicals, pulp and paper, computer technology, biotech, food processing, and more. Manufacturers, in turn, depend on extensive networks of local and global suppliers for raw materials, component parts, and ancillary services.

Through energy use and process emissions, California manufacturers account for 18 percent of total state GHG emissions. Oil refiners and cement plants represent fully half of the industrial sector GHG emissions. Not counted in these totals are the GHG emissions associated with transportation services related to both suppliers and goods movement to retail consumer accounts.

Electricity is a significant cost component for most manufacturers operating in the state. California has traditionally been a high cost state when it comes to electricity supplies. In fact, the current rate premium is estimated to be 35 percent. That said, industries operating in California have shared in California's energy efficiency successes. As a result of state policies promoting energy efficiency, per capita energy usage has gone from roughly similar to the national average to about a third less than the national average, according to the California Energy Commission. These savings have been achieved in the industrial, commercial, and residential sectors. Even with these significant energy savings, California's electricity, labor, tax and real estate costs combine to make the cost of doing business here 23 percent more expensive than the national average. These costs come on top of the 32 percent cost burden US manufacturers face generally when compared to their international competition.

Pressures linked to globalization translate into the need for California companies to adopt cost-effective energy efficiency measures to remain competitive. This end-use efficiency, when combined with the high percentage of renewable, hydroelectric and nuclear power in the state's electricity generation mix, makes California manufactured goods much less carbon intensive than products manufactured elsewhere. If the policies adopted under AB 32 inadvertently encourage industrial production to shift to unregulated regions of the world net GHG emissions would actually increase while state employment would decrease, lowering state tax revenues. This scenario is a lose-lose outcome that must be avoided.

Thus, the challenge for California policy makers is to encourage further GHG emission reductions from the state's manufacturers (and their suppliers) and commercial enterprises without adding costs and burdens that would lead to declining production and leakage to other unregulated regions. This can be accomplished if technologies, regulations and tax policies support adoption of cost-effective GHG emission reduction

measures. To that end, the following discussion by the ETAAC industry subgroup outlines the technological advances that should be supported by State programs and policies. Also addressed are the policy barriers that need to be removed to improve competitiveness and to prevent leakage of GHG emissions outside of AB 32's jurisdiction.

Other important State policies and emerging technologies discussed in this chapter relate to end-use energy management tools and technologies, among them energy efficiency improvements, distributed generation, customer choice of energy supply, building and appliance standards, and different waste management programs and techniques. (The electricity/natural gas contains utility and supply-oriented opportunities, and opportunities to reduce transportation fuel use and emissions are discussed in the Transportation Chapter). All of these tools, technologies and policies can reduce the carbon footprint of California's industrial, commercial and residential sectors of the economy. Outlined in this section are some of the promising opportunities to capture and cut carbon on the demand-side of the energy equation.

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II. Industrial Technologies and Policies

A. "Cleantech" Tax Incentives

Tax policies such as those addressed in Assembly Bills 1506, 1527 and 1651 would encourage small (and large) businesses to undertake measures to meet AB 32 goals that would otherwise be cost prohibitive.

- *Timeframe:* In place 2012.
- *GHG Reduction Potential:* 1-5 percent reduction of GHG emissions from small business, assuming an emissions reduction potential of 10-30 percent per business with 10-15 percent of small business participating.
- *Ease of Implementation:* Moderate. Requires passage of the bills and developing the programs within State government.
- *Co-benefits / Mitigation Requirements:* Assists small business and encourages technology development in California.
- *Responsible Parties:* State Legislature, Board of Equalization.

Problem: Excess cost or uncertainty related to many GHG emission reduction measures limits business' willingness to implement these measures. In addition, many measures do not have a positive economic return. Economic incentives will increase the implementation and development of clean technologies and reduce costs for business.

Possible Solution: The ETAAC should consider tax policies such as those addressed in Assembly Bills 1506, 1527 and 1651 to encourage small (and large) businesses to undertake measures to meet AB 32 goals that would otherwise be cost prohibitive. AB 1506 requires Business, Transportation and Housing Agency to study how to provide incentives for small businesses to adopt cleaner technologies. AB 1527 would provide RD&D tax credits to small businesses doing research related to clean technologies. AB 1651 would give a 10 percent income tax credit for the purchase of Cleantech equipment by small businesses.

B. Rebates for Load Reduction

Expand load reduction rebate programs to include non-electric generation technologies.

- *Timeframe*: In place by 2012.
- *GHG Reduction Potential*: 0.1 to 0.4 MMT (Assuming a GHG emissions reduction of 10-20 percent, implementation for 1-2 percent of electricity usage, and total GHG emissions of 100 MMT for electricity generation.)
- *Ease of Implementation*: Easy to moderate.

- *Co-benefits / Mitigation Requirements*: Reduces demand on natural gas-fired peaker generation units which often have higher emissions of priority pollutants than base load units.
- *Responsible Parties*: Utilities

Problem: Many technologies that could provide GHG emission reduction benefits (as well as peak demand reduction) fall through the cracks of current rebate programs funded by electric utility customers.

Possible Solution: Expanding load reduction rebate programs to include non-generation technologies is a possible solutoin. Examples include solar technologies that provide refrigeration/cooling without combustion or compression, waste heat technologies that provide refrigeration/cooling and energy storage technologies that allow peak reduction and demand response (as an alternative to running GHG emitting peaker units). See Appendix IV for descriptions of additional load reduction technologies.

C. Improve Policies For Combined Heat and Power Plants

California has yet to tap the full potential of Combined Heat and Power (CHP) facilities to reduce GHG emissions with efficient on-site power generation. The Waste Heat and Carbon Reductions Act (AB 1613) offers an opportunity for California to promote CHP on the basis of both climate change and industrial competitiveness.

- *Timeframe*: In place by 2009. AB 1613 passed the legislature in September2007 and was chaptered into law in October of 2007.
- *GHG Reduction Potential*: CO_2 reductions of 25-45 percent are possible with well-designed CHP systems, resulting in 0.6 to 1.5 MMT annually per 1,000 MW of installed CHP capacity.
- *Ease of Implementation*: Moderate.
- *Co-benefits / Mitigation Requirements*: Will also reduce priority pollutant emissions from coal based or existing natural gas fired electricity generation.
- *Responsible Parties*: CEC, CPUC, industry.

Problem: CHP installations can provide significant energy efficiency improvements in industrial applications by generating electricity to displace retail purchases while using otherwise rejected heat for process heating or cooling. A CHP project can contribute to AB 32 goals if it is designed to consume less fuel, which translates into less emissions than the alternatives (i.e. emissions from on-site boilers and electricity generation from natural gas-fired combined cycle units.) While CHP is not a new technology, State and utility policies pertaining to “self-generation” have discouraged penetration of cost-effective CHP into the industrial sector and commercial sectors.

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Possible Solution: ETAAC recommends that the State first define what constitutes qualifying CHP, determine the total amount of CHP potential that meets the qualifying criteria, and then adopt a statewide target to install a predetermined amount of qualifying CHP by 2020. Qualifying CHP would need to be defined, depending on the technologies employed, the equipment being replaced, alternative supply emission characteristics, and provisions contained in AB 1613. The CEC has estimated CHP facilites could supply as much as 5,348 MW of electrical capacity under an "Aggressive Market Access" scenario that features climate change mitigation incentives.[1]

AB 1613 implementation will be determined by the CEC and CPUC. To accomplish the goal to expand small- and large scale CHP, the State should consider the following:

- Recognize qualifying CHP as an efficiency measure in California's electricity supply Loading Order (so long as all other cost-effective energy efficiency has been achieved at the site of the CHP facility);
- Qualifying CHP installations (like other energy efficiency measures) should not be subject to utility departing electricity load charges;
- To maintain maximum CHP system efficiency and economic viability, CHP systems usually need to be sized to satisfy a facility's full thermal load. Frequently, this means that the system will generate more electricity than can be used on site. California needs new CHP-friendly CA ISO tariffs and a robust wholesale market ready to purchase this excess power.
- The facility owning the CHP system should maintain ownership of GHG emission credits for trading in the State's cap and trade program
- Recognize the GHG emission reduction benefits of CHP units that boost electrical efficiency and decrease thermal energy requirements – "double-benchmarking" -- as is done in several EU member states.
- Restore qualifying combustion technologies to the Self Generation Incentive Program
- Provide incentives for utilities to participate in the development of qualifying CHP units.
- Maintain the current power purchase program administered by the CPUC to provide markets for the excess electric power generated by CHP units.

D. Distributed Renewable Energy Generation: Solar PV

Based on an assessment of California's solar resources, rooftop solar photovoltaics (PV) have the technical potential to generate 74,000 MW at peak output.[2] While the peak solar output is not a direct match with electricity system peaks in demand, solar PV can clearly make a substantial contribution to reducing the need for the most expensive (and often most polluting) peak power requirements. This technology has significantly higher than market costs today. If the right steps are taken, its costs are projected to drop below conventional grid power by 2020 in regions featuring the best solar resources. ETAAC recommends that California build on existing solar incentive policies by reducing system

installation costs and ensuring that residents and businesses receive compensation for the value of net excess electric generation.

- *Timeframe:* In place 2012-2020
- *GHG Reduction Potential:* Every 1,000 MW installed will save 1 MMT CO2 per year.
- *Ease of Implementation:* Difficult to reduce system costs to parity with grid costs or below, low to moderate once costs are reduced.
- *Co-benefits / Mitigation Requirements:* Increased distributed renewables will reduce pollution for peaking power plants, and avoid transmission bottlenecks. They will create a potential clean energy source for zero emission vehicles, and increased deployment of solar PV will likely lead to greater innovation and world-wide usage.
- *Responsible Parties:* State Legislature, CPUC, utilities, and California residents and building owners.

Problem: The recent McKinsey Report[3] states that from a national perspective, there are several barriers to rebust solar PV development. These barriers lead to wide variations in predictions about the scale of future PV solar deployment. Cost compression and climbing up the learning curve on production and installation efficiencies are keys to expanding the solar PV market. Each doubling of manufacturing capacity drops solar PV cell costs drop by about 20 percent.[4] Despite a recent silicon shortage that created temporary price spikes, great progress has been made in reducing solar PV cell costs. The future success of solar PV will also depend on the level of cost improvements achieved in module efficiency, DC-AC conversion efficiency, inverter design, installation, and interconnection compatibility.

The Silicon Valley Leadership Group created SolarTech as a means to address some of these challenges.[5] SolarTech discovered that U.S building and installation expenses comprise 20 percent of solar PV system costs compared to 10 percent in Germany and Japan, where workers are paid comparable wages. The greatest difference in costs was explained by differences in the building and installation standards of each respective market. SolarTech also found that building permit and utility interconnection costs in the U.S. are also a substantially higher proportion of total solar PV system costs than they are in European and Japanese markets.

Potential Solutions: California currently offers substantial subsidies to reduce the high initial capital costs of solar PV systems. Time-of-use metering recognizes solar PV generation provided during peak periods of demand has a higher economic value than off-peak generation. Another incentive is federal tax credits that expire at the end of 2008. One more opportunity to promote solar PV, which is identified in the McKinsey Report[6], is to pay distributed generators for excess electricity production.

Residents and businesses should be compensated for the value of power provided to the grid when the value of solar PV output exceeds the value of on-site use. PV solar reduces

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carbon emissions by displacing the need to purchase peak power from fossil generators. This policy is especially valuable for residents and businesses with low demand for electricity or multi-unit buildings where it is not economically feasible to split solar PV output to each individual meter. This sort of excess power purchase policy would also facilitate the goal of "zero net energy" buildings.

Other potential policies that could be employed to cut installation costs for solar PV systems include these recommendations from the Silicon Valley Solar Center of Excellence:

- Performance Standards
- Installation Standards
- Utility Interconnections and Rebate Processes
- Building Permits Standards
- Education & Training (see Chapter 2.D
- Financing Tools: (see Chapter 2.F)

Rebates, tax credits, and other incentives can overcome solar PV current high costs to achieve near term GHG emission reductions throughout the industrial, commercial and residential sectors. To provide the greatest long-term impact on GHG emissions in California, the nation, and the world, solar PV will need to benefit from innovation that allows PV solar to compete with grid electricity without subsidies.

E. Customer Choice of Electric Service Provider

For many years, Californians have demonstrated a desire to purchase electricity from providers other than the incumbent utility under “direct access” rules. However, this option was suspended in California during the energy crisis of 2000-2001. The CPUC should examine how expanding direct access opportunities could affect our goals to increase renewable energy, energy efficiency and other GHG goals, and if adopted, determine how best to further these goals through direct access.

- *Timeframe:* Fully implemented by 12/31/08.
- *GHG Reduction Potential:* If the ability for individual and business contracting for electricity increased the state’s overall portfolio of renewables to 33 percent it would translate into a 15 MMTCO2E reduction per year, according to the Center for Energy Efficiency and Renewable Technologies (CEERT).[7] CEERT asserts that a 50 percent renewable purchase share is achievable, in which case the total reduction attributable to an open retail electricity market could be as high as 32 MMTCO2E.[8]
- *Ease of Implementation:* Low to Moderate.
- *Co-benefits / Mitigation Requirements:* Increased renewable energy supply will displace fossil fuel emissions from the electricity sector. Innovation in

renewable energy will likely lead to greater usage nation-wide. Empowering consumers will involve individuals and businesses in proactive efforts to mitigate climate change and sustain low-carbon lifestyles.

- *Responsible Parties:* State Legislature; CPUC.

Problem: Achieving significant GHG emission reductions by 2020 requires ordinary citizens to take many individual actions that, in the aggregate, will make a difference. Individuals can take personal responsibility for reducing GHG emissions by changing to Compact Fluorescent (CFL) bulbs or purchasing a hybrid vehicle, for example. An open retail electricity market expands this option to include electricity purchasing so they can choose how much of their electricity comes from carbon free renewable sources. Customers not grandfathered under the pre-2001 suspension date for direct access purchases may not contract for higher levels of renewables than the amount that their utility is required to procure on their behalf —20 percent by 2010.

Possible Solution: The CPUC is now conducting a proceeding to investigate lifting the suspension and re-opening direct access. The CPUC should examine how expanding direct access opportunities could affect our goals to increase renewable energy, energy efficiency and other GHG goals, and if adopted, determine how best to further these goals through direct access.

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III. End User Energy Efficiency

F. Building Efficiency Programs and Incentives

Encourage better energy performance in new buildings and cost-effective building retrofits.

- *Timeframe*: In place for 2020 targets.
- *GHG Reduction Potential*: 3 – 13 MMT (Green buildings have the potential to reduce energy use in buildings by 30 -70 percent. Buildings are responsible for 39 percent of the state's GHG emissions. If these measures are implemented in 25 -50 percent of the buildings in the state by 2030, emissions related to electricity use in buildings could be reduced by 3 to 13 Mt per year.)
- *Ease of Implementation*: Moderate.
- *Co-benefits / Mitigation Requirements*: Many green building measures also improve the quality of the interior work and living spaces.
- *Responsible Parties*: CEC**,** building industry, building owners.

Problem: The use of energy in buildings is a large component of the GHG emissions in California. The Governor started a "Green Buildings Initiative" to reduce energy use in state building, and the CEC periodically updates energy efficiency standards for new construction in the state. Existing technologies are sufficient to reap significant energy efficiency savings if incentives are aligned correctly and policies support their adoption.

Possible Solution: The following are ideas are presented by the ETAAC industrial sector committee to encourage better energy performance in new buildings, and to encourage cost-effective building retrofits:

- Support green building fast-track permitting and provide funding and training for building officials
- Provide incentives and technical assistance for tenants and building owners to retrofit leased space for energy efficiency.
- Fund and organize collection of climate data and the development of software to aid in building designs that would work with the climate to minimize energy use.
- Encourage CHP systems where appropriate.
- Maintain a State online directory of green building technology and service providers, so that businesses have easy access to this information.
- Provide education and training for contractors in energy efficient alternatives and green building technology.

G. Combustion Devices: Energy Efficiency

Develop uniform energy efficiency standards for all types of combustion devices.

- *Timeframe*: In place by 2012.
- *GHG Reduction Potential*: 0.3 to 1.3 MMT (Assuming a 10-30 percent improvement in efficiency, implementation for 20-30 percent of industrial/commercial combustion, and total emissions of 14.5 MMT for industrial/commercial combustion.)
- *Ease of Implementation*: Moderate.
- *Co-benefits / Mitigation Requirements*: Improved energy efficiency reduces costs to consumers and reduces criteria pollutants as well.
- *Responsible Parties*: CARB, CEC, local air districts, product manufacturers.

Problem: More efficient combustion devices would reduce fuel usage and GHG emissions. Energy efficiency standards are currently set by the CEC for some appliances (e.g. water heaters), but uniform efficiency standards have not been established for other types of combustion devices.

Possible Solution: The CEC should establish energy efficiency standards for new combustion devices, especially for the commercial/industrial sector. Regional air pollution control districts, CARB and CEC should then assess links between energy efficiency and air emission limits. These same air districts should revisit combustion regulations to identify opportunities at industrial, institutional and commercial boilers, steam generators and process heaters to incorporate:

- Emission limits expressed in terms of mass emissions per unit of power output, rather than pollutant concentrations;
- Design of new units to maximize heat recovery;
- Fuel utilization and heat transfer optimization;
- Insulation of piping.

H. Industry/Government Partnerships To Reduce Industrial Energy Intensity

To make the state's industrial sector more competitive and climate friendly, California should join the "Superior Energy Performance Partnership." Led by the Federal Department of Energy (DOE), the Federal Environmental Protection Agency, the Manufacturing Extension Partnership, and a number of industrial firms that include 3M, Dow Chemical, DuPont, Ford, Toyota, and Sunoco, this public-private partnership is an effort to improve energy management across the country.

- *Timeframe:* In place by 2012.
- *GHG Reduction Potential:* Assuming conservative implementation rates, the annual estimated GHG emission reductions from implementation of the key

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elements of Superior Energy Performance Partnership program after 10 years is 10 MT beyond business as usual. This equates to 10-15 percent of GHG emissions related to overall industrial energy use **in the US [?].** This figure equates to more than 25 percent of GHG emissions linked to total electrical and natural gas consumption in industry **in California [?].**

- *Ease of Implementation:* Moderate. Requires staffing and development of such a program within Cal/EPA (or the CEC, which already has some experienced staff). Cost share may be available from DOE.
- *Co-benefits / Mitigation Requirements:* Expands the market in California for energy efficiency services and technology. Increases the competitiveness of California industry in global markets. Creates exportable expertise in energy management and system optimization. Energy management techniques also applicable to commercial, institutional, and governmental facilities.
- *Responsible Parties:* Cal/EPA, CEC, member firms.

Problem: Industrial facilities are not aware of the substantial energy savings available to be developed at their own facilities and lack the management systems required to continuously shrink their overall energy intensity.

Possible Solution: This initiative will certify facilities for energy efficiency and achieve significant cost effective GHG emissions reductions. These energy savings and emission reductions will be secured through company commitments, energy management plans, adoption of best practices and an annual reporting on compliance with AB 32 reduction targets. Resources to assist industry include tools, training, and assessments. The proposed incentives for meeting the AB 32 emission reduction goals include public recognition and perhaps a funding preference during RD&D project solicitations.

I. Revolving Fund for Technology Demonstration Projects

A new program for California Demonstrations for Industrial Energy Technologies (California DIET) would accelerate adoption of emerging, technically proven energy efficiency technologies through industrial demonstrations. A low-cost loan fund could be created and could be replenished by royalties on successful demonstration projects, shared energy savings, and shared carbon credits banked for future use or sale.

- *Timeframe*: In place for 2020 targets.
- *GHG Reduction Potential*:
- *Ease of Implementation*:
- *Co-benefits / Mitigation Requirements*: Encourages the development and commercialization of new technologies.
- *Responsible Parties*:

Problem: Companies are reluctant to be the first to adopt technologies coming onto the market, particularly when the technologies could jeopardize tested manufacturing

processes. The risks are simply too great when a failure could threaten the health of the company, relationships with suppliers, the confidence of consumers, etc. Until proven under actual operating conditions, emerging technologies will not pass muster with permitting agencies, will not qualify for utility rebate programs, and may not qualify for financing. But without successful demonstrations, cutting edge technologies will never gain a foothold in any market. At present, there are limited funds to overcome these barriers. Only eight percent of the current PIER program is allocated to industrial RD&D purposes. Yet another issue is that there is often uncertainty over appropriate reimbursement rates for the state portion of cost-share funding when a company wishes to retain equipment from a successful demonstration. The extent to which prevailing wage laws apply to further private investment in technology developed with some level of public funding is another sticking point.

Possible Solution: A new program for California Demonstrations for Industrial Energy Technologies (California DIET) would accelerate adoption of emerging, technically proven energy efficiency technologies. Industrial demonstration projects of these technologies could be encouraged through the use of the following:

- A low-cost loan fund, to be replenished by royalties on demonstrated projects, shared energy savings, and shared carbon credits banked for future use or sale;
- Demonstration funds disbursed on a cost-sharing basis to industry or developers;
- Clear guidelines on cost-reimbursement for the public share of the costs of demonstration equipment that the host companies wishes to keep after successful demonstrations. These guidelines should consider: the environmental benefit of encouraging continued use of successful demonstration projects; fair reimbursements for public sector dollars invested in equipment costs; and the value that the State would receive from return of the cost-shared equipment.
- Clarify the boundaries of prevailing wage requirements
- Evaluate whether providing accelerated depreciation would be appropriate for technology demonstration equipment.
- Encouraging industry supported technology transfer and promotion

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IV. Waste reduction, Recycling and Resource Management

J. Develop Suite of Emission Reduction Protocols for Recycling

Development of the appropriate protocols for the recycling sector will result in GHG emission reductions far beyond the limited success available through minimizing fugitive methane emissions from landfills. Recycling itself can truly act as mitigation measure to reduce GHG emissions across all sectors of the economy.

- *Time Frame:* 2008-2010.
- *GHG Reduction Potential:* Not Estimated.
- *Ease of Implementation:* Moderate.
- *Co-benefits / Mitigation Requirements:*
- *Responsible Parties:* CARB, CIWMB.

Problem: The recycling industry consists of a broad and highly varied group of interested stakeholders including local governments and private sector recycling, waste management and manufacturing companies. Every ton of secondary material used in new product production has to be separated from its source. This is true whether that source be separated recyclable material or discarded waste material collected, sorted, and processed by the recycler for sale to mills and smelters for use as a feedstock material. Processors are often required to further clean and process feedstock for input into the final manufacturing process of new products. Due to the complexity of this process, no protocols have been developed to provide proper incentives to recycle in order to reduce GHG emissions.

Possible Solutions: The use of secondary materials in the manufacturing process reduces GHG emissions through almost every stage of product production. From extraction of natural resources to transportation, preprocessing, manufacturing and the final stages of production, the use of post-consumer (secondary) materials saves substantial energy and resources. Tracking these emission reductions across sectors and properly attributing them to deserving entities is necessary to effectively grow the recycling infrastructure in California.

CARB, in consultation with CCAR, CIWMB and other interested agencies and stakeholders, needs to ensure that the AB 32 Scoping Plan includes a process for developing and adopting a suite of recycling protocols early in the rule-making process. Potential protocols could include methods for quantifying and reporting the following:

- Direct GHG emission reductions stemming from energy savings attained through the use of secondary materials in the manufacturing process.
- Life-cycle emission reductions associated with recycling.
- Emission reductions from the production and/or use of compost.

- Local government protocols that include the life-cycle impacts of all solid waste-related decisions.

K. Increase Commercial-Sector Recycling

Recycling offers the opportunity to cost-effectively reduce GHG emissions from the mining, manufacturing, forestry, transportation, and electricity sectors while simultaneously reducing methane emissions from landfills. Recycling is widely accepted. It has a proven economic track record of spurring more economic growth than any other option for the management of waste and other recyclable materials. Increasing the flow through California's existing recycling or materials recovery infrastructures will generate significant climate response and economic benefits.

- *Time Frame:* 2008.
- *GHG Reduction Potential:* A modest 25 percent increase in recycling of commonly disposed materials would generate over five MMTCO2E in emission reductions.
- *Ease of Implementation:* Moderate.
- *Co-benefits / Mitigation Requirements:*
- *Responsible Parties:* CARB, CIWMB.

Problem: For 18 years, California's state-mandated recycling efforts have focused on residential recycling to meet California's waste reduction and recycling goals. The private-sector recycling industry has expanded the recycling to the commercial and industrial sectors, particularly with respect to metals and electronics. The commercial sector alone generates 63 percent of California's waste. Today, the commercial sector recycles at a significantly lower rate than the residential sector. Large office buildings, for example, recycle only 6 percent of their waste, compared to the statewide average of 54 percent diversion. Moreover, highly-recyclable cardboard and paper make up the single largest component of disposed commercial waste (26 percent). When disposed in landfills, these materials generate significant amounts of methane.

Multi-family dwellings (which are considered part of the commercial sector) recycle at a significantly lower rate than single family households. The vast majority of Californians living in single family housing have ready access to residential (curbside) recycling. Nevertheless, nearly 60 percent of residents of multi-family housing still lack basic recycling service. Although just 19.1 percent of Californians live in multi-family dwellings, these housing units account for 26 percent of the residential waste stream. Expanding curbside recycling to multifamily dwellings could divert an additional 329,000 tons of recyclable materials.

Possible Solutions: Recycling in the commercial sector could be substantially increased if the CARB and CIWMB required any firm that generates 4 or more cubic yards of waste per week to implement a recycling program that is appropriate for that type of business. Businesses should also be required to comply with state-determined material-specific

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disposal limits that would restrict the disposal of recyclable materials, such as cardboard, paper, or construction and demolition waste, regardless of whether it is collected by a refuse company or hauled to the landfill by the business itself. Furthermore, owners of multifamily dwellings should be required to arrange for recycling services that are appropriate for the multifamily dwelling, consistent with state or local law or requirements.

L. Remove Barriers to Composting

Compostable organics make up 30 percent of California's overall waste stream, contributing over 12 million tons annually to the state's landfills. In landfills, this material undergoes anaerobic decomposition and produces significant quantities of methane, much of which is not captured by landfill gas systems. Composting offers an environmentally superior alternative to landfilling organics. Composting avoids these landfill emissions, offers greater carbon sequestration in crop biomass and soil, a decrease in the need for GHG-releasing fertilizers and pesticides, and a decline in energy-intensive irrigation. Compost has been proven to provide effective erosion control and to drastically improve the quality of ground water aquifers, both of which could be crucial elements of mitigating the impacts of climate change.

- *Time Frame:* 2008-2012
- *GHG Reduction Potential:* Not estimated.
- *Ease of Implementation:* Easy to Moderate
- Co-benefits / Mitigation Requirements: Among the co-benefits associated with composting is the creation of nutrient-rich soils and supporting sustainable agriculture. Furthermore, the vast majority of composting occurs in-state, so composting is truly a "California-Grown" technology. While composting emits VOCs and ammonia, these emissions have been proven to be far lower than the emissions arising from the same materials if they were to simply biodegrade naturally.
- *Responsible Parties:* CARB, CIWMB, CalTrans

Problem: CIWMB has set a goal of cutting the amount of organic materials that go to landfills by half by 2020. CIWMB has stated that even if some of this material were converted through other processes, the State would still need at least 50 new large composting facilities. However, new composting facilities face a series of regulatory challenges, siting problems, and artificially low landfill costs which would make achieving this goal very difficult. Even the current backbone of our state's greenwaste composting infrastructure is at risk because of these challenges.

Possible Solutions: CARB and CIWMB could take several steps to promote the expansion of composting:

- The State should work with San Joaquin Valley Air Pollution Control District and the South Coast Air Quality Management District to ensure that they consider the net impact of any forthcoming regulations on the composting industry, including biogenic emissions and greenhouse gas impacts. If cost-prohibitive mitigation measure for criteria pollutants will become required by a regional air pollution control district, the State should offer financial incentives to keep compost operations in business.
- The State should consider adopting a per-ton GHG emission surcharge on landfill operators that will minimize the competitive disadvantage that composting faces. By incorporating the externality of methane production into the cost structure of the landfill industry, other waste management options with lower GHG emission impacts will be on a level playing field.
- The State needs to boost the procurement of compost for use by CalTrans and other State agencies; it should also encourage procurement of compost by municipalities for use in parks, schools, and general landscaping.
- The State should work to increase the use of compost in agriculture.

M. Phase Out Diversion Credit for Greenwaste Alternative Daily Credit

In many markets, greenwaste composting faces undue competition for materials from landfills because operators of landfills are able to get "diversion credit" for using greenwaste as Alternative Daily Cover (ADC). This practice is another barrier to developing a more robust composting industry in California and contributes to the climate change threat.

- *Time Frame:* 2008-2012
- *GHG Reduction Potential:* Not estimated.
- *Ease of Implementation:* Easy.
- *Co-benefits / Mitigation Requirements:* Not estimated.
- *Responsible Parties:* CARB, CIWMB

Problem: Landfill operators are required to cover the active face of the landfill at the end of every day to prevent odors and public health risks. The traditional material used for this purpose is soil, but operators have found that other materials such as processed green waste, auto shredder fluff, and tarps can also be used for this same purpose.

Under AB 939, the State's waste reduction and recycling law, the use of these alternative cover materials (ADC) is counted as recycling, and the materials are not considered "landfilled." This law was intended as a temporary measure designed to spur the development of a collection infrastructure for these materials, which could then be composted. Instead of a temporary measure, greenwaste ADC has become the dominant end use of this material. Existing policy provides a perverse incentive for local governments to use greenwaste as landfill cover to meet their recycling goals.

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There are three ways in which this practice contributes to global climate change. First, greenwaste materials are porous and therefore are not very effective landfill covers. As a result, significant GHG emissions escape into the atmosphere. Second, the greenwaste itself produces methane when it decomposes anaerobically in the landfill. Third, this practice diverts these materials from composting and anaerobic digestion processes that diminish GHG emissions. By providing an incentive for the use of greenwaste as ADC, the State is inadvertently contributing to climate change.

Possible Solutions: CARB and CIWMB should seek legislative authority to phase out the current diversion credit for the use of greenwaste as ADC.

N. Reduce Agricultural Emissions through Composting

Greater agricultural use of compost has been proven to substantially reduce the demand for irrigation and fertilizers/pesticides, while increasing crop yields. This is an extremely cost-effective way to reduce agricultural GHG emissions while sustaining California's agricultural industry by returning organic nutrients to the soil.

- *Time Frame:* 2008-2020.
- *GHG Reduction Potential:* Not estimated.
- *Ease of Implementation:* Moderate.
- *Co-benefits / Mitigation Requirements:* Agricultural compost utilization offers significant water quality and erosion co-benefits.
- *Responsible Parties:* CARB, CIWMB, California Department of Food and Agriculture (CDFA).

Problem: California's agricultural industry is a significant source of GHG emissions. These emissions can be linked to activities such as the application and nitrification of nitrogen-based fertilizers and pesticides. The massive flow of energy required to irrigate California's crops also contributes to climate change. Given the difficulty in quantifying the GHG emissions from this sector, agriculture is unlikely to be included under a AB 32 carbon cap. While agricultural use of compost can reduce on-farm and indirect agricultural sector GHG emissions, unprecedented regulatory and financial challenges have significantly threatened the greenwaste composting industry in California.

Possible Solutions: CARB could partner with CDFA and the CIWMB to develop specifications and demonstration projects for using compost on a variety of California crops. This would send the right signals to California farmers interested in using compost on their fields.

In addition, farmers could also be given a direct monetary incentive for reducing irrigation, use of fertilizers, pesticides, and herbicides. Making this transition to a more sustainable operation could be funded by several different means, including a per-ton

GHG emission surcharge on landfill tipping fees. Another option would by market cap and trade auction revenue.

Finally, the State might consider developing protocols to quantify the GHG-reductions associated with agricultural use of compost. These protocols would allow farms to reduce their GHG emissions and sell corresponding offsets to other economic sectors. To begin on this process, the State would need to quantify the avoided fugitive emissions from landfills and then measure the GHG emission reductions that flow from less irrigation, less fertilizers, less pesticides, and less herbicides.

O. Waste Conversion Evaluation

Establish policies to encourage the development and implementation of waste conversion technologies.

- *Timeframe*: 10 percent implementation by 2012; 30 percent by 2020; and 100 percent by 2050.
- *GHG Reduction Potential*: 0.5 MMT by 2012; 1.4 MMT by 2020; 4.7 MMT. by 2050 (Assuming 42 million tons of waste per year; 60 percent biogenic; 9 MMBtu/ton; 35 percent conversion efficiency; replacing natural gas combustion at 52.78kg/MMBtu; 12.5 kg/ton transportation avoidance.)
- *Ease of Implementation*: Moderate to difficult.
- *Co-benefits / Mitigation Requirements*: GHG emission reduction benefits would flow from diverting waste from landfills (a significant source of methane emissions), reduced transportation of waste, and providing feedstock for low emission biomass electricity and fuel production.
- *Responsible Parties*: State and local governments.

Problem: Conversion of municipal waste to fuels and other products can potentially reduce landfill-related GHG emissions and displace fossil fuels. However, these conversion technologies can also potentially impact air, land, and water resources depending on the type of technology and product employed.

Possible Solution: The ETAAC industrial subgroup recommends that CARB, CIWMB, CEC, and the California Water Resources Board assess whether existing research is adequate to identify technologies that can reduce GHG emissions and offer other co-benefits and would be overall beneficial. These State agencies should also determine where existing research and evaluation of technologies needs to be supplemented. For technologies considered as beneficial to meeting AB 32 goals, it is recommended further evaluation should be performed to analyze whether permitting guidance would facilitate further development. The purposed of this guidance would be to facilitate, and not replace, any case-by-case permitting and public involvement requirements. This evaluation could also address whether existing there are gaps in existing RD&D activities and how these technologies are treated under solid waste diversion laws.

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[1] CEC, *Assessment of California Combined Heat and Power Market and Policy Options for Increased Penetration* (November 2005), (pg 2-18, 2-19).
[2] California Energy Commission, *California Solar Resources*, Staff Draft paper in Support of the 2005 IEPR, April 2005.
[3] McKinsey & Company, *Reducing U.S. Greenhouse Gas Emissions: How Much at What Cost?* – U.S. Greenhouse Gas Abatement Mapping Initiative; December 2007, p 62-63.
[4] Solar cell costs have dropped by 19 percent with each doubling in manufacturing capacity (Dr. Richard Swanson, SunPower founder and CTO, June 2007)
[5] SolarTech, *Creating a Solar Center of Excellence* (White Paper), June 2007, page 5
[6] McKinsey Report, p. 65
[7] Comments to this committee by Rachel McMahon dated October 1, 2007
[8] CEERT attributes a cost of utility compliance with the 33 percent RPS at $100 million. To the extent that incremental renewable costs are born by the consumer in a reinvigorated retail market condition, thus obviating the need for the subsidy, restoration of customer choice would yield a net avoided cost of $100,000,000.

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5. ELECTRICITY AND NATURAL GAS SECTORS

I. Introduction

The electricity and natural gas industries offer a significant challenge for California's in meeting AB 32's mid- and long-term GHG emission reduction goals. Yet these sectors also offer golden opportunities for the State to build upon its track record of bringing promising energy solutions to market.

California must design a strategy that not only reduces in-state emissions from electricity generation (about 10 percent of the state's GHG emission inventory), but also recognizes the need to cut GHG emissions from more polluting out-of-state electricity generators (another 10 percent of the state's GHG emission inventory). Securing adequate natural gas supplies for electricity generation, heating and transportation is also a challenge (as is developing alternative fuels to displace natural gas.)

ETAAC recognizes four major areas where the electric and natural gas sector will play a leading role in helping the State reach a 90 percent per capita reduction by 2050:

- Accelerating energy efficiency upgrades;
- Expanding renewable electricity supplies;
- Removing and storing carbon from remaining fossil fuel and biomass electricity production;
- Developing enabling technologies to increase zero carbon renewable electricity available to fuel low and zero tailpipe emission vehicles.

The ETAAC electricity and natural gas sector subgroup approached the challenge of meeting AB 32's GHG emission reduction goals from two perspectives:

Technology Categories: What is the development status of electricity generation and end-use technologies that promise to deliver zero and low-carbon energy services to California consumers at reasonable costs? ETAAC has assessed which of these clean technologies should be further analyzed and has prepared a more detailed Appendix with a broader assessment beyond the main "game changers" listed in this chapter. This Appendix provides a broader reference for energy-related technologies that could contribute to the State's strategy to combat climate change.

Policy Issues: What are the technological, financial, institutional and regulatory barriers to the broad deployment of these clean technologies within the AB 32 compliance timeframe of 2020? Can they play a role in helping the State maintain a trajectory to meet the even more aggressive 2050 GHG emission reduction goals? If applied correctly, these policies foster innovation, accelerate commercialization timeframes, and facilitate market adoption. Getting the

policies exactly right is critical to fostering robust technological development within the parameters of current economic feasibility.

Utility energy efficiency programs put into place in response to visionary State policies have shown impressive results. California electricity usage has remained flat as national rates of consumption have increased by 50 percent. These programs that support energy efficiency by industrial, commercial, and residential end-users must continue to generate "nega-watts" to help meet the state's energy resource needs. In fact, energy efficiency resources are expected to meet approximately six of the 11 gigawatts (GWs) in demand growth in California over the next decade.

State climate change policies need to recognize the value of energy efficiency. It is important to recognize the important to maintain existing momentum on the energy efficiency front, even if overarching AB 32 policies such as a carbon cap are implemented. “Nega-watts” generated by energy efficiency programs produce no GHG emissions. But because these energy savings are captured at the point of consumption, inefficient transmission, distribution or transformation losses are avoided. These carbon-free resources do not require the permitting or construction of any type of power plant. In other words, energy efficiency is much quicker to “construct” than any other energy source and begins to “produce” power almost immediately

The ETAAC electricity and natural gas sector subgroup notes the recent CPUC Decision (D.07-10-032) establishing targets for statewide, long-term energy efficiency planning. The objective of this planning effort is “zero net energy” construction in the residential market by 2020 and the commercial market by 2030. ETAAC reinforces the importance of continued technology development in the energy efficiency arena to reach these critical targets. Recognizing the long-term need for energy efficiency and the development of next generation solid state lighting technologies such as Light Emitting Diode (LED), this chapter’s recommendations complement the end-user energy efficiency recommendations located in Chapter 4 on industrial, commercial and residential energy use. These programs will not only accrue climate change mitigation benefits to California directly, but spread these same benefits throughout the world.

California also has in place the most aggressive renewable energy development goals in the country. It is therefore quite likely California will maintain its leadership role in terms of connecting the largest amount of renewable energy supply to its electricity grid. California boasts world-class wind, geothermal, and solar resources that can be greatly expanded to meet future supply needs. This Chapter identifies potential policies for permitting and siting of large-scale renewable energy systems. Small-scale distributed energy generation options -- such as onsite CHP and distributed solar PV -- are also addressed in Chapter 4. California's agricultural and forest sectors also have large quantities of animal and agricultural waste resources that can be converted into renewable electricity supply as noted in Chapters 6 and 7.

Development of renewable energy systems will have a significant impact on meeting California's GHG emission reduction targets as electricity load growth is met with carbon

free fuels. As noted in Chapter 2 by the financial sector subgroup, Cleantech is also a major economic development opportunity for the state.

Another route to reduce the climate change impact of electricity generation is capturing and storing the carbon content of fossil and biomass fuels, a technology known as Carbon Capture and Storage (CCS). ETAAC recognizes this as a priority not just for in-state generation, but on a broader national and international scale where coal use is much more prevalent than in California. This technology can offset GHG emissions associated with coal-fired electricity imported into California. Thus, development of this technology is currently viewed as one of several critical technology opportunities for broader national and international efforts to reduce carbon and other GHG emissions. ETAAC stresses the importance of continuing to focus California's efforts through partnerships at the national and international level to better assess the benefits, costs, and uncertainties of this technology.

Finally, ETAAC recommends a number of policies to foster the development of enabling technologies that can create a bridge between the electric utility and transportation sector's need for low and zero tailpipe emissions vehicle using non-traditional fuels. These policies also support sufficient renewable energy development to achieve a 33 percent Renewable Portfolio Standard (RPS) by the 2020 timeframe. Motor vehicle and non-vehicle energy storage is one promising area of synergy as is "smart grid" technology.

With the appropriate strategies, policies and incentives, these energy efficiency and renewable energy technologies will spur monumental reductions in GHG emissions while altering the way that energy is traditionally generated and used. The majority of these recommendations will take several years to fully implement. With the lifespan of power plants being 40 years or more, decisions made today will determine whether California can reach its full-potential of California's zero and low carbon energy resources.

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II. Utility-Level Programs to Accelerate Energy Efficiency

The U.S. Energy Information Administration projects that residential energy consumption is expected to rise on average one percent per year between 2001 and 2025, with the most rapid growth expected for computers, electronic equipment, and appliances. Commercial energy demand is projected to grow at an average annual rate of 1.6 percent between 2001 and 2025. The most rapid increases in demand are projected for computers, office equipment, telecommunications, and miscellaneous small appliance uses.[1] In addition to efficiency standard for consumer audio and video equipment in standby-passive mode, the CEC has implemented standards for external power supplies which went into effect in 2007 and which will ratchet down farther in 2008. Still, additional technology and policy efforts are needed to improve product in efficiency both active and standby modes to curb rising miscellaneous energy use.

A. Aggressive LED Energy Efficiency Programs

Energy efficiency is the first resource of choice according to the California Energy Action Plan's "Loading Order" and is one of the most cost effective GHG emission reduction measures. California must aggressively pursue the next generation of energy efficiency technologies to capture unrealized technical and economic potential. One technology that cuts across multiple end users is Light Emitting Diodes (LED).

- *Time Frame:* 2007-2012.
- *GHG Reduction Potential:* Not estimated.
- *Ease of Implementation:* Moderate.
- *Co-benefits/ Mitigation Requirements:*
- *Responsible Parties:* CARB, CEC, CPUC.

Problem: Through its aggressive energy efficiency programs, California has already transformed the compact fluorescent lamp (CFL) market. LED technology provides the next-generation of lighting energy efficiency opportunities. These lights can save up to 30 percent more energy than CFL technology. LED technology is currently being used in niche markets such as traffic signs and supermarket refrigerated case lighting. The next generation LED products -- as well as other solid state lighting technologies -- have the potential to again transform the lighting market. RD&D is underway to improve fixture design, thermal management, light diffusion, reflector design, and others. However, most of the technological advancements are taking place in the laboratory and are not transferring well to consumer markets. LED technology suitable for general illumination is estimated to be 5-10 years away from full commercial status.

Possible Solutions: The State of California should work with utilities to aggressively deploy current LED technology. Furthermore, the State should invest in near-term development and demonstration of LED lighting suitable for general illumination, identify and prioritize advancement areas that meet mass market needs, support RD&D

of other solid state lighting technologies, expedite knowledge transfer to the marketplace, and encourage open source sharing of intellectual property. The CPUC is considering the establishment of a California Institute for Climate Solutions, which could conduct much of the needed RD&D in this area. The State of California must act now to maintain the momentum and continue to "fill the pipeline" to garner additional energy efficiency savings and GHG emissions reductions. California can both show leadership and advance the LED market by committing to use market-ready LEDs in public sector buildings and other State-owned properties.

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III. Expanding California's Successful Renewable Energy Programs

California possesses enough renewable resource potential within its borders to provide several times the current electricity needs of the state as well as make substantial contribute to AB 32's GHG emission reduction goals. California has made some significant progress on its way to meeting a state-wide 20 percent RPS target by 2010. Yet stubborn obstacles and delays and significant barriers to entry remain. If California can address these barriers and then meet its RPS target, it could facilitate acceptance of an RPS at the Federal level. Resolving these barriers will become even more critical if California codifies a 33 percent RPS by 2020, a goal that is supported by the Governor, the CEC and CPUC**.** This more aggressive renewable energy target would help California comply with AB 32 by introducing carbon-free electricity into the state's grid.

This section of the ETAAC electricity/natural gas sectors subgroup report addresses a number of the barriers to meeting energy efficiency goals. It contains both policy recommendations for siting and permitting new generation, as well as a brief summary of the state of technology for the largest renewable energy technologies in the state. The Appendix VI to this report contains additional policy recommendations including trading of "unbundled" renewable energy credits for in-state renewable energy; renewables pricing established by the CPUC; production tax credits; and other policy recommendations. It also contains more detailed information on renewable electricity generation technology.

B. Competitive Renewable Energy Zones

California possesses enough renewable resource potential within its borders to provide several times the state's current electricity needs and contribute substantially to GHG emission reductions. However, there are still hurdles to sufficiently developing these non-carbon resources.

- *Time Frame:* 2007-2012.
- *GHG Reduction Potential:* 8.2 MMT CO_2e for investor-owned utilities and 3.2 additional MMT CO_2e from municipal utilities by 2020. (These total emission reductions are based on the calculation cited in the *Updated Macroeconomic Analysis of Climate Strategies Presented in the March 2006 Climate Action Team Report* for a 33 percent RPS. If renewable penetration exceeds 33 percent in 2020, GHG emission reductions would be higher.)
- *Ease of Implementation:* The resource zone designation process has commenced, and the CEC and the Federal Bureau of Land Management (BLM) have created a coordinated siting process. The transition to this new siting process will take time, effort, coordination and communication. It represents a paradigm shift in the planning, resource development and permitting.
- *Co-benefits / Mitigation Requirements:* Renewable energy sources release zero or near-zero emissions. Displacing fossil fuel generation with renewable energy

resources will reduce all criteria air pollutants over business-as-usual scenarios, especially nitrogen oxide (NOx).

- *Responsible Parties:* CPUC, CEC and CA ISO and other State agencies such as the California Department of Fish and Game and the Regional Water Quality Control Board. The following Federal agencies would also be likely involved: BLM, Fish and Wildlife Service, National Park Service, Army Corps of Engineers, and Department of Defense land managers.

Problem: Renewable resources are usually located significant distances from urban load centers and lack adequate transmission infrastructure to wheel power from where it is generated to where it can be consumed. Because of this dilemma, some renewable resource-rich areas, such as the Mohave Desert, have been only minimally developed. Many of these resource basins have a myriad of wildlife, archaeological and other siting issues that must be addressed before development of these renewable resources can proceed in earnest. Federal and State agency processes to site and permit renewable energy projects can be complex, arduous, and quite lengthy.

In order to begin developing any renewable energy generation project, land leasing and permitting are required. Specific permitting hurdles vary by type of renewable technology (e.g., wildlife impacts), and must continue to be fully assessed in the environmental review process. Multiple levels of jurisdiction (federal, state and local) and associated processes for renewable development are common problems[2] across all renewable energy technologies.

Another key to supplying more renewable energy to the grid is improved transmission access. Gaining access to the grid can be expensive and time consuming. The financial benefits are often too low to encourage development of new clean renewable generation.

Possible Solutions: California could adopt a policy to identify and assess Competitive Renewable Energy Zones (CREZs) throughout the state and then develop a strategy for public agencies and other stakeholders to facilitate next generation build-out of these carbon free technologies. Supportive transmission infrastructure would be factored into this planning process. This policy should be coupled with a coordinated siting, environmental review and permitting process that is coordinated between the Federal, State and local agencies, similar to the CEC and BLM's current joint National Environmental Policy Act (NEPA)/California Environmental Quality Act (CEQA) process for concentrating solar power plants. This new siting process will create common environmental documents and consolidated state and federal permits within one year. The program has a sunset date of January 1, 2012.

In 2007, both Colorado and Texas adopted policies similar to CREZs. California has just commenced such a process: the California Renewable Energy Transmission Initiative (RETI). Over the next two years, the RETI will assess renewable resource zones, prioritize those zones, and develop coordinated, cost-effective resource development plans that could provide sufficient renewable capacity by 2020 to meet the AB 32 GHG emission reduction targets.

RETI will build upon the work of the Tehachapi Collaborative Study Group and should accomplish the following:

- Statewide identification and assessment of CREZs;
- Prioritize CREZs and create conceptual transmission plans for each of these zones;
- Development of Plans of Service (POS) for highest priority CREZs that provide detailed plans for necessary transmission and infrastructure upgrades, but will not select specific transmission routes.

In regards to permitting issues, the key is local, State and Federal agency coordination when multiple layers of jurisdiction exist. ETAAC suggests a coordinated process that retains the same level of current rigorous environmental review. A well-coordinated Federal/State siting process will reduce the time and legal and administrative costs for project developers, the cost of agency administration to taxpayers, and speed up renewable development on a timeframe necessary to meet AB 32 goals.

In making this recommendation, the ETAAC electricity and natural gas sector subgroup emphasizes the importance of continuing progress on transmission and resource development efforts already in progress. This recommendation should in no way delay current efforts in the development of CREZs and transmission plans.

ETAAC did not fully explore solutions to the issue of the "clogged" CA ISO transmission interconnection queue, but does encourage ongoing work to fix this problem. Currently, there are 118 renewable projects in the CA ISO queue, representing 57,686 MW. The CA ISO is exploring some options to clean up the queue: clustered interconnection studies; increasing the reservation payment from its current level of $10,000; increasing penalties for project delay or withdrawal; and prioritizing requests for interconnection based on State policy objectives.

C. Renewable Energy Technology Assessments

California has proven world-class wind, geothermal and solar resources that can be expanded to meet future needs. Deployment of renewable energy installations will have a significant impact on meeting California's GHG emission reduction targets by displacing more carbon intensive technologies otherwise needed to meet growth in electricity demand. Deployment of these "game changing" technologies in large volumes will spur significant reduction in carbon emissions and alter the way energy is traditionally supplied and distributed.

The technology assessment below addresses central generation technologies. Appendix IV of this report contains additional information on these and other technologies, including equipment converting animal and agricultural waste to clean renewable fuels and green electricity; distributed renewable technologies, like solar water heating, solar

photovoltaics and solar heating and cooling; ocean tidal energy; and fuel cells that tap waste gas as fuel.

- *Time Frame:* See recommendation B above.
- *GHG Reduction Potential:* See recommendation B above.
- *Co-benefits / Mitigation Requirements:* See recommendation B above.
- *Ease of Implementation:* See recommendation B above.
- *Responsible Parties:* US DOE; CEC; CPUC; private sector; local governments and others.

Problem: Though California has abundant renewable energy resources, these resources have yet to be developed at a sufficient scale to make the necessary reductions in carbon and other GHG emissions to meet the near and long-term goals embodied in AB 32.

*Possible Solutions***:** In the course of examining a wide range of renewable and clean electricity generation technologies, the ETAAC electricity and natural gas sector subgroup arrived at a number of technology-specific observations that may be beneficial to CARB as it seeks to cultivate the development of a robust state renewable energy portfolio. The discussion which follows is not meant to suggest that any technology not referenced is unimportant to California's energy future; rather the observations about energy solutions listed below appear to ETAAC to be insufficiently publicized in current debates over solutions to global climate change.

- **Wind Power:** The CEC has estimated that there exists a total technical potential of 99,945 MW of wind generating capacity (including both high-speed and low-speed wind) in California, for a total estimated energy generation potential of 323.94 million MWhs.[3] These numbers translate into a technical potential to offset an estimated 130 million metric tons of CO_2.[4] (It is important to note that these figures do not capture estimates of the potential of off-shore wind resources, which is described in the Appendix IV.) A substantial portion of this carbon-free energy is available through repowering of existing vintage wind facilities with new modern multi-MW turbines. Despite the availability of better wind technology, there has been little progress in replacing aging wind facilities with new and more efficient technology in California. CARB should actively investigate and promote repowering as an AB 32 compliance strategy.

- **Solar:** California boasts one of the greatest solar resources in the world. NREL[5] estimates of technical utility-scale solar potential in California are huge – 877,204 MW capacity to produce 2,074,763 gigawatt-hours per year – many times the state's own peak electric needs. Only a very small fraction of this resource has been developed – 354 megawatts – with more projects coming on-line in coming years from utility solicitations. Some policy and technology development efforts will be helpful to ensure further development of this resource. Extension of property tax exemptions or abatements would help lower the developers' cost and

their power prices. Establishment of manufacturing investment credits (MIC) would encourage manufacturing and assembly in California, as opposed to other states. Extension of the federal PTC – which was not included in the recently passed Federal energy legislation - is also important to lower costs. Most utility-scale solar technologies require substantial amounts of water for cooling. Dry-cooled system development is underway to minimize water use. Storage system development is also underway, and should be available in the fairly near term. New parabolic trough plants will likely employ molten salt storage tanks that will have the ability to retain heat efficiently to generate power off-peak, if needed, for up to 12 hours. Solar farms are one option for utilizing Brownfield areas, such as regions of the Central Valley that have been damaged by excessive salt/selenium build-up.

California also has substantial potential for distributed solar technology – both electric and thermal systems. According to the CEC, rooftop solar PV has a technical potential of more than 74,000 megawatts.[6] At present, there are about 198.2 megawatts of grid-connected PV systems.[7] The California Solar Initiative is a $3.2 billion, 10-year program that will bring on-line new solar PV capacity of approximately 3,000 MW. Solar PV requires consistency in, and eventual augmentation of, existing policy to continue development and deployment. NREL estimates that 65 percent of residential and 75 percent of California's commercial buildings could be outfitted with solar collectors for hot water systems and for space heating and cooling systems.[8] The huge potential to offset air conditioning peak load with solar-powered cooling systems is currently largely untapped. This technology would benefit from additional study by the CEC and State incentives.

- **Geothermal:** California has the largest developed geothermal resources in the U.S. at approximately 1,900 MW. CEC studies have shown the potential for an additional 2,900 MW[9] using conventional flash and binary technologies in known resource areas. US DOE estimates California resource potential at between 12,200 and 15,100 MW.[10] In order to better pursue this valuable base load renewable resource, California should consider undertaking a number of steps. Resource identification is a costly and time-consuming process, one that might be assisted by targeted State intervention. The US Geological Survey is undertaking a new resource assessment, updating the last assessment which was completed in 1979. The new assessment, however, will not examine new technologies and their potential in California, nor will it examine direct uses, heat pumps, or other non-conventional geothermal resources (like oil field co-production or geo-pressured resources). The CEC should support its own complementary assessment to examine California's geothermal potential in a more comprehensive and up-to-date manner. Roughly one-half of the cost of a geothermal project is estimated by the Geothermal Energy Association to be related to subsurface exploration and resource characterization. These costs also raise the greatest risk to investors, and are usually not financially feasible. Cost-shared exploration drilling by the

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federal DOE has been successful in the past. It should be explored by the State of California in the future.

- **Biomass and Waste:** Only 15 percent of the technically recoverable potential of biomass wastes and residues from agriculture, forestry and municipal waste is currently being converted into clean energy in California. Dedicated energy crops could add to this rich state clean energy potential in the future. Biomass projects require infrastructure to collect, process, transport and store feedstock and then distribute biofuel products. On top of that, collaboration among various industries -- agriculture, forest products, electric power, waste management, chemicals, oil and gas, and the automobile industry – has yet to occur to take full advantage of California's diverse biomass inventory. State regulators could play an important role in coordinating, and potentially underwriting, this critical stakeholder cooperation.

  Most biomass projects currently focus on power generation and transport fuel production such as ethanol and biodiesel. Another promising opportunity is in biomethanation, or production of pipeline quality natural gas generated from biomass resources. Compared to biomass combustion, bioemethanation provides greater flexibility as a dispatchable resource; however, further technology demonstration is needed to spur widespread commercialization. As with other biomass and waste projects, barriers relating to feedstock supply, regulatory treatment and permitting issues also need to be addressed.

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IV. Enabling Technologies for Zero Emission Electricity and Vehicles

There are several technologies that can improve the GHG emission profile and/or service provided by today's electric grid. These technologies can also provide infrastructure to support advanced technology vehicles powered by zero emission fuels.

D. Electricity Storage as an Enabling Technology for Renewable Energy

Energy storage addresses the need to integrate intermittency and works to shift excess off-peak power production to peak periods of demand and, as noted below under plug-in electric drive vehicles, achieve synergies that support both zero carbon renewable electricity for current uses and vehicle energy. For instance, wind power is often generated at night. The greatest demand for electricity in California's occurs during late afternoon peaks, when wind generation may be at lower levels. When energy storage is used to provide the necessary services to integrate wind power into the grid when needed, it displaces fossil fuel generation that would otherwise be needed to provide ancillary services (e.g., regulation up and down, ramping, spinning reserve) as well as meet capacity needs. Energy storage can provide those services more efficiently and without the CO_2 emissions associated with fossil fuel generation. Thus, large-scale successful storage technologies can help to transform wind generation into a reliable resource for energy planning, enabling California to take full advantage of this renewable resource abundant throughout the West.

- *Time Frame:* 2007-2012.
- *GHG Reduction Potential:* GHG emission reductions may vary based on the type of peaking power that is displaced and the generating source of off-peak power.
- *Ease of Implementation:* Moderate to Difficult. Requires focused attention to technical issues associated with storage, as well as the planning, ratemaking and financing challenges of integrating a new resource into grid operations at scale.
- *Co-benefits / Mitigation Requirements:* Potentially significant co-benefits, as storage technologies may make wind power more available at times of peak demand, when some of the most polluting and least efficient fossil resources are typically deployed.
- *Responsible Parties:* CA ISO is ultimately responsible, but CEC and CPUC play roles during policy development and support. Potential involvement of CARB as coordinating entity, especially since electricity storage facilitates the market for electric-drive transportation technologies, might also be desirable.

Problem: Electricity storage has the potential to help integrate higher penetrations of wind energy in California's power supply portfolio, allowing the state to take better advantage of its superabundance of this renewable resource. Research has been conducted into this issue on a statewide level, and ETAAC notes that there is a lack of consensus. The CEC's Intermittency Analysis Project (IAP) was tasked with evaluating the potential impacts of increased levels of intermittent renewable generation on the California grid. The IAP concluded that integrating an RPS with a 33 percent renewable

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energy contribution would require expansions in transmission infrastructure and changes to operation of the grid. This CEC analysis did report, nonetheless, that there was enough flexibility in the existing system of fossil resources and pumped hydro stock to provide this balancing function. The CA ISO has acknowledged the difficulty in planning for and integrating wind resources in its recent *Integration of Renewable Resources Report*. CA ISO concluded that more storage resources are necessary to integrate the increased penetration of intermittent renewables.

Several important challenges presently limit the ability of storage technologies to reach full commercial status. The high price of batteries discourages independent wind farm developers from developing a battery storage component because it would drive the wholesale electricity prices above competitive rates. At the same time, there is currently a lack of clear policy recognition of the role of energy storage in managing intermittent wind energy. Associated policy or regulatory direction to pursue development of these technologies is still lacking. The ability of electricity grids to absorb intermittent generation is currently limited. Without reforms, these limits could be reached before the full potential of these renewable resources is exhausted (unless other resources are added to compensate for times when wind generation output does not match electricity load profiles and CA ISO balance and integration requirements.)

Possible Solutions: The potential for a transformative effect from electricity storage is truly "game-changing" and that is why ETAAC recommends pursuit of these technologies. As described below, electric vehicle storage can reduce the GHG emissions from both electricity and vehicle usage by operating as an energy storage system for the grid when not in use. Other stationary energy storage technologies such as pumped hydroelectric storage, compressed air, or batteries can provide the enabling technology to shift wind power from off-peak generation to peak power consumption, and providing a dispatchable resource to firm up supply flowing to the grid. Storage may reduce the state's reliance on polluting gas-fired peaker plants to firm intermittent energy contributions. Storage could also provide emergency and remote-area power supplies.

The State of California should recognize the value of energy storage and encourage the advancement of energy storage technologies through the following technology push programs:

- **Utility Resource Planning:** California should direct its utilities to integrate demonstration and deployment of electricity storage technologies -- including MW installation targets -- over the full period covered in their integrated resource plans.

- **Incentives for Technology Development:** Utilities should develop procurement plans to stimulate competition among storage technology providers, analogous to the "Golden Carrot" approach in demand-side management or the RPS program for renewable generation. Under this approach, regulators and utility planners would develop performance specifications for storage technologies – including cost, reliability and environmental impact of the solution – and would establish a durable framework for the financial support of technologies that meet these

specifications. For example, utilities could hold a competitive solicitation for a specified number of MW of storage capacity meeting these performance criteria, and technology providers would compete to meet the identified need.

Energy Storage Background: Examples of Non-Vehicle Storage Technologies

Flywheel Storage: Flywheels are effective for smoothing short-term fluctuations. PG&E is testing a CEC-funded 100-MVA project in San Ramon, California.

Pumped Hydro: Pumped hydro is the most widespread energy storage system in use on power networks with large scale capacity. Due to its quick deployment, pumped hydro can be particularly effective for wind resources with diurnal generation profiles. Pumped storage facilities can be developed with minimal environmental impact if they use existing reservoirs or otherwise previously developed sites. Modern pumped storage facilities operate at approximately 75 percent efficiency and cost from $1,500 to $2,500 per kilowatt, depending on how much existing infrastructure can be used.

Compressed Air Energy Storage: This technology reduces "parasitic" loads at a conventional power plant – a form of energy storage -- but is not presently used to generate electricity directly.

Batteries: Older technologies are commercially viable, while newer technologies are being tested. For example, Sodium-Sulfur Batteries (NaS) are a technology being demonstrated at over 30 sites in Japan, offering more than 20 MW of capacity with stored energy suitable for daily peak shaving. The current life of the batteries is about 15 years. The largest NaS installation is a 6 MW unit for Tokyo Electric Power Company that can store energy for approximately 8 hours. Combined power quality and peak shaving applications in the U.S. market are under evaluation. American Electric Power (AEP) has been using a 1.2 MW NaS battery in Charlestown, West Virginia over the course of the past year and plans to install a 2.4 MW elsewhere in the same state in 2008. AEP recently announced a plan to install six 1-MW NaS batteries in conjunction with wind projects to assess the benefits of combining intermittent renewables with energy storage.

In both of these examples, costs are currently prohibitive -- $4,500 per kilowatt -- though prices are expected to drop within the next 10 years due to the economies of scale associated with mass production.

Flow batteries are a special class of battery where electrolyte is stored outside the main power cell of the battery, and circulated through it by pumps, like a reversible fuel cell. Flow batteries can have relatively large capacities and are gaining popularity in grid energy storage applications.

Thermal storage: These technologies store heat, usually from both utility-scale and distributed active solar collectors in an insulated repository for later use in space heating, domestic or process hot water, or to generate electricity off-peak. Some new utility-scale

solar plants will likely employ molten salt and "flash" water storage technologies to generate as much as 12 hours off-peak, when the sun is not shining.

E. Plug-in Electric Drive Vehicles as Storage Devices

As noted earlier, plug-in hybrid and dedicated electric drive vehicles (PHEV/EV) could serve as energy storage devices. (Fuel cell vehicles could also serve this purpose.) The primary advantage of this approach is that these vehicles can be charged at night, when less expensive (and potentially less polluting) excess electrical generating capacity is available. As noted above, they also have the potential to support the electric grid reliability. In the future, it is possible that on-site generation of hydrogen for fuel cell cars could be another form of vehicle-based storage in addition to the possibility of fuel cell/battery hybrids.

- *Time Frame:* 2012-2020.
- *GHG Reduction Potential:* Not estimated.
- *Ease of Implementation:* Moderate to Difficult.
- *Co-benefits/ Mitigation Requirements:* Electric vehicles use energy more efficiently than fossil-fueled vehicles. They also produce far less roadside pollutants, which is an important Environmental Justice issue since lower income families are more likely to live close to major thoroughfares.
- *Responsible Parties:* CARB.

Problem: PHEV/EV development and other electric drive vehicles that could potentially store energy from the grid face a variety of technological, financial, institution, and regulatory barriers. For example, continued improvement is needed regarding capacity, durability and enhancement of current grid infrastructure to enable multidirectional flows of both actual energy and the data necessary to monitor and manage power. PHEV/EV technologies feature higher upfront costs than conventional vehicles largely due to high cost of today's batteries. Fuel cell vehicles are also not yet commercially available. The actual fuel and climate benefits from PHEV/EV and other electric drive vehicles depends on a variety of factors. They include the amount of time the vehicle is operating in electric mode, the generation mix of the electricity supply portfolio, time when the car is being charged, and whether the excess capacity of the grid can be tapped during periods of low demand.

Increased PHEV/EV penetration represents a potential cross-sector transfer of GHG emissions. Even though the charging of PHEV/EV will typically occur during off-peak hours -- when there is excess capacity on the grid -- the increased energy consumption still contributes to GHG emission reductions (albeit at a lower rate.) As demand for electric transportation options grows, GHG emissions that would otherwise have been the responsibility of the transport sector will shift to the electricity sector. This shift of GHG

emissions between sectors does not frustrate AB 32's GHG emission reduction targets. Absent mitigating measures accounting for increases in electrified transportation, a carbon cap imposed on the electric sector could thwart advanced vehicle fuels that cut GHG emissions.

Possible Solutions: In order to reduce disincentives for substituting electricity for petroleum transportation fuels, a level playing field must be created for all fuel sources once fuel alternatives reached commercial status. A carbon cap that stretches across both transportation and electric utility sectors could achieve this goal, although there are numerous other policy considerations. Since the PHEV/EV market has the potential to supply distributed generation to the grid during peak hours or provide ancillary services in the future, this approach offers multiple benefits. PHEV/EV technologies enable greater reliance upon off-peak renewable resources and may provide cleaner and less expensive peak and ancillary service resources.

F. Smart Grid as Enabling Technology for Renewables and Clean Vehicles

Today's grid was designed to only transmit electricity from central generation source to the point of consumption. A "smart" and interactive grid and communication infrastructure is necessary to enable to the two-way flow of energy and data need for widespread deployment of distributed renewable generation resources, PHEV/EVs, and end-use efficiency devices.

- *Time Frame:* 2007-2012.
- *GHG Reduction Potential:* This is a support technology that does not directly reduce GHG emissions. However, the ability to use more carbon-free electricity -- such as solar PV -- is also improved by a smart grid. These grid upgrades also help shrink GHG emissions by avoiding the need to operate the least efficient power plants to meet peaks in electricity demand.
- *Ease of Implementation:* Moderate.
- *Co-benefits / Mitigation Requirements:* Two-way flow of energy and data would allow customers to respond to price signals to consume less energy at peak times of demand, when the lowest efficiency fossil units are operating. Peak days of energy demand often coincide with "spare the air days" in California. Reducing fossil generation at peak gives a boost to regional air quality.
- *Responsible Parties:* CPUC; State Legislature.

Problem: Today's electricity grid is essentially 1950's infrastructure out of sync with modern telecommunications technologies and emerging on-site distributed generation technologies. Inadequate sensors limit transmission over congested lines and the connective tissue necessary to enable more sophisticated management of both supply- and demand-side resources is lacking. The grid must be modernized to enable increasing amounts of distributed resources generated near points of consumption, which would reduce overall electricity system losses, and corresponding GHG emissions. Two-way

flow of energy and data is needed to allow customers to respond to price signals to reduce usage at peak times, when the lowest efficiency fossil-fired units are operating.

Possible Solutiosn: California should actively investigate upgrades to distribution-level infrastructure that will be needed to support both increased distributed generation penetration by renewables and the power flows associated with plug-in PHEV/EVs. In particular, the CPUC should work with utilities to ensure investments in smart grid are implemented on the most accelerated timeframe possible. Furthermore, State government can play a key role in improving information-sharing efforts, including making sure there is less of a proprietary effort by supporting developments of open standards and guidelines for smart grid interoperability, such as those being developed by EPRI's Intelligrid Consortium and the GridWise Alliance.

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V. Carbon Capture and Storage and Unifying Program Standards

G. Carbon Capture and Sequestration in Geological Formations

Demonstration of carbon capture and sequestration (CCS) in geological formations is a key opportunity for California to benefit from partnerships nationally and internationally. Broad commercial deployment of technology for CCS in geological formations faces significant challenges. On the other hand, it offers a potential opportunity for achieving long-term reductions in GHG emissions, especially on a national and international scale.

- *Time Frame:* demonstration projects can be in place by 2012, with potential for full commercialization by 2020

- *GHG Reduction Potential*: California has the technical potential to store 5.2 GT CO2 in oil and natural fields, and the capacity in deep saline formations may be one or two orders of magnitude greater.[11] The Intergovernmental Panel on Climate Change (IPCC) estimates that CCS has the potential to abate CO_2 emissions by between 15-55 percent of the cumulative mitigation effort needed by 2100 on the international scale.

- *Ease of Implementation:* Difficult

- *Co-benefits / Mitigation Requirements:* Demonstration of this technology may facilitate large benefits if it results in commercial application in coal-dependent areas outside of California. The energy required for CCS would require additional fuel combustion (which could be offset to the extent that CO_2 injection displaces steam for oil production). Some technologies to capture CO_2 also reduce criteria pollutants like NOx and SO_2. If fuel combustion increases, without increased emissions control, emission decreases elsewhere will be required in areas that fail to meet clean air standards. Leakage risk must be assessed at a general level for the technology and for specific potential sites.

- *Responsible Parties:* federal and state governments and agencies and the private sector

Problem: Geological CCS refers to the separation (or capture) of CO_2 from industrial and power generation sources and then the transportation to storage locations for long term isolation from the atmosphere. (This chapter of the report does not include biological storage in the agricultural and forestry sectors). Many component technologies for CCS have already been developed, but both the size and number of demonstration projects are very small with respect to the scale necessary to mitigate significant future CO_2 emissions. Commercialization of CCS technologies will require a willingness to bear the initial high cost and potential risks of first-generation systems and continued technical advances to build up the required infrastructure. The low end of cost estimates ranges tend to start at $25 per ton or more for capture and compression. Cost estimates vary, at least in part because the technology has not been demonstrated. Part of that cost can

potentially be recovered if CO_2 is used for Enhanced Oil Recovery (2005 dollars), while transportation and injection is an additional cost.[12]

In addition, there is relatively little experience to date at the federal or state level in combining CO_2 capture, transport, and storage into a fully integrated CCS system. Furthermore, regulatory uncertainties and legal issues regarding property rights and liability are significant barriers for CCS that must be resolved before the CCS could play any major role in meeting AB 32's GHG emission reduction goals. Access and liability issues present another challenge. Different states have different laws regarding land rights, pore rights, and mineral rights; therefore, developers of CCS projects face varying state regulations pertaining to underground storage. More importantly, the long term responsibility and liability associated with the CCS projects must be clearly defined. Monitoring techniques and standards that need to be approved at various governmental levels, and then accepted by the insurance industry, have yet to be put in place. The issue of long-term liability for gradual or catastrophic future leakage is clearly hampering demonstration projects.

Possible Solution: California should continue to participate in partnerships such as WESTCARB to advance technology assessments and demonstrations. Key priorities identified by WESTCARB for upcoming pilot projects in California and other western states include:

- Testing technologies
- Assessing capacity
- Defining costs
- Assessing leakage risks
- Gauging public acceptance
- Testing regulatory requirements
- Validating monitoring methods.[13]

The support of federal funding is especially important since CCS has even greater importance nationally than in California. International partnerships should be leveraged to spur efforts to develop lower cost carbon capture technologies, as well as storage research to the extent that there are common challenges and solutions (most likely for deep saline formations).

The state should also work with the federal government to address the legal, regulatory, and safety barriers and issues associated with CCS. One important issue is the development of a legal framework to address long-term liability associated with carbon sequestration. [14] Private insurers may lack a framework for evaluating CCS projects, especially multi-generational liability. The federal and state government could play a productive role, while carefully balancing the interests of taxpayers and the need to maximize incentives for careful carbon management decisions by the private sector.

Currently, potential pilot projects are evaluated on a case-by-case basis under general Underground Injection Control permitting requirements. The California Department of Oil and Gas Resources (DOGR) has delegation from US EPA for oil & gas fields (US

EPA retains oversight). Federal US EPA has responsibility for deep saline formations and DOGR is also developing their own regulations for deep saline formations (and can work with US EPA to request lead permitting responsibility once that process is completed). Drawing on the experience learned from the permitting process for pilot projects to develop standards and guidelines at the state and federal level may also help CCS project developers navigate the permitting process.[15]

Unlike many efficiency measures, CCS is unlikely to bring a positive economic return under even the most optimistic scenarios currently foreseeable. In addition to these efforts, a clear and reliable price signal (as discussed elsewhere in this report) and/or performance standards such as AB 1386 will be necessary to commercialize this technology.

H. Unifying Standards for Climate-Related Programs

California's multiple programs for clean and alternative energy development, many of which were described above, have been largely designed in isolation from one another with the intent of stimulating innovation or improving environmental performance in discrete technology sub-categories.

- *Time Frame:* 2012-2020.
- *GHG Reduction Potential:* Not estimated. This policy initiative is intended to enable easier coordination of multiple climate-related programs, which may increase program efficiencies and hence increase GHG emission reductions over time.
- *Ease of Implementation:* Moderate; can be undertaken either as part of existing regulatory proceedings (i.e., IOU resource planning), or as a new, discrete proceeding.
- *Co-benefits / Mitigation Requirements:* Not estimated. Closer coordination and common frames of reference across climate change programs may reveal co-benefit opportunities.
- *Responsible Parties:* Principally CPUC, with input from CEC and CARB (i.e. for the Low-Carbon Fuel Standard).

Problem: Energy efficiency programs have individual budgets and targets, the RPS program stimulates particular technologies up to a certain percentage of the state's electricity provision, and solar PV programs aim to achieve specific capacity installation targets from just one renewable energy fuel. Other opportunities in renewable energy development -- such as waste heat recovery and methane capture and utilization -- are not fully developed under existing State programs. Though these are important programs individually, they do not encompass all of the technologies relevant to the unifying challenge of GHG emissions mitigation. The State's resource planning process is not optimized when these efforts are uncoordinated. As the implementation of AB 32 proceeds and GHG emission savings become the "coin of the realm," there may be value

in better coordinating these programs so that they are all directed towards a common end. Clear ownership rights and credits for early action, as recommended above, will aid in establishing this coordination, but other steps are needed as well.

At the same time, ETAAC recognizes that cuts in CO_2 are typically not the *exclusive* goal of these programs. There are important benefits to long-run innovation when policy initiatives support pre-commercial technologies in a targeted and efficient manner. Suggesting that California look to better coordinate its multiple clean energy programs does not diminish the importance of these programs in supporting technological advances. The intent of this recommendation is to ensure that these disparate technology programs emphasize innovation that is cost competitive in the long run, so that low or no-carbon energy supply technologies can ultimately be accurately benchmarked against each other.

As an important aside, ETAAC notes intense debate concerning carbon offsets in a cap and trade program. Some ETAAC members are concerned that a broad offset program will lessen the incentive for innovation within capped sectors. The continued role of the targeted clean energy programs discussed above, however, support technological advances within a climate change framework and may help to counter the innovation-suppressing effects of a broad carbon offset program.

Possible Solutions: CARB should pursue a uniform strategy for implementation of new carbon reducing technologies after 2012, with carbon-equivalent savings that would link all existing clean energy programs and mandates. All actions within the electricity and natural gas sectors that result in such savings would contribute to GHG emission reduction targets under AB 32. Such a policy provides an incentive for all energy market participants to undertake what are now generally unrecognized beneficial carbon-reducing acts. It would also provide certainty to those making investments that credits for GHG emission savings will accrue to them. This unifying standard, however, should not jeopardize programs that play important roles in nurturing certain technologies to a position of market readiness. Such programs should continue in a targeted and efficient manner, connected to the climate change regime by clear performance metrics that apply across all technology categories. In this regard, the State should, as a first priority, begin to develop a unified GHG emission accounting process across clean energy programs, to support rationalization of policy and financial priorities post-2012.

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VI. Suggested Legislative and Regulatory "To Do" List

Table: Immediate Horizon Legislative Action Items

Item	Relates To	Primary Reponsibility
1. Create a process for the early valuation of carbon. (See report introduction Chapter 1.III.)	Carbon valuation	CARB
2. Ensure that voluntary and mandatory efforts to reduce GHG are counted in the crediting of energy efficiency program achievements. (See Appendix 5 Introduction)	Energy Efficiency	CPUC
3. CARB can work with the building standards setting agencies, the CEC and CPUC to encourage rapid deployment of currently available LED lighting technology, as well as encourage development and demonstration of LED lighting suitable for general illumination. (See Chapter 5.A)	Energy Efficiency/ LED	CARB, CPUC, CEC
~~4.~~ Allow for the use of unbundled Renewable Energy Credits (RECs) generated within California for Renewable Portfolio Standard (RPS) compliance. (See Chapter 5 section III and Energy Appendix)	Renewable Energy	CPUC and CEC
5. Revisit pricing structure of renewable portfolio standard and either modify or eliminate to simplify the structure. (See Chapter 5 III and Energy Appendix)	Renewable Energy	Legislature, CPUC and CEC
6. Authorize and implement development policy and plans for Competitive Renewable Energy Zones. (See Chapter 5.B)	Renewable Energy Development Zones	Legislature CPUC CEC, Ca./federal land use agencies
7. The State of California should recognize the value of energy storage in advance vehicles and/or non-vehicle storage as an enabling technology for intermittent renewable sources. Storage in vehicles to provide zero low GHG vehicle energy and shift-off peak energy to on-peak may also facilitate both greater renewable energy. A "golden carrot" program or other technology push programs may be a good approach. (See Chapter 5.D & E)	Storage	CPUC
8. Create legal framework for long term liability associated with carbon sequestration, including issues relating to legal rights, as well as regulatory framework for monitoring storage and ensuring compliance. (See Chapter 5.G)	Carbon Capture and Sequestration	Federal Government, California Legislature, energy and environmental agencies
9. Create financial incentives to spur CCS technology and	Carbon	Legislature

implementation. (See Chapter 5.G)	Capture and Sequestration	
10. The CPUC is expected to address the issue of longer term energy efficiency project commitment/funding in the 2009-2011 program planning proceeding. The CPUC should continue to remove barriers for utility incentive programs to pursue long term savings.	LED	CPUC
11. Provide property tax abatements for renewable energy projects. Amend the California Investment Incentive Program (Government Code § 51298) to include renewable energy projects as "qualified manufacturing facilities". The CIIP provides tax abatements for qualified manufacturing facilities based on the assessed value of the improvements that exceed an investment minimum of $150 million.	Renewable Energy	Legislature
12. Consider the role of low-carbon power in the next version of the Energy Action Plan	Other Technologies	CPUC, CEC

Additional Recommendations Addressed in Other Chapters		
13. Regulatory reform to encourage capture of methane from anaerobic digesters. (See Agricultural Chapter)	Biomass to energy	Water Quality Control Board
14. Create incentives for unsupported distributed generation that reduces gas, like economic solar hot water and advanced solar thermal (solar heating and cooling). (See Industry, Commercial & Residential End-Use Chapter and Energy Appendix section G)	Solar water and space heating and cooling	CPUC CEC, Legislature

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[1] Energy Information Administration, *Annual Energy Outlook 2003 With Projections to 2025* http://www.eia.doe.gov/oiaf/archive/aeo03/index.html#consumption

[2] For example, resource exploration and identification of geothermal resources require land rights be secured or leased before exploration. Both federal and state agencies are involved with leasing of California land, and mixed federal/state/private lands can mean multiple levels of processing. This can cause delays and disagreements among the agencies. In fact, a significant part of the cost of a greenfield project may be attributed to the delays associated with leasing and permitting.

[3] Yen-Nakafuji, Dora, *California Wind Resources*, Draft Staff Paper, California Energy Commission. April 22, 2005.

[4] Assuming an average emissions factor of 805 lbs CO2e/MWh.

[5] U.S. Department of Energy, *Report to Congress on Assessment of Potential Impact of Concentrating Solar Power for Electric Power Generation*, February 2007.

[6] California Energy Commission. *California Solar Resources*. Staff Draft paper in Support of the 2005 IEPR. April 2005.

[7] California Energy Commission. *Grid Connected PV Capacity (kW) Installed in California.* http://www.energy.ca.gov/renewables/emerging_renewables/GRID-CONNECTED_PV.PDF. December 31, 2006.

[8] P. Denholm. *The Technical Potential of Solar Water Heating to Reduce Fossil Fuel Use and Greenhouse Gas Emissions in the United States.* NREL Technical Report, NREL/TP-640-41157, March 2007.

[9] E. Sisson-Lebrilla, V. Tiangco, *California Geothermal Resources*, California Energy Commission, April 2005

[10] US DOE Energy Efficiency and Renewable Energy. *Geopowering the West – California State Profile.* http://www1.eere.energy.gov/geothermal/gpw/profile_california.html. January 17, 2007.

[11] Quarterly Report, West Coast Regional Carbon Sequestration Partnership California Energy Commission, May 2005, page 8.

[12] Quarterly Report, West Coast Regional Carbon Sequestration Partnership California Energy Commission, May 2005, page 15; Reducing US Greenhouse Gas Emissions: How Much as What Cost ? December 2007 page 59; Carbon Dioxide Capture and Geologic Storage 2007 page 33.

[13] WESTCARB Regional Partnership Phase II: Providing Underpinnings for Deployment Larry Myer WESTCARB Technical Director, California Energy Commission, May 11, 2006

[14] The state of Texas, where CO_2 is used routinely for increased oil & gas production, has passed a law accepting liability for a potential "Future Gen" project with CCS that Texas is hoping will be located in Texas.

[15] Personal communication from George Robin, US EPA Pacific Southwest Region, Water Division, Underground Injection Control, to Ed Pike December 5 2007.

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6. AGRICULTURAL SECTOR

I. Introduction

Agriculture in California generates $31.7 billion in farm receipts. The state's agricultural sector utilizes nearly 10 million acres of irrigated cropland and large areas of rangeland to support significant animal production[1]. It is estimated that the raising of these agricultural crops absorbs over 120 $MMTCO_2E$ every year via plant respiration and photosynthesis.[2] While the carbon cycle returns the majority of this carbon to the atmosphere, sequestering a portion of this carbon or converting it into renewable energy, fuels or permanent products, would translate into a significant reduction of California's carbon footprint.

Agriculture also requires inputs that generate GHG emissions and other pollutants. Among these inputs are energy sources such as diesel fuel, natural gas and electricity, which are used to power field equipment or processing systems. It is estimated that in 2004, all California agricultural sources accounted for about 30 $MMTCO_2E$.[3]

The agricultural sector also offers the opportunity to reduce GHG emission reductions through the capture and use of renewable carbon. Other specific farm-related GHG emission sources can also be controlled and mitigated. Technology that can deliver these benefits already exist in many cases. Yet a concerted RD&D effort and new regulatory incentives and programs will be needed to meet the GHG emission reduction goals included in AB 32.

In this chapter, seven areas have been identified that offer the most promise for climate change mitigation in agricultural settings. A summary of these areas is given in Table 1, which includes current estimates of the gross and technical CO_2 reduction potentials for each identified technology. The ETACC agricultural sector committee projects that there is the technical potential to derive about 17 $MMTCO_2E$ of greenhouse gas benefits from California production agriculture, which is about 10 percent of the goal for 2020 or about 3.5 percent of the 2004 California inventory.

Table 1: Summary of California Agricultural Programs to Reduce GHG Emissions

Technologies	*Potential California Program Size*			*Estimated Reduction*	*Net Annual California Reduction Potential*	
	Gross (units/yr)	Technical (units/yr)	Units	Unit Factor ($MTCO_2E$/yr)	Gross ($MMTCO_2E$)	Technical ($MMTCO_2E$)
Manure-to-Energy Facilities	3,600,000	1,800,000	Head	1.70	*6.1*	*3.1*
Enteric Fermentation	4,100,000	2,050,000	Head	0.39	*1.6*	*0.8*
Agricultural Biomass Utilization	21,000,000	8,000,000	dry tons	0.51	*10.7*	*4.1*
Dedicated Bio-fuels Crops	1,000,000	500,000	acres	1.92	*1.9*	*1.0*
Soil Carbon Sequestration	10,000,000	5,000,000	acres	0.61	*6.1*	*3.1*
Farmscapes Sequestration	500,000	500,000	acres	5.80	*2.9*	*2.9*
Fertilizer Use Efficiency	10,000,000	5,000,000	acres	0.36	*3.6*	*1.8*
Total					***33.0***	***16.7***

Note: These estimates will need to be refined per RD&D efforts based on technical feasibility and economics.

While many of these technologies described are feasible and available today, further RD&D programs are needed to launch critical elements of a climate response program by 2012. The keys to developing the full menu of opportunities in the agricultural sector is to prioritize research needs, establish easily accessible guidance methodologies, protocols for monitoring and verification, provide ability to receive carbon credits or private and/or public incentives, conduct grower outreach and education, and receive the cooperation of regulatory agencies in developing needed infrastructure. All of these barriers can be overcome, but will require a robust multi-agency and industry cooperative effort.

The global warming solutions program described below will net genuine GHG emissions reductions and carbon capture from the land based agricultural sector through technologies for energy production from manure and biomass, improved enteric fermentation, cropping systems for bio-fuels, sequestration of carbon in soil and farmscapes, and improved efficiency of fertilizer and water use.

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II. An Agricultural Global Warming Solutions Program

A. Manure-to-Energy Facilities

The use of manure digesters to capture and utilize methane rich biogas is well established and could generate up to 350 MW of new renewable energy production.[4]

- *Timeframe:* 2012 (25 percent implementation) to 2020 (100 percent implementation).
- *GHG Reduction Potential*: 3.1 $MMTCO_2E$. (Assuming the 1,800,000 mature dairy cattle in the state and a nearly equal number of support stock represent a gross potential of 6.1 $MMTCO_2E$. Operating these systems requires investment and expertise on the part of the dairy operation, thus the technical potential is expected to be reduced roughly half.)
- *Ease of Implementation:* While the technology exists, the key to developing a program in this area will be coordination of utility and regulatory agencies. Nearly 20 systems have been installed in California with many thousands worldwide. There are well-established protocols for quantifying the amount of emissions reductions achieved with these systems, including the recently developed "Livestock Project Reporting Protocol" by the California Climate Action Registry[5].
- *Co-benefits / Mitigation Requirements*: Processing manure in these systems reduces methane emissions while producing renewable energy, rendering a net benefit of about 1.7 $MTCO_2E$ per dairy animal. Digesters are effective at reducing VOC's from lagoons, a relatively small emission source on most dairies, but the combustion of biogas in an engine to generate electricity can emit NOx. Controls can reduce the amount of NOx in exhaust gasses. Nevertheless, the types and sizes of engines typically used in conjunction with a dairy digester they may not be available, cost effective or able to meet local air district NOx requirements. Digester biogas also contains impurities, including hydrogen sulfide, which must be removed from the biogas before combustion in the engine if a NOx control device is used. If the hydrogen sulfide is not removed from the biogas, the sulfur in the exhaust gas will destroy the control device and render it ineffective. Additional beneficial vector control and water quality improvements can result from improvements in the manure management system during the implementation of a digester project.
- *Responsible Parties:* For permitting, the State Water Resources Control Board (SWRCB) and regional water quality control boards, CARB and local air quality management districts. For energy policy, pricing and funding, the CEC, CPUC and the California Pollution Control Financing Authority (CPCFA). For implementation and funding, private anaerobic digester technology companies, dairy owners, producer groups and local governments. For overall state policy, the Cal/EPA and member boards, offices and departments and the California Department of Food and Agriculture (CDFA).

Problem: Less than 1 percent of dairy manure is currently processed in digesters in California. In the current marketplace, it has been difficult for projects to realize a positive return on investment because they realize only a portion of the retail value for displaced electricity and receive little or no compensation for excess power delivered to the grid. On the regulatory front, projects can see uncertain and potentially cost prohibitive requirements for permitting new

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digesters and engines. Air and water requirements by the local air and water boards make digesters significantly more expensive to build and entail a lengthy approval process.

Possible Solutions: Effectively addressing climate change by the California livestock industry will require significant cross media coordination between regulatory agencies to continue successful air quality improvements while reducing GHG emissions. Traditional approaches to regulatory oversight where agencies solely focus on their particular media will likely impede achieving AB 32 goals. California needs to take a cross media approach to regulation that looks at the full impacts of projects across air quality, water quality, species protection, waste management, etc. A clear pathway to permit approval of manure-to-energy systems based on regional risk to groundwater and air is needed. For example, there are well-developed National Resources Conservation Service manure impoundment standards that may be suitable for many locations and more feasible than hazardous waste standards. Areas where there is high groundwater impact risk could be treated with more stringent requirements.

Cross media coordination to promote strategies to reduce GHG emissions will be helpful in each of the agricultural areas suggested in this chapter. Because of their GHG emission reduction potential and lack of technical barriers, methane digesters could be used as a demonstration program for how this coordinated approach could be developed and function. A whole systems approach should be pursued to balance the benefits attributable to these projects with other environmental goals so that the net result is a positive using the concept of "net environmental benefit."

In addition to a clear pathway to achieving permitting approval, more certainty in the marketplace must be ensured by developing a standard contracted price for power from manure-to-energy facilities. If regulatory and price certainty are addressed, it would encourage investment in biogas systems. If the requirements are cost prohibitive in areas of higher risk, incentives could be developed to offset these costs.

What follows is a summary of necessary standards, policy tools and new incentives to accelerate development of manure-to-energy facilities state agencies regulating water, air, electricity, natural gas and solid waste.[6]

> **Water Quality:** A salt loading and compliance process for anaerobic digestion needs to be developed to address the salinity concerns of the Central Valley Regional Water Board (CVRWB). This will require research on the salt and nutrient content of liquid digestate to inform the development process, especially in co-digestion proposals. CVWRB should also develop a simplified design process to help assess and develop criteria to determine the potential need for pond reconstruction and pond/digester liners that is practical and clarifies regulatory oversight and approval processes. Consider the possibility of potential sites for "Tier 2" type ponds to be grouped by site characteristics and each group can be assessed for leakage potential.
>
> **Air quality:** Need to develop a regulatory compliance mechanism at CARB for dairies with cow numbers below district permitting thresholds to use distributed generation

equipment to produce electricity from biogas. The State should determine the net air and water quality benefits of digesters in order to promote this climate friendly technology.

Electricity: After January 1, 2008, the existing The Self-Generation Incentive Program will no longer provide incentives to certain distributed generation technologies, thus eliminating incentives for electricity fueled from biogas. This program should be amended to continue to provide incentives for electricity produced from biogas in anaerobic digesters and allow excess electricity sales. A CPUC program should be developed to require electric utilities to purchase excess electricity from biogas production at an attractive rate. To promote competition, the CPUC should also implement power purchase agreements that have flexible terms such as 3, 5, 10 year agreements instead of the sole offerings currently being offered from investor-owned utilities. Review existing agricultural tariffs to determine whether rate structures discourage distributed generation and modify rates where appropriate. Eliminating demand charges from NEMBIO (net metered biogas) operations that have only infrequent service interruptions due to routine maintenance is also recommended. Finally, the CPUC should permit the owner/generator (i.e. the farmer) of an electricity generating biogas distributed generation system to retain the environmental attributes. These attributes include carbon reduction credits and any Renewable Energy Credits (RECs) not directly related to Renewable Portfolio Standard (RPS) compliance or other specific contractual arrangements. All RECs and carbon credits must accrue to the farmer generating the electricity. The generator can then own and negotiate the sale of those attributes, which are sure to become more valuable over time.

Natural Gas: The CPUC, in partnership with natural gas utilities and bio-methane producers, should conduct research to investigate the type and level of biogas impurities, (including the co-production biogas) to determine if bio-methane gas quality standards are needed. The CPUC has established a market price referent (MPR) to provide a target price for renewable energy contracts and to determine eligibility for financial incentives. Determining a MPR for biogas provides policymakers an opportunity to consider whether this renewable fuel represents significant environmental benefits and warrants a premium. The necessity of using a MPR is unclear since it requires the application of certain heat rates and capacity factors which may not yield an accurate number. Developing a separate MPR specifically for biogas projects could facilitate new development by providing price targets for generators and key market data for utilities. Since each of these digester systems can cost more than $1.2 million (not including scrubbers, catalysts or compression gear), securing the initial capital for development and construction is vital to create a viable market.

The CPUC should therefore assess existing interconnection processes and costs to determine whether they are appropriate for introduction of bio-methane into the natural gas transmission system and develop uniform standards for introducing biomethane into natural gas distribution pipelines. Utilities should be required to interconnect biogas electrical generators under the Rule 21 process with a fixed time frame and with prescribed resolutions in case of delays. If purification and injection is a preferred use of biogas, monetary incentives should be given and interconnection costs shared among

natural gas utilities. Whereas the potential generation of electricity and transportation fuel from biogas exists for the majority of farms in California given the right incentives, injecting biogas into natural gas supply system may only be financially feasible for 5 to 10 percent of state farming operations. This circumstance is likely to encourage buyers to "cherry-pick," leaving market opportunities out of reach for the balance of farms.

Solid Waste: Legislative and regulatory clarification is needed regarding which State agencies have jurisdiction over which parts of the biogas production and utilization process. For example, the role of the California Integrated Waste Management Board needs to be clearly defined.

B. Enteric Fermentation

Reductions of methane emissions from ruminant agriculture –beef cattle and dairy cows - may be achieved by utilizing recommended feeding practices, the use of dietary additives or agents that impact digestion efficiency, and longer-term breeding and management changes.

- *Timeframe*: 2020 (50 percent implementation) to 2050 (100 percent implementation).
- *GHG Reduction Potential***:** 0.8 $MMTCO_2E$ (Assuming half of the technical potential represented by the state populations of these animals is developed. Overall emissions can be reduced up to 30 percent, equating to about 0.39 $MTCO_2E$ per mature dairy cow).
- *Ease of Implementation:* Feeding to National Research Council (NRC) guidelines to optimize efficiency can be expected to reduce overall emissions. Productivity improvements from breeding and better management practices reduces the methane output per unit of product produced thereby reducing overall methane output and energy inputs. The use of agents such as concentrates, oils, ionophores, probiotics and propionate precursors are aimed at suppressing methanogenesis and improving feed efficiency, but their effectiveness and other impacts must be carefully and thoroughly considered over a longer term (20+ year) development timeframe. Overall it has been estimated that methane emissions can be reduced up to 30 percent (equating to about 0.39 MTCO2E per head based on mature dairy cow), with about 16 percent from NRC recommended feeding practices, 11 percent from specific agents, and 3 percent from long-term management and breeding.[7]
- *Co-benefits / Mitigation Requirements***:** One key benefit may be improved feed utilization which boosts the productivity of animal feeding operations. In addition, better feed nutrient utilization could also reduce manure impacts. Need to insure that all environmental impacts are considered before recommending the use of any productivity agent improvements.
- *Responsible Parties:* University of California and California State University systems (for developing a sound applied research program); CDFA for developing a statewide animal feeds and feeding program.

Problem: The production and release of methane during digestion (fermentation) of food is a natural part of ruminant biology. Feed is also the costliest input to managing animal production

operations. Because of the cost, animal diets in California have been highly optimized for maximum efficiency of production and, therefore, additional improvements may be more costly than their potential returns in productivity. Feeding is also highly variable across the state and can often include regional food processing byproducts. One of the key challenges in this area will be to develop techniques that are cost effective and can be implemented with a variable yet economically optimized system that exists today. Establishing a baseline and developing protocols to accurately measure this technology will require a significant amount of research work.

Possible Solutions: Efficiency of feed is an important ongoing effort for nutrition experts in the California animal industry. With additional research funding, these experts can continue their work with additional focus on cost effective methane emissions reductions. A significant research program that focuses on California conditions and diets as specifically related to the avoidance of GHG emissions and other air quality concerns is needed to develop new approaches and establish protocols for this technology. Once protocols have been developed, CDFA , UC and CSU university systems can assist with dissemination of results to the producer community and implementation of this program.

C. Agricultural Biomass Utilization

Agriculture generates nearly 21 million tons of residues every year. Roughly 8 million dry tons of this potential waste material is technically available for sustainable energy and fuels production.[8] Only a small portion of these resources is currently utilized.

- *Timeframe:* 2020 (25 percent implementation) to 2050 (100 percent implementation).
- *GHG Reduction Potential*: 4.1 $MMTCO_2E$ (Assuming a potential for 920 MW of energy production or 11 million barrels of oil equivalent in bio-fuels each year[9] from 8 million tons of agricultural biomass. With additional technically available resources including 14 million tons of forest residues and 9 million tons of other green biomass[10], a total potential for over 16 $MMTCO_2E$ from 3600 M MW or about 43 million barrels of oil equivalent could be derived from all available biomass.)
- *Ease of Implementation:* This program would require significant private and public investment in new biomass processing facilities. Whereas both biochemical and thermo-chemical technologies are projected to produce cost effective transportation fuels when RD&D targets are reached, thermo-chemical technology is likely to be more appropriate for California. (See Industrial/Commercial/Residential Energy Use sector regarding other feed stocks.) Both technology and regulatory hurdles exist and are discussed below.
- *Co-benefits / Mitigation Requirements*: These facilities would provide energy and national security because they would displace some imported outside fuel and energy resources. Emissions from open burning and other impacts of biomass waste disposal would be reduced by utilizing this resource for energy production. Depending on the technology, there could be some level of environmental impact that would need to be mitigated when developing new facility sites.

- *Responsible Parties:* For permitting, SWRCB and regional water quality control boards, CARB and local air quality management districts. For energy policy, pricing and funding the CEC, CPUC and CPCFA. For implementation and funding, private anaerobic digester technology companies, dairy owners, producer groups and local governments. For overall state policy, Cal/EPA and member boards, offices and departments and CDFA.

Problem: Power generation from biomass is well-established technology in the state with 30 existing biomass direct combustion power plants generating 569 MW.[11] However, the cost of producing wholesale electricity from biomass using these older facilities may not be cost effective because of low efficiencies. Advanced thermochemical technologies are being developed, some that possibly combine the production of electricity and renewable liquid fuels. However, a significant amount of investment is still needed to prove these technologies on a commercial scale. The ability of these facilities to sell power is not certain, however, as the utilities have not always been willing to buy power from third-party renewable generators. Ownership of the RECs is also subject to differing interpretations, particularly when it comes to the GHG emission reduction value beyond the netting of carbon emissions.

These projects also face significant regulatory hurdles. Because of the way California regulations are written and interpreted, gasification and pyrolysis plants that convert byproducts are potentially handled under several agency jurisdictions including the California Integrated Waste Management Board (CIWMB) under regulations that are designed for solid waste facilities, CARB and local air districts. Few plans for biomass conversion plants have been approved in recent years. It is estimated to take up to five years to permit and build a thermochemical conversion plant in California with the current uncertain regulatory process.

Possible Solutions: California could be a much more active player in developing and deploying advanced technologies for converting biomass to high value transportation fuels. Making California a suitable marketplace for advanced bio-fuels production is a key to technology development. Incentives and research support are needed to encourage the development of an advanced bio-fuels industry in California. This could include investment credits, low interest loans, and fuel tax credits, as well as ongoing support for RD&D funding. In addition, there is a need to establish clear and consistent state policies for sustainable management and development of biomass to help reach climate change goals with production of renewable power and fuels and meet the needs for environmental protection. Regulations need to be revised to differentiate between solid waste facilities that take Municipal Solid Waste (MSW) from fuel and electricity generation facilities and facilities that use dedicated agricultural, forest, urban tree prunings and other discrete feedstock. The CPUC needs to clarify ownership of the RECs and carbon credits in future rulings and regulations.

Both biochemical and thermo-chemical conversion technologies are being actively developed for conversion of biomass by many public and private actors. Biochemical conversion relies on specialized mixtures of enzymes or acids to break down a cellulosic material to derive desirable sugars that ferment into ethanol.[12] Generally corn and grasses have been the preferred feedstock because of the high sugar yield and low lignin content. Thermo-chemical conversion transforms biomass into gaseous carbon and hydrogen compounds used directly for energy production or reconfigured into liquid fuels using synthesis catalysts.[13]

Developing alternative uses for biomass would complement regulatory programs requiring farmers to reduce open burning of residues. For example, approximately 1.1 million tons of rice straw is produced annually, with over 95 percent available from the Sacramento Valley. In 1991, a law requiring the phase-down of rice straw burning was passed.[14] This spurred the industry on to manage rice straw though intensive non-burning alternatives that cost the California rice industry approximately $16-$18 million each year.[15] Other commodity providers in the San Joaquin Valley are facing the same regulatory pressure to reduce or eliminate open field burning. These regions are ideal for investment in a conversion facility capable of using rice straw or other locally-produced biomass. Such investment could contribute significantly to AB 32 objectives and address the economic burden experienced by rice growers and other farmers complying with burning phase-down legislation.

D. Dedicated Bio-Fuels Crops

A concerted California biofuels development program could supply a significant amount of renewable fuels in the short term while advanced technologies for biomass conversion are being developed and proven. The Low Carbon Fuel Standard establishes a statewide goal of reducing the carbon intensity of California's transportation fuels by at least 10 percent by 2020. Biofuel crops grown and processed in California could help meet this new standard. As noted in the Transportation Chapter, it is important to steer bio-fuels development towards lowering the GHG of bio-fuels on a life-cycle basis.

- *Timeframe:* 2012 (25 percent implementation) to 2020 (100 percent implementation).
- *GHG Reduction Potential***:** 1 MMTCO2E per year. (Assuming up to 500,000 acres could be available in the near term for starch, sugar and oil crops for producing bio-fuels[16]. This would result in an estimated 180 million gallons of ethanol or 2.6 million barrels of oil in bio-fuels equivalent.)
- *Ease of Implementation:* While the technologies are readily available for conversion of sugar and starch crops to ethanol and conversion of oilseed crops into fuel with improved energy efficiency and reduced emissions the development of bio-fuel crop production in California to supply these facilities will require extensive crop production research and long-term market commitment by the facilities and the community. Much research on issues associated with renewable fuel production is new and ongoing and dispersed throughout the world. Funded by Federal, State and private monies, access to this research is of paramount importance for the agricultural and regulatory communities to make sound decisions regarding best-approaches for moving forward.
- *Co-benefits / Mitigation Requirements:* Using fall and winter cover crops could help reduce the potential for dust emissions in some cropping systems. There is also potential for growing bio-fuel crops with saline water or on salt-effected land that is moving out of conventional production in the San Joaquin or Imperial Valley.[17] For example, several winter cover crops being considered as bio-diesel feed stocks can extract selenium and salt from the soil. New bio-fuels facilities would require permitting and mitigation of any local impacts.

- *Responsible Parties:* Cal/EPA and member boards, offices and departments, CDFA and the agricultural community should work with the private and public research community to coordinate and prioritize California bio-fuel crop production research needs. To avoid duplication, the U.S. Department of Agriculture (USDA) should serve as clearinghouse for bio-fuel crop production research. The CEC, CARB and CDFA should coordinate on bio-fuel crop lifecycle assessment. Private bio-fuel companies, the fossil fuel industry, agricultural producers, producer groups and local governments should work together on fuel processing implementation and funding. For permitting of new bio-fuels facilities, the SWRCB and regional water quality control boards, CARB and local air quality management districts, and local land authorities.

Problem: Several commodity crops in California suffer from diminishing markets and the ability to shift to bio-fuel crops would help farmers with new options in crop rotations. Technology is readily available to more efficiently convert sugar and starch crops to ethanol while minimizing emissions. The development of this technology, however, requires market certainty. At present, there is no established State funding for bio-fuel field crop RD&D. Unfortunately, other Federal and private grants are not being directed to California bio-fuel field production research.

To have a viable bio-diesel industry using California grown feedstock, processing plants must be constructed that can economically extract oil from seed. Oil press extraction technology is well developed, but it often requires hexane to get the additional oil needed to make processing economically feasible. Priority must be given to developing a hexane extraction process that can obtain state regulatory approval while meeting the agricultural industry's oil crushing needs.

Possible Solutions: California government can send a strong market signal that there is a long-term bio-fuels market in California by making it a policy and regulatory priority. This would spur the long-term investment needed in conversion facilities. California also needs to develop a dedicated funding source for bio-fuel crop research using the resources of UC, the State university system and other schools with the expertise and willingness to conduct this research.

California can grow feed stocks for bio-diesel within its own borders in a sustainable manner. Winter cover crops, which can be grown as bio-diesel feed stocks, can sequester carbon because they add biomass back into the soil. New energy efficient production techniques could deliver greater CO_2 benefits over production of ethanol in older plants in other parts of the country by taking advantage of California's proximity to feed market outlets for distiller's grain (i.e. dairies and livestock operations).

A central bio-fuels information clearinghouse that links information resources for ease of access and serves as a repository for information and tools for all stakeholders needs to be developed. This resource should be housed at the USDA Beltsville Agricultural Library or other appropriate and accessible location and should be available online. This collection would be of great use to stakeholders around the nation -- and the world -- who are growing bio-fuel crops, researching production issues, and planning for the future. They can use the latest research results to develop up-to-date and relevant research projects. Ensuring that bio-fuels researchers and decision

makers have access to the latest research will facilitate the development of the U.S. bio-fuels industry and make the best use of public and private investment in bio-fuels research.

As land use changes occur to accommodate potential conversion of crop and non-crop lands to bio-fuel production a number of research areas will need to be addressed in California to avoid unintended environmental or ecological impacts including:

- Changes in water needs, availability, and water quality impacts;
- Competition for grains and oilseeds, and impacts on food and feed availability and prices;
- Lifecycle assessment and GHG emission accounting for bio-fuels production;
- Recommend sustainable residue removal rates to maintain soil organic matter levels for soil health;
- Assessing co-benefits of bio-fuel production, such as soil quality, reduced erosion from marginal crop lands, and enhanced wildlife benefits.

E. Soil Carbon Sequestration

Soil is a major reservoir for carbon and nitrogen in the terrestrial environment. It contains twice as much carbon than terrestrial vegetation and the atmosphere *combined*. Though much work has been done on Midwest crops such as soybeans and corn, little is known about the sequestration potential of California's 400 agricultural commodities. California has abundant acreage of permanent crops such as wine grapes and fruit and nut trees that could benefit from further research to determine above and below ground sequestration potential. The term "conservation tillage" designates crop production systems that maintain a minimum of 30 percent plant residue cover on soil after planting, which has significant potential to reduce GHG emissions.

California's rangelands and managed open spaces may also serve as an expansive carbon sink via maintenance and enhancement of herbeaceous materials that effectively sequester GHG emissions. Of California's 100 million acres, 38 million are range and pasture lands which represent a major statewide repository for GHG emissions. Preliminary research demonstrates that rangeland and working landscapes have the potential nationwide to sequester 17.5 to 90.5 MMT annually.[18]

- *Timeframe:* 2012 (25 percent implementation); 2020 (50 percent implementation); 2050 (100 percent implementation).
- *GHG Reduction Potential:* 3.1 MMT CO_2E (Assuming California agricultural soils can sequester or displace about 0.4 to 0.8 MT CO_2E per acre over a 10-20 year period using various techniques.[19] If sequestration technologies were applied to all cropland in California, reductions could add up to about 6.1 MMT CO_2E per year, not including the unknown potential from rangeland and open space. Half of that figure is technically feasible since these approaches may be difficult to implement or quantify.)
- *Ease of Implementation*: Conservation tillage is currently used on less than 2 percent of California's annual cropland. There will be little to no ability to make any operational

changes without financial support and incentives. Financial credits for GHG emission mitigation will greatly benefit a significant portion of the farm population in California. A simple, web-based interface, such as the NUGGET should be expanded to other California commodities and made readily available to growers and all interested parties to allow the selection and quantification of site-specific management strategies that are sustainable, reduce environmental impacts and are potentially more profitable. However, ranchers and land managers would require specific direction on what herbaceous species effectively sequester carbon and how to properly manage these living systems.

- *Co-benefits / Mitigation Requirements*: Production practices that minimize tillage are gaining interest because they can provide many co-benefits that improve soil and water quality as well as reduce fertilizer, dust, water consumption and diesel fuel usage. Conservation tillage requires less fuel use compared to conventional tillage. Enhanced rangeland sequestration may promote the development of land use strategies that conserve open space and prevent urban sprawl.
- *Responsible Parties:* CDFA and the agricultural community should work with the private and public research community to coordinate and prioritize California soil carbon sequestration research needs and coordinate with USDA/NRCS to develop incentive programs. CDFA and the agricultural community should coordinate with CEC and the SWRCB on water and energy efficiencies of soil carbon production practices. CDFA and USDA/NRCS should work with the ranching community and those interested in funding additional research to evaluate what perennial or annual grasses sequester carbon and develop voluntary management practices to aid land managers on how to implement management strategies in an effective manner.

Problem: Converting to reduced-till production alternatives requires a number of significant operational changes, and each of these requires an upfront investment (in additional research, equipment, time and management) in order to be successful. It also will demand significant technical work and outreach to expand the use of new farming techniques. These methods need to reduce the need for future practice changes that could return the stored carbon to the atmosphere.

One primary hurdle for adoption is that California leaves crop residues on the soil surface where they interfere with furrow irrigation practices. Use of subsurface drip can facilitate the adoption of conservation tillage by overcoming the need for furrows as a means to deliver water to crops. California has invested relatively little in RD&D to overcome hurdles to adopting conservation tillage and other favorable practices for carbon sequestration.

Establishing and monitoring the amount of carbon stored could be difficult if it requires more work than the value of the credit. In addition, transaction costs may be too high for an individual farmer to play directly in the carbon market.

Possible Solution: Quantifying soil carbon sequestration is only one part of a larger accounting puzzle that needs to address soil carbon and trace gas emissions of methane (CH_4) and nitrous oxide (N_2O) holistically to be valid and effective. When specific soil carbon sequestration recommendations are made based on the new research, this information will need be used in models and ultimately in web-based documentation tools that provide growers the mechanism to

obtain support and incentives to make potential operational changes through carbon credits. A monitoring network integrated with modeling will be necessary and aggregation of credits on a commodity or regional basis is the likely way that farmers can participate in the carbon market.

Additional research is required to evaluate rangeland's carbon sequestration capability specifically reflective of herbaceous species in and around California rangelands. Further research will aid land managers in the development of guidelines and management practices to preserve and enhance California's rangelands. Research should also encompass the result of livestock grazing on rangeland to manage invasive species and promote healthy and regenerative landscapes that will more likely sequester carbon.

California cannot address the issue of soil carbon sequestration by itself. Therefore it should coordinate its efforts in this promising arena for GHG emission reductions by coordinating with federal government agencies. Among the recommendations of the ETAAC agricultural subgroup are the following:

- The USDA should convene a working group of university and government scientists and stakeholders to establish minimum protocol standards for the measurement, monitoring and verification of agricultural GHG emission reductions and carbon sequestration.
- USDA should establish a national network of on-farm soil measurements for carbon stocks to complement existing models and experimental data in order to develop a national inventory and baselines for soil carbon markets. This should be done in conjunction with the USDA NRCS Natural Resource Inventory.
- The Secretary of Agriculture should actively support a minimum of $15 million in funding annually for five years for research on GHG emissions and carbon sequestration in agriculture through a national effort such as the Consortium for Agricultural Soils Mitigation of GHGs (CASMGS) in the 2007 Farm Bill and ensure coordination among all participating CASMGS institutions and USDA agencies nationwide.
- The GHG Reduction through Agricultural Carbon Enhancement Network (GRACENET) should be expanded beyond its current 29 sites to better represent the geographic diversity and spatial variability of GHG emissions across the U.S. GRACENET represents a coordinated national effort by the USDA Agricultural Research Service to provide information on the status of soil carbon and GHG emissions related to current agricultural practices. It also can serve as a platform to develop new management practices to reduce net GHG emission and increase soil carbon sequestration primarily through improved soil management. The focus should be comparing common management scenarios at each location. The soils, crops and condition will be location specific, but consistent methods and detailed record keeping will be used to facilitate cross-location comparison and to ensure quality control.

Recommendation: Additional State Soil Science RD&D and Web-based Tools

Further state sponsored RD&D is also needed to help answer questions about how soil texture, crop rotation, residue type and amount, all influence yield response and alternative tillage choices, and, ultimately, corresponding reductions in GHG emissions. A dedicated and significant research funding source on the order of $3 - $5 million dollars to investigate these practices in common California cropping patterns is well-justified. More funding for UC Cooperative Extension in this area is critical.

California should establish a long-term program to encourage new technology for reduced tillage, organic fertilization, cover cropping and low-input farming. This should include research (in-field and modeling), monitoring and incentive/education/outreach programs for farmers to convert to new equipment and techniques. Coupling conservation tillage systems with the use of high efficiency, slow-release nitrogen fertilizer materials under California conditions needs to be investigated, too.

Yet another exciting field of research that could help reduce GHG emissions is "precision farming," a term that refers to carefully tailoring soil and crop management to fit the different conditions found in each field using three technologies - remote sensing, in-field sensing, geographic information systems (GIS) and global positioning systems (GPS). Using GIS record keeping systems, farmers can record all of the field operations such as planting, spraying, cultivation and harvest (along with specific information such as type of equipment used, rates, weather information, time of day performed, etc.). Remotely sensed data can be analyzed and added to the GIS using soil maps, digital terrain and field operations information as ground truth. This can be used to guide further field operations like spraying, fertilizing and irrigating plus it would serve record-keeping purposes.

Current USDA research using dynamic, process modeling has created geospatial tools for quantifying nutrient fluxes to air and water, changes in carbon stocks and GHG emissions across a range of management practices in San Joaquin and Merced Counties. This initial research project will have an emphasis on computer modeling water and air emissions from dairies and provide a decision-making tool for economical use of fertilizer and manure resources called the Nutrient and Greenhouse Gas Evaluation Tool, or NUGGET. This tool will utilize GIS capabilities to capture spatial and temporal variability in agricultural, environmental, and climatic conditions. The DeNitrification-DeComposition (DNDC) model is also being used for these studies. It will take $600,000 over a two-year period to implement this effort on dairies statewide.

With its unique Mediterranean climate, California dominates the nation with our 1.8 million acres of tree crops valued at $6.7 billion. These key agricultural commodities should take advantage of the Forest DNDC model that was developed by the United States Forest Service, which could be adapted for use on the state's tree crops. California should establish a long-term program to encourage new technology for reduced tillage, organic fertilization, cover cropping and low-input farming. This should include research (in-field and modeling), monitoring and incentive/education/outreach programs for farmers to convert to new equipment and techniques. Coupling conservation tillage systems with the use of high efficiency, slow-release nitrogen fertilizer materials needs to be investigated under California conditions.

F. Riparian Restoration and Farmscape Sequestration

One way to store carbon on agricultural lands is to re-establish natural woody vegetation on rangeland, field edges and marginal farmland and riparian areas that have been cleared.

- *Timeframe:* 2012 (10 percent implementation); 2020 (25 percent implementation); 2050 (50 percent implementation).
- *GHG Reduction Potential*: 2.9 $MMTCO_2E$ (Assuming 500,000 acres on the edges of cropland and rangeland might be available for re-vegetation or farmscaping with woody shrubs and trees and that annual carbon storage over the initial 20 years of vegetation growth amounts to 5.8 $MTCO_2E$ per acre).
- *Ease of Implementation:* A current challenge is to facilitate the process of restoration to increase both biodiversity of native species and associated ecosystem services. A toolbox of management practices, and an understanding of potential site-specific interactions (e.g., grazing pressure, soil type, microenvironment, and plant species composition), would facilitate greater establishment of restored native grasslands on marginal lands. Agricultural policies that favor soil conservation and potentially enhance carbon sequestration and nutrient retention would likely be required to help facilitate these conversions. Eventually this understanding could be employed to mitigate and adapt to climate change. This will require better information on the impact of land use history on soil biology and soil carbon sequestration in relation to plant species composition. As this type of information becomes available, it will also be possible to scale up to landscape-level predictions of carbon sequestration by grasslands across different soil types and management regimes. Assessments of tradeoffs involved in land use change from grasslands to other different types of ecosystems would also be possible.
- *Co-benefits / Mitigation Requirements*: These efforts can benefit erosion control, water quality and wildlife habitat.
- *Responsible Parties*: CDFA and the agricultural/ranching community should work with the private and public research community to coordinate and restoration research in California ecosystems and coordinate with USDA/NRCS to develop incentive programs.

Problem: The cost of installing an acre of re-vegetation could be prohibitive if done only for carbon credit generation. Based on estimates for woody hedgerow plantings,[20] costs could be on the order of $12,000 per acre for initial planting and $500 for annual maintenance in the first five years. Clearly management optimization is needed to reduce costs of irrigation, maintenance and nursery stock while maximizing growth. In addition, not enough data is available on multifunctional benefits of woody species in agricultural landscapes in California to quantify the value of other benefits. There are also possible crop losses from wildlife that intermittently feed on crops and issues with federal cost support (e.g. the Environmental Quality Incentive Program and other federal conservation programs).

There is no current data on the relationship between shrub and tree dimensions e.g., height or diameter, and carbon sequestered in above- and below ground wood for the species used in

California, although some research is underway. The rate of growth per year needs to be researched for the riparian and hedgerow species that are frequently used in California, under different site conditions. The growth rates and woody biomass depend greatly on site characteristics, nutrient and water availability. Assessing the amount of carbon stored in common species can be achieved with simple field measurements.[21]

Possible Solutions: Conduct research to quantify the carbon storage from these practices and develop protocols that give landowners the ability to generate carbon credits (see Forestry Chapter for more information). This research program should include an economic and technology assessment portion that develops the most cost effective approaches and looks at monetizing the other benefits. Additional support is needed for funding and then managing implementation and ongoing monitoring systems. As with all forms of carbon sequestration, commodity or industry programs to aggregate credits may be a suitable approach for marketing these credits, which, in turn, could provide fiscal support for development and performance monitoring.

It may also be possible to grow revenue generating tree crops or perennial bio-fuel crops in these buffer strips, making installations more economically attractive, particularly in combination with Federal programs such as the Conservation Reserve Program, etc. It may even be possible to layer grasses with tree crops in such a way as to have multiple environmental and economic benefits or to "buy" annually the incremental value of a long term crop asset (i.e. high value wood like walnut) which provides incentive for plantings that would not otherwise occur.

G. Fertilizer Use and Water Management Efficiency

There is growing interest in reducing nitrous oxide (N_2O) emissions from managed soils due to high probability of GHG emission releases during fertilization.

- *Timeframe:* 2012 (10 percent implementation); 2020 (25 percent implementation); 2050 (50 percent implementation).
- *GHG Reduction Potential***:** 1.8 $MMTCO_2E$ (Assuming reducing these emissions on typical California crops in the order of 0.4 $MTCO_2E$ per acre per year by reducing fertilizer input by 25 percent.[22] If this were to translate to all California agricultural crops, this could be a potential gross emissions reduction on the order of 3.6 $MMTCO_2E$. Start-up and implementation issues reduce this gross potential by half).
- *Ease of Implementation:* Measuring N_2O poses a double enigma. Not only are measurements of annual N_2O emissions laborious and therefore expensive, N_2O fluxes are often very erratic and highly dependent on fertilization and irrigation levels. Nitrous oxide fluxes are also strongly influenced by environmental conditions such as climate, soil type, and cropping system.[23] This makes extrapolation of the little available data measured across different cropping systems and climate zones highly suspect.
- *Co-benefits / Mitigation Requirements***:** Improving fertilizer efficiency and water management appear to be promising ways to reduce N_2O. These approaches should be further investigated to measure impacts on crop yield, air and water quality, and returns on investment for participating farmers. By combining field information, soil measurements,

event-related N_2O measurements, and simulation modeling, a reliable annual GHG emission budget could be calculated under current and possible future conventional and alternative cropping system scenarios for California.

- *Responsible Parties:* CDFA and the agricultural community should work with the private and public research community to coordinate and prioritize California fertilizer management research needs and coordinate with USDA/Natural Resource Conservation Service to develop incentive programs. CDFA and the agricultural community should coordinate with CEC and the SWRCB to determine potential water and energy efficiencies from any operational changes.

Problem: One of the key barriers to reducing fertilizer inputs is the potential impact to crop yield that would reduce farm income and diminish the emissions benefit per net amount of crop produced. Substantial research needs to be conducted on the wide variety of crops and soils in California on N_2O emissions, the effect of different cultivation practices, and ways to reduce inputs without impacting yield. Research on no-till soils generally shows an increase in nitrogen -containing trace emissions upon conversion from conventional tillage practices. This increase has been attributed to an increase in soil bulk density under no-till.[24] The researchers suggest that mitigation of nitrogen containing trace gas emissions may take up to 20 years of continuous no-till management.

While it is estimated that N_2O accounts for up to 50 percent of all agricultural GHG emissions (CH_4 accounts for 37.5 percent, and CO_2 for 12.5 percent[25]) there is great remaining uncertainty surrounding the N_2O emissions inventory. There is therefore a need to not only quantify the amount of N_2O emissions, but also the uncertainty around estimates of agricultural N_2O emissions at multiple spatial and temporal scales.

Possible Solution: Optimizing N-fertilizer application rates with improved technologies and management practices could provide the double benefit of cost savings and N_2O reduction. There may be potential "insurance" products for paying farmers who reduce nitrogen use against yield decline that occurs as a result. Additionally, some types of conservation tillage practices, like strip tillage, may not have the same increases in bulk density that are found in no-till approaches. The ETAAC agricultural subgroup suggests growers look to the full suite of conservation tillage technologies – as well as other management practices -- that have the greatest combined economic and environmental benefits.

This type of quantification requires accurate measurements of N_2O fluxes and well validated and calibrated biogeochemical simulation models that can estimate annual N_2O budgets for a range of representative cropping systems. A database of event-related and background N_2O emissions, crop development and controlling factors (e.g. soil temperature, soil moisture, and soil mineral nitrogen) must be constructed in a range of representative Californian cropping systems, soils, and climates. This database could then be used to calibrate and validate the biogeochemical models. Costs estimates for constructing this database and developing a biogeochemical model validated with California crops and soils would cost on the order of $2-$3 million. The models could then be used for scenario and trade-off analysis of potential agricultural practices to minimize annual N_2O and other GHG emissions in California agriculture. (Please see also the

composting options in the waste reductions, recycling, and resource management section of the Industrial, Commercial, and Residential Energy End-User Chapters)

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[1] California Department of Food and Agriculture,*California Agriculture Resource Directory*, (2006), www.cdfa.ca.gov.

[2] For irrigated crops, using a total biomass yield (including roots) per acre of 5 dry tonne, a 41 percent carbon content for plant carbohydrates, gives an estimated CO_2 uptake per acre of 5 tonne x 0.41 x 44 lbs CO_2 /12 lbs C=7.5 tonne CO_2/acre. A biomass yield per acre of 2 dry tonne for rangeland is used in this calcualtion. Total estimated uptake = 120 $MMTCO_2E$ = 75 (cropland) + 45 (rangeland).

[3]California Air Resources Board, *DRAFT California Greenhouse Gas Inventory*, updated 8/22/07, www.arb.ca.gov.

[4] California Biomass Collaborative, *Biomass Resources in California: Preliminary 2005 Assessment*, California Energy Commission' Contract 500-01-016, Sacramento, CA, April, 2005.

[5] California Climate Action Registry, *Livestock Project Reporting Protocol*, June, 2007.

[6] Anders, Scott J. *Biogas Production and Use on California's Dairy Farms: A Survey of Regulatory Challenges*. Energy Policy Initiatives Center, University of San Diego School of Law (2007).

[7] Smith, P. et al. *DRAFT - Greenhouse Gas Mitigation in Agriculture*, IPCC Panel on Agriculture, (2007). Provided by Charles Rice, Kansas State University.

[8] California Biomass Collaborative, *An Assessment of Biomass Resources in California*, California Energy Commission Contract 500-01-016, December 2006, p.1.

[9] Assumes 20 percent efficiency in conversion of biomass to electrical power and 45 percent efficiency in thermo-chemical conversion of biomass to synthetic fuels.

[10] California Biomass Collaborative. 2006.

[11] California Biomass Collaborative. 2006. p 123.

[12] A. Aden, M. Ruth, K. Ibsen, J. Jechura, K. Neeves, J. Sheehan, B. Wallace, L. Montague, A. Slayton, and J. Lukas, *Lignocellulosic Biomass to Ethanol Process Design and Economics Utilizing Co-Current Dilute Acid Prehydrolysis and Enzymatic Hydrolysis for Corn Stover*, National Renewable Energy Laboratory Report No. TP-510-32438, Golden, CO, June 2002.

[13] Phillips, S., A. Aden, J. Jechura, D. Dayton, and T. Eggeman, *Thermochemical Ethanol via Indirect Gasification and Mixed Alcohol Synthesis of Lignocellulosic Biomas*, National Renewable Energy Laboratory Report No. TP-510-41168, Golden, CO, April, 2007.

[14] California Health and Safety Code Section 41865.

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7. FORESTRY SECTOR

I. Introduction

Forests cover 30 percent of California. Every day, photosynthesis by forests is one of the few processes that remove and store a portion of California's ongoing GHG emissions.

Conversely, the loss of forests is a carbon emission. Scientists estimate that deforestation is responsible for approximately twenty percent of global CO_2 emissions linked to human activity, adding almost two billion tonnes of carbon per year[1]. Most of the loss has occurred in tropical forests, but the United States and California are not immune. In the U.S., 1 million acres of private forestlands were lost to development per year by the 1990s[2], and housing is expected to increase by about 25 percent on private land near national forests by 2030[3]. In California, nearly 3 million acres of private forest and rangelands are conservatively projected to be lost to conversion over the next four decades[4]. Forest loss has a dual emission impact –the loss of forest photosynthesis that removes atmospheric carbon, and the emission of stored forest carbon back to the atmosphere through biomass combustion, decay and soil disturbance.

Similar to other ecosystems, forests are vulnerable to climate change. As temperature and precipitation patterns change, some forest types will be lost and others will shift their location and diversity. Current stresses to forest health in California already compromise forest resilience. Earlier spring snowmelt coupled with unnatural stocking in some forests -- too many stems per acre -- from decades of fire exclusion now make some forests more vulnerable to wildfire, pests and water stress[5]. Other forests are under-stocked, the result of stand-converting wildfires or management practices that maintain carbon stocks below their natural potential. The effects of climate change will not hit all forests equally, and managing forests to improve resiliency requires a better understanding of processes in all forest types.

Forests offer many opportunities to increase carbon storage and avoid emissions, thereby offering mitigation opportunities to climate change under AB 32. The biggest potential forest sector solutions to climate change include the following:

- Enhancing carbon storage in forests and in wood products
- Avoiding carbon emissions from forestland conversion
- Reducing wildfire emissions that result from unnatural forest conditions
- Utilizing waste forest biomass to generate electricity or other fuel
- Substituting low-emission wood products for other building materials that produce high GHG emissions (e.g. concrete, steel)

The full extent of climate-gain opportunities from forests has not yet been realized. Until recently there has been little compelling reason to pursue forest projects for climate

purposes. Additionally, many forest management projects have been stymied by broad disagreements over forest land management and low public trust that environmental values will be protected. Many project types that would produce climate benefits have already been debated, at least in part, in the context of other forest issues. Thus these topics are not entirely new and substantial literature is available for each.

CARB and state climate policy can bring value and a new perspective to the forest debate. CARB can have a significant effect not only in addressing the climate change threat, but in finding co-benefits that address long-standing management concerns surrounding California's forests. This chapter purposely does not focus on specific issues related to forest protocols and standards for forest carbon accounting, since these already have a separate stakeholder forum before CARB. The chapter does however highlight a set of key areas where CARB action would have significant effect.

II. The Policy Context

California's forestlands provide a wealth of ecosystem and economic benefits ranging from tree-covered watersheds that supply much of the state's water, to wildlife habitats, recreation and open space lands, to sustainable wood products and employment. The forest and paper industry in California employs approximately 60,000 workers, supports a $1.4 billion payroll, and contributes 4.1 percent of the state's total manufacturing workforce[6].

The durability and health of California's forests are threatened by numerous factors. These include the push to convert forests to other land uses as homes expand into wildlands, the increased occurrence of intense wild-fires relative to historic fire cycles, the lack of appropriate forest management in some areas, and increased stress on forests from global climate change itself. Conflicting policy arenas also confound progress on some projects, such as the "chicken-and-egg" dilemma surrounding the siting of biomass plants in conjunction with fuel reduction projects designed to restore forests to more natural structure.

The immediate stakeholders and general public are highly attuned to changes in forest use and forest policy. Each of the many forest values has a savvy political constituency which participates actively in forest policy debates. A long history shows that opposing sides can counter and deadlock each other politically and in the courts, leading to gridlock when it comes to implementing solutions.

Global climate change brings a new dimension to the table and offers opportunities for positive rather than negative outcomes across ownerships in the forest sector. Recognizing that CARB has limited regulatory authority over forest management, CARB can nevertheless offer a broad bridging role to the forest sector by helping to develop the frameworks, metrics, structure and incentive-based policies for the sector to participate positively in climate solutions.

III. Key Policy Principles

The overarching theme to guide forest sector policies can be summed up as: "Enhance gain, avoid loss."[7] In essence, this recognizes that forests already perform a critical role countering GHG emissions, but – with proper new policies -- can do even better. Enhancing gains and avoiding loss will help "resile" both forest ecosystems as well as forest landowners. (To 'resile' is to make resilient, to spring away from an impact[8].)

Ways to enhance gain include:

- Manage forests to develop larger carbon reservoirs in trees, wood products and soils;
- Reforest areas that could naturally hold more trees;
- Utilize excess wood biomass for generating electricity and production of other fuels.

Ways to avoid loss include:

- Keep the existing forest land base as forest, rather than converting to development and associated GHG-emitting activities. Preserving forestland can take the form of both 1) increasing conservation forests as parks and natural ecosystems, and 2) retaining the working-forest land base of industrial and non-industrial private forestlands which are most vulnerable to conversion and development;
- Retain a multi-faceted forest industry with sufficient infrastructure (mills, equipment, workforce) to beneficially utilize wood materials consistent with AB 32 goals;
- Reduce GHG emissions from wildfire by bringing unnatural stands of trees back to more natural fire-adapted conditions;
- Understand climate impacts on forests and work towards fostering greater resilience.

Public comments have suggested various additional roles for forests including: plantation afforestation to provide fiber for wood products or fuel; increasing small-scale wood-heat applications including wood densification; reducing the consumption of wood products; natural re-seeding rather than re-planting following wildfire; questioning the efficacy of forest thinning as an emissions reduction measure, among others. Each of these suggestions can be further explored as the discussion matures regarding forests in the carbon context. Each will need to be evaluated in terms of whether it offers net carbon benefits on a life cycle basis, and each also raises forest policy issues that need further development, but are beyond the scope of this chapter.

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In order for forests to be key players in California's efforts to reduce GHG emissions, the ETAAC forestry subgroup offers the following key principles to guide future policy recommendations:

Use CARB's stature to reinforce the concept that forests play a necessary role in solutions to global climate change. CARB can bolster public understanding of forest processes, the role of carbon storage in trees and wood products, and forest health needs.

Acknowledge forests as both a sequestration and emission sector in its own right. Gains achieved in GHG reductions within the forest sector can stand on their own merits, in addition to other important roles they may play as offsets in voluntary markets or cap-and-trade systems.

Develop climate policies appropriate to each forest sub-sector. Look for early gains in forest contributions to climate stabilization appropriate to each class of ownership and forest use (e.g. public and private; protected and managed; industrial and non-industrial; and large and small owner). It is not necessary to pit sectors and management objectives against each other or to promote one-dimensional goals under the guise of a climate benefit. This is similar to the approach recommended for low-carbon fuels, where specific technologies are not singled out as winners but rather are left to progress on their own merits[9]. If and when a market option develops for sequestering forest carbon, owners will respond according to their own motivations. It is premature to pick winning forest sectors now, but we can find gains and policies within each sub-sector to encourage early actions to reduce GHG emissions.

Establish flexible and durable frameworks for forest landowners to work within, and let them find their own way to participate.

IV. Key Overriding Themes

The ETAAC forestry subgroup makes the following recommendations to CARB:

<u>1. Continue to affirm the metrics and structure for forest carbon accounting and reporting</u>. California needs to remain compatible with existing international accounting conventions, as reflected in the recent adoption by CARB of the California Forest Protocols as a voluntary "Early Action" measure pursuant to AB 32.

<u>2. Establish the role forests will have in carbon markets</u>: Legitimate "gold standard" forest carbon credits compliant with the standards of the California Climate Action Registry (CCAR) are already in play in the voluntary carbon market and the European Kyoto-based market. If a state, regional or national cap-and-trade market is established, decisions will be needed: *whether* offsets will be allowed for flexibility, *how much* of the cap obligation can be met with offsets, and *what kinds* of offsets will be permitted (i.e. will forests be eligible). The forest sector argues "yes" for eligibility as a legitimate

offset should a California market develop. ETAAC cautions however in its response to the Market Advisory Report[10], that *"…in order for (an offsets) market to work properly, offsets must be real, additional, permanent, enforceable, predictable and transparent"*, all of which describe the current standards of the California Climate Action Registry and CARB policy. Recognizing the hesitancy of the carbon market and many stakeholders towards accepting forest offsets, CARB must uphold rigorous and credible accounting standards in order for forest carbon credits to have meaningful market value. While California market decisions are in process, the forest sector will meanwhile continue to participate in the voluntary and Kyoto-based markets, receiving highest value from credits that meet the highest standards.

3. Consider protocols for additional forest activities: Current CCAR Protocols address 'Forest Management', 'Reforestation' and 'Avoided Deforestation'. New CARB and CCAR stakeholder workgroups are currently evaluating whether additional protocols or guidance are needed for addressing public lands, urban forestry, biomass, wildfire avoidance and other activities.

Recommendations on RD&D Needs

Support further research on the forest carbon cycle: Data needs are not trivial. Among the recommendations of the ETAAC forestry sector subgroup are the following:

- Improve methods for assessing sequestration and emissions
- Test more efficient remote assessment techniques for carbon inventory, e.g. lidar; spectral analysis from new satellite and conventional imagery
- Model advances in the forest sector to inform state emission data
- Examine how forests become C saturated; examine forest carbon exchange through eddy flux
- Track climate change impacts on forests; evaluate management approaches designed to improve resilience and respond to impacts
- Model inputs, outputs and flow of wood carbon to maximize sequestration.
- Pursue small-scale biomass technologies

Wood products research is also needed on

- Alternative wood-based liquid and gas fuels, e.g. fine wood gasification, pyrolysis to bio-oils, ligno-cellulosic conversion technology
- Stronger and more versatile wood-based building materials

There is always room for new ideas in the forest sector:

- Look for efficiencies in harvest methods, equipment, combustion techniques and manufacturing
- Test incentives such as small changes in tax structure, electricity rate, position in the regulatory queue, grant funding and purchase preferences for their effect in stimulating climate- and energy-efficient forest projects

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A. Link Forest Fuels Management and Biomass Utilization: Develop a "Green Bio-fuels Index"; Offer Economic Incentives and Technology Development

Public support of forest fuel management projects can provide a three-way climate gain by restoring forest ecosystems to more resilient conditions, directing excess fuels to biomass energy production to help meet low-carbon fuel standards, and reducing wildfire emissions.

- *Time Frame:* Fuel management projects are now underway but very limited. Develop a public process for Green Bio-fuels Index by 2012.

- *GHG Reduction Potential:* Highly variable; based on assumptions of acres treated; wildfires avoided or reduced; and development of facilities to produce electricity and bio-fuels. Estimate 3 MMTCO2e/yr at 2020 (.09 avoided emissions; 1.9 power and fuels) assuming $400/acre average treatment cost. Assume $37 million from existing sources and an increase to $5 million for California Forest Improvement Program (CFIP) support.[11]

Ease of Implementation: Several key barriers to biomass utilization prompt development of a Green Bio-fuels Index.

> A "chicken-and-egg" dilemma confounds success in linking fuel reduction projects to biomass facilities. Biomass facilities cannot be sited, sized and financed without some horizon of dependable supply. Dependable supply cannot be provided without public trust that forests won't be overexploited by fuel reduction projects. A federally-supported "Community Wildfire Protection Plan" process now encourages public input for community fuel breaks and defensible space, but challenges by stakeholders continue on larger forest projects and post-fire salvage. State support of a "green labeling" process could help identify projects that meet environmental standards and help firm up a supply of fuels to support biomass facilities. Efforts to combine urban, agricultural and forest waste streams would help stabilize supply.
>
> RD&D is also underway on alternate fuels from wood wastes. Wood products laboratories are currently exploring conversion of wood to alternate liquid and gas fuels, e.g. in-woods pyrolysis to bio-oils or gas.

- *Co-Benefits / Mitigation Requirements:* Multiple benefits can accrue to forest ecosystems, reduced wildfire emissions and biopower generation from appropriate projects designed to improve forest ecosystem health and resiliency, especially in face of climate change. Forest co-benefits include: improved water quality, reduced erosion, reduced sedimentation of stream habitats and downstream storage facilities; improved wildlife habitat diversity; improved air quality through a reduction in criteria pollutants

and smoke emissions; reduced risk to life and property; and greater employment in rural communities. Increased biomass utilization also helps meet state biopower and bio-fuel targets while reducing reliance on fossil fuels and other imported energy sources. CARB should emphasize rigorous CEQA and NEPA review of forest management mitigation projects.

- As a side note regarding forest carbon accounting, forest carbon from the various aspects of fuel reduction, "wildfire avoidance" and electricity generation from biomass should be separately accounted, and be cognizant of the importance of full accounting of upstream and downstream pools.

- *Responsible Parties:* Ongoing international efforts by environmental stakeholders may provide a model "Green Bio-Fuel Labeling" program for CARB to consider. The model could be adapted for California in cooperation with local and state environmental groups, USFS and CDF.

Problem: Decades of fire suppression have left many forest stands with unnatural excess levels of stocking (too many stems per acre) and growth of mid-successional fuel ladders. Excess fuels intensify wildfire behavior, impacts to ecosystems, and risks to life and property. Stress from drought, pests and global climate change further exacerbate wildfire risks and damage. Fuel reduction projects are expensive and require extensive public processes for design, review and final approval.

Possible Solutions: A three-pronged effort featuring the following components:

- Support for a "Green Bio-Fuels Index" -- comparable to a green-labeling program -- developed with key stakeholders to increase public trust in appropriate projects and address the gridlock of project design and approval. A "Green Biofuels Index[12]" would rank projects and improve public confidence in biofuel sustainability. Based on the "green labeling" concept, the index develops a green biofuel protocol; uses environmental labeling to distinguish products; allows the market to reflect efficient labeling and claims; gives preference for green biofuels; offers incentives for environmental performance; and establishes aggregate green biofuels performance standards.

- A small price increase for biopower would mobilize more wood waste out of the forest, at least to a break-even point to support fuel reduction costs.

- State support for technology development and demonstration of

    - Small-scale, mobile gasification (or other) units;

    - More efficient conversion technology to feed 1-5 MW distributed generation plants located close to supply forested communities.

B. Reforestation and Forest Management for Enhanced Carbon Storage

Reforestation and enhanced management of established working forests to store greater carbon stocks will provide climate benefits by absorbing CO_2 from the atmosphere and storing it as carbon in trees for hundreds of years or longer

- *Time Frame:* Additional gains by 2012 and ongoing.

  GHG Reduction Potential: The California Department of Forestry and Fire Protection estimates cumulative sequestration from reforestation projects of 15 MMT CO2 by 2020 (Assuming 0.53 MMT CO2/yr by 2010 from 117,000 acres of forest established on forest and rangelands; 1.98 MMT CO2/yr by 2020 assuming 430,000 acres established on forest and rangelands[13]).

- *Ease of Implementation:* Reforestation is not limited by current technology, however project assessments will be necessary to assure that reforestation will be successful in face of climate change. Increased reforestation is a function of available funding. CDF already provides delivery programs and CEQA compliance via the California Forest Improvement Program (CFIP). The California State Parks system can deliver reforestation programs on state park lands.

  The building of carbon stores in established working forests is a landowner management decision. A high value carbon credit for additional stored carbon is emerging, established through the accounting standards of the CCAR California Forest Protocols and stimulated by the rapidly expanding voluntary carbon market. Development of national and international markets for forest carbon credits will further incentivize forest carbon storage projects.

Co-Benefits / Mitigation Requirements: Multiple ecosystem and economic co-benefits result from reforestation and enhanced carbon storage in established forests. Active planting with native tree species and management of forest stands to store additional carbon can provide watershed improvement, wildlife habitat diversity, erosion stabilization, and forest health. Economic benefits include short- and long-term job creation in rural regions from forest management. The CEQA process is already in place for CFIP and forest management mitigation activities. CCAR Forest Protocols currently address “Forest Management” and “Reforestation” Projects.

- *Responsible Parties:* CDF for technical support and program delivery; ARB/CCAR for Protocol adoption; Resource Agency and Cal-EPA in support roles; State Parks Department for reforestation on state park lands; Legislature for potential tax and other incentives.

Problem: Millions of acres of native forests on private and state ownerships in California are estimated to remain below natural stocking capacity due to wildfire or forest management that maintains forests below their carbon storage potential. Only 3.8

percent of all acres burned in 2001 in California have been replanted. Nationally there is a growing reforestation backlog, now one million-acres and increasingly daily.

Industrial forestlands under conventional management are typically managed to store less carbon stock in the forest than their natural potential, being instead managed to move forest carbon to the wood product pool. Wood products are an important carbon storage pool, with storage lasting from days to centuries, but carbon loss does occur between the tree in-situ and the harvested wood product.

Possible Solutions: Gains from forest management in established working forests to increase carbon storage and sustain the long-term production of wood products are substantial. Forested land is now estimated to sequester approximately 14 MMTCO2eq from the air annually. Total carbon stored in California forests is estimated to be 1.7 billion tons. To build upon this base of carbon sequestration, the ETAAC forestry subgroup offers the following recommendations:

- Augment support for reforestation on private and state lands via existing CDF cost-share programs and new forest carbon offset revenue (CDF suggests a $5 million CFIP augmentation).

- CCAR Forest Protocols establish accounting standards for reporting additional forest carbon from 'Forest Management' and 'Reforestation' projects. A forest carbon market would incentivize landowners to participate in carbon storage projects, producing forest carbon as a new "forest product", opting to increase rotation age, tree size and forest complexity with accompanying ecosystem co-benefits.

- Income tax credits or other incentives would accelerate reforestation/ sequestration efforts by landowners.

- Apply existing state Water Bond funds to reforestation of upper watersheds to help develop water-holding capacity of soils and vegetation, and mitigate effects of diminished snow pack on state water supplies.

C. Urban Forests for Climate Benefits

Accelerated urban tree planting programs will cool landscapes, sequester carbon and provide biomass for renewable biopower.

- *Time Frame:* Program delivery systems in place and expandable by 2012 and ongoing. Not technology limited.

- *GHG Reduction Potential:* The CDF goal is to plant 5 million trees by 2010 to deliver 4 MMTCO2e by 2030. The estimated GHG reduction potential is 0.88 MMTCO2e/yr at 2020 (0.14 sequestration; .05 shade; .69 biomass)

- *Ease of Implementation:* Planting technology and delivery programs are already highly feasible. Urban wood waste is a relatively consistent supply of material. CDF has broad existing authority to implement its Urban Forestry program. Program and CEQA processes are established and ongoing.

  Barriers include the following:

  - Additional funding for tree planting at state and local levels
  - Ongoing maintenance of planted sites.
  - Siting of biopower facilities to link urban forest waste streams with agricultural, forest and other wood wastes to serve as feedstock for biopower.

  Ways to overcome these barriers:

  - Pursue funding to augment tree planting: grants, bonds, increased USFS, city and utility support (e.g. SMUD and other utilities now provide free shade trees if planted to effectively reduce summer energy use).

  - Support expanded tree-nursery programs at existing CDF and private nurseries to provide tree stock for planting

  - Biomass facility siting is a function of regulatory agency action, location, energy price and dependability of supply

- *Co-Benefits / Mitigation Requirements:* There are multiple co-benefits, including energy efficiency from shading; park, recreation, school, street tree and property benefits from trees; reduction of landfill disposal of wood wastes. *A* CEQA process is already established for mitigation requirements.

- *Responsible Parties:* Urban cities and districts, CDF, State Parks Department, USFS, Cal Trans

Problem: A renewed state focus on existing Urban Forestry programs can deliver gains in carbon storage, energy efficiency and energy production, but is currently lacking. Tree plantings in strategic locations will store carbon as trees grow, provide shade for buildings and parked cars (reducing energy emissions from air conditioning) and shade roadways to help reduce the urban Heat Island effect. Biomass facilities combusting urban waste will divert wood waste from landfills and supplement feed stocks from agriculture, construction and other sources.

Current funding from CDF Urban Forestry program, USFS and Propositions 12, 40 and 84 are insufficient to meet the goal of 5 million trees planted by 2010.

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Possible Solution: Further emphasis on possible grant, bond and other sources of funding to increase planting programs and provide tree stock. As biomass/biopower capacity develops, urban tree programs and wood waste streams will receive more focused attention.

D. Endorse "California Climate Solutions": Give Preference to CCAR and CARB-compliant climate products and actions

California should champion home-grown products and actions that contribute to climate solutions. Provide in-state purchasing preferences and priority in regulatory queues whenever feasible. Give preference to offset products certified by the California Climate Action Registry in voluntary or cap-and-trade market systems.

- *Time Frame:* Now and ongoing
- *GHG Reduction Potential:* The aggregate of all contributions from climate actions.
- *Ease of Implementation*: CalEPA and CARB in conjunction with private sector Trade Associations can develop an umbrella "California Climate Label" for products and actions that result from (or are derived in compliance with) state climate policies and programs.
- *Co-Benefits / Mitigation Requirements*: Granting preferences for California entities where feasible will help counter competitive disadvantage of entities operating within an "early actor" state relative to non-regulated states. It will also promote public awareness of climate change, climate solutions and the California entities that are stepping forward
- *Responsible Parties*: CARB, Trade Associations, California Business, Transportation and Housing Agency.

Problem: California is a national leader in promoting climate solutions but compliance presents potential costs and competitive disadvantage to entities that compete with unregulated out-of-state businesses.

*Possible Solution***:** Require state purchase preferences for entities that comply with a new "California Climate Label." Provide priority in regulatory queues where feasible. Give preference to offset products certified by the California Climate Action Registry in voluntary carbon markets and cap-and-trade systems.

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8. ETAAC Review of MARKET ADVISORY COMMITTEE REPORT

I. Introduction

CARB requested that ETAAC provide a consensus view on how various policy mechanisms referenced in the Market Advisory Committee (MAC) report might affect investments in -- and the implementation of -- technologies and other solutions designed to help meet AB 32's GHG emission reduction goals. CARB directed the ETAAC to provide comments on three specific market design objectives highly relevant to the effective implementation of AB 32: (1) Early Action; (2) Innovation; and (3) Clear Price Signals.

CARB also requested ETAAC to comment on how auction revenues under a cap and trade system for GHG should be utilized (if indeed a decision is made to auction some or all of the permit allocations.) This requested review should not be considered a comprehensive analysis of all of the risks and benefits of particular market designs -- or how traditional regulations, tax incentives, or other alternatives to a market system -- might affect early action, innovation, and price signals. While these are all very important goals, the ETAAC acknowledges that there are additional factors that policymakers should consider when designing new markets for carbon and other GHG emission reductions.

The rationale for focusing on the aforementioned three market design mechanisms is summed up below:

1. **Early Action:** It is imperative that California implement policies that encourage early emissions reductions and investments in climate change mitigation prior to the imposition of emissions limits in 2012. CARB therefore requested that ETAAC comment on how various market design features either encourage or discourage early action.
2. **Innovation**: While efficiency improvements and existing technologies can provide substantial GHG emission reductions throughout California, it is clear that the long term goals will require significant technological innovations in renewable energy, cleaner transportation options, as well as innovation in many other sectors of California's economy. With this in mind, CARB asked the ETAAC to comment on how various market design features either encourage or discourage the development and deployment of innovative technological solutions to climate change.
3. **Clear Price Signals:** Both the carbon market, as well as emerging markets for Cleantech technologies and services, require clear and persistent price signals to provide certainty for investors. Absent this certainty, firms are less likely to invest in the development of new technologies or to install existing emissions-reducing technologies. CARB therefore asked the ETAAC to comment on how various market design features either encourage or discourage the establishment of these critical and clear price signals.

The ETAAC identified and then commented on eight different market design mechanisms that offer clear implications as California aims to meet the three just described policy goals:

- Scope of the Carbon Cap

- Point of Electricity Regulation
- Allowance Allocation Method
- Use of Auction Revenues
- Offsets
- Banking
- Borrowing
- Cost Containment Mechanisms

A global observation of ETAAC is that a well-designed cap and trade system cannot address all of the different market failures that may prevent or impede the development and deployment of new low-carbon technologies. Complementary measures and regulations will also be necessary.

A. Scope of Carbon Cap

A broader cap is preferable in order to meet all three policy goals in the most cost effective manner. Therefore, the AB 32 carbon cap should include as many different sectors of the economy as is practical.

> *Early Action:* To the extent that a broad scope encourages more sectors of the economy to act, it may reveal more cost-effective near-term investment opportunities, and can thus encourage early action on a larger scale.
>
> *Innovation*: A broader scope should lead to more innovation by encouraging investments in more sectors as each regulated entity seeks to reduce GHG emissions. Some ETAAC members noted that trading would have an ambiguous effect on innovation: buyers of credits may escape the pressure to innovate by purchasing GHG emission reduction credits, while sellers may profit from innovations resulting in excess GHG emission reductions. If the scope of the cap is not broad, it becomes more important to have a mechanism to encourage reductions in sectors outside the state cap. Two ways of accomplishing this are allowing offsets or directing funds from auction proceeds through a mechanism such as the proposed California Carbon Trust (see Chapter 2, section IIA).
>
> *Clear Price Signals:* A broader scope will likely provide greater liquidity in carbon markets. Including many sectors of the economy under the carbon cap should also stabilize prices due to the increased diversity of characteristics, needs, and risks among capped entities. This approach would also boost the number of GHG emission reduction opportunities available under the cap. By increasing the breadth of these opportunities throughout California's economy, the true cost of GHG emission reductions will be revealed over time. Furthermore, the higher number of entities covered by a broad cap should increase liquidity, thereby improving confidence in market signals. Ultimately, this stability and liquidity could attract more capital while lowering costs.

B. Point of Electricity Regulation

Some members of ETAAC believe that if CARB chooses to pursue a "first-seller" model of electricity GHG emission reductions, then certain steps become important to ensure that price signals fostering innovation can be effectively acted upon. Load Serving Entities (LSE) – such an electric utility -- may be better positioned than first-sellers to directly stimulate innovation by virtue of their likely greater economic power, their resource planning processes, and their diverse portfolios of energy assets. For example, the creation of an entity such as the proposed California Carbon Trust (see Chapter 2, Financial Sector, section II A) may be necessary under a first-seller approach to aggregate the potentially diffuse economic power of first-sellers of electrical power into a funding stream that is robust enough for the task of technology transformation. On the other hand, some ETAAC members believe that incentives to innovate exist under the first seller model because:

- LSEs will have a AB 32 compliance responsibility as a first seller;
- Costs will flow to LSE customers, creating an economic incentive to innovate;
- To the extent the first-seller model is consistent with what is likely to be implemented at the national level of carbon governance, the expectation of a smoother transition to uniform national standards and linkages with other markets may help reduce investor risk, increasing the willingness to invest in innovation.

C. Allowance Allocation Method

ETAAC considered the impacts of the free allocations of GHG emission allowances based on historical emissions (known as grandfathering), free allocations based on economic output, and revenue-generating allowance auctions. ETAAC members agreed that grandfathering is bad for all three criteria. There was general agreement that some level of auctioning will be necessary.

Early Action: Allowance auctions, whether partial or full, provide the strongest incentives for early action. Entities that reduce emissions early will not have to purchase as many allowances at auction. Free allocation systems, whether grandfathering or output-based, do nothing to encourage early action. Grandfathering actually provides a disincentive to innovation. As a result of grandfathering, firms that undertake early emissions reductions receive smaller allowance allocations. In contrast, output-based free allocations do not discourage early actions.

Innovation: Allowance auctions provide the strongest financial incentives for innovation within capped sectors. With auctioning, permits are allocated efficiently and all parties have an incentive to innovate so as to reduce the number of permits they must purchase. Auctions are also an easy way to permit the entry of innovative new firms into the market. The revenue from auctions can be used to encourage innovation. However, it was mentioned that firms have limited available capital and money expended for purchasing permits can reduce their ability to invest in new technology.

Some ETAAC members felt that a well-designed free allocation system with a stringent cap could provide the needed incentives for innovation, as all companies would still have to meet a hard cap and ultimately decrease their emissions. This would also reduce the

need to purchase additional allowances. All ETAAC members agreed that if a free allocation method is to be used, output-based free allocation methods are preferable to grandfathering. Any free allocation method should be designed in such a way that the setting of baseline emissions levels does not discourage early reductions.

Clear Price Signals: Some amount of auctioning is necessary for establishing a clear and early price signal. Auctions expose the true market-clearing price for all GHG emissions under a cap, whereas free allocation systems conceal mitigation prices for emission reductions that are not traded.

D. Use of Auction Revenues

In legal terms, auction revenues are a "fee" because they meet the legal standard established by the Sinclair Paint court decision. According to "Sinclair Test" requirements, fees must be reasonable and there must be a nexus between the purpose of the fee and the use of its corresponding revenues. In this case, the fee will be determined by market forces and therefore will be reasonably related to the value of GHG emissions reductions. The fee is intended to further the goals of AB 32 by reducing GHG emissions in California. The revenues from the auction should therefore be directed to accomplish the very same goal of GHG emission reductions. In addition, it is important to put these revenues to use quickly to avoid "fiscal drag." It does not serve the greater public interest to withhold these funds from the economy while state regulators decide what to do with them for extended periods of time. So long as the fee starts generating revenues (and corresponding potential public benefits), it is at least indirectly compensating consumers and companies for any price increases associated with the implementation of AB 32. .

The following four areas would be productive and appropriate uses of these auction revenues:

- Direct investment in and purchase of additional GHG emissions reductions and support the development and deployment of low-carbon technologies through an investment program. This could be accomplished in a number of ways including, but not limited to the following: create a direct investment program that is outsourced to a private entity; work with existing private nonprofit organizations that make clean technology investments for the public benefit; create a new investment vehicle specifically charged with making and managing direct investments in low carbon technologies with auction fees.
- Allocate funds to California universities, colleges, research facilities for RD&D dedicated to technologies with potentially high GHG emission reduction value. Leverage and provide coordination among existing college and university RD&D efforts to help individual technologies with particularly high promise achieve commercialization quickly (see Chapter 2, Financial Sector, II. B).
- Create financial vehicles and/or programs that address specific gaps, imperfections, or opportunities in the low carbon market in order to serve as a catalyst for both private and public sector participation. This could include, but is not limited to, providing fiscal incentives for first production facilities, efficiency improvements in rental properties,

vehicle demonstrations for clean transportation technologies, etc. (See Finance Sector II. B)

- Take advantage of Environmental Justice co-benefits and GHG reductions in disadvantaged communities. Co-benefits from emission reduction projects, such as criteria pollutant reductions and improvements in disadvantaged communities, are important state objectives under AB 32 and should be considered when evaluating overall GHG emission reduction strategies.

If auction revenues exceed the level where they can be efficiently applied for abatement of carbon and other GHG emissions, these revenues can be used to reduce distorting taxation or payments to ratepayers. This represents another potentially important policy option because it could improve the economic efficiency of the overall California economy. Alternatively, these revenues could be used to make the California economy more equitable, in particular by assisting communities or industries that are disproportionately affected by climate change or by climate change mitigation. 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.

E. Offsets

Offsets allow a capped entity to claim credit for emissions reductions achieved outside the cap and trade system. Offsets can help contain costs and target sectors outside of those subject to a mandatory cap, while taking pressure off of those entities within the carbon cap's jurisdiction. The development of an offsets market may therefore be beneficial. Yet in order for this market to work properly, offsets must meet be real, additional, permanent, enforceable, predictable and transparent. ETAAC agrees that a standards-based approach to offsets is preferable to case-by-case review since this approach reduces transaction costs as well as increases predictability, both of which encourage early action, innovation, and clear price signals. ETAAC received significant input on the subject of offset rules. Specific comments can be seen at the ETAAC website (see www.etaac.org after February 10, 2008).

For a variety of reasons, policymakers may choose to place a quantity or a geographic limit on offsets used for compliance with AB 32. Limits on offsets would help encourage action and innovation within a specific sector, which can be useful if policymakers are trying to drive progress within a particular sector of the economy. Limits on offsets could increase compliance costs if the cap and trade system is not broad, however, and may make more sense in some sectors than in others (due to differences in potential cost and prospects for technological innovation.)

Early Action: ETAAC does not believe that offset rules have any direct implications for early action. Offsets themselves provide no incentives for early action. However, to the extent that other policies encourage early action, offsets can increase the scope of potential emission reduction projects in the early going.

Innovation: There is a tradeoff between incentives to innovate and the cost of compliance. The increased flexibility provided by unlimited offsets would reduce AB 32 compliance costs, but could also reduce the pressure to be creative within a given sector and weaken

price signals for would-be innovators. Limits on offsets are therefore useful for encouraging new technological advances within specific capped sectors.

Quantity limits on offsets can help restore some of the innovation incentives by restricting flexibility somewhat, but still require some portion of GHG emissions reductions to actually come from within each sector. Some ETAAC members noted that, in sectors with particularly high mitigation costs, overly strict limits on offsets could drive up compliance costs and thereby reduce the amount of capital available for investment. Any limits on offsets should therefore vary by sector based on the ability of each particular sector's ability to innovate and reduce GHG emissions. A report by McKinsey – *Reducing US Greenhouse Gas Emissions: How Much at What Cost?* provides a detailed cost estimate of a variety of GHG reduction projects.[1] While quantity limits on offsets can be valuable for encouraging action and creative thinking within a sector, it should be pointed out that it is difficult to come up with a "scientific" number to justify any specific for the limit.

Out-of-state offsets will send money out of the California economy, thereby limiting innovation and investment within the state's borders. Geographic limits on offsets could therefore be helpful in promoting in-state innovation and reductions. Keeping these activities in-state would also ensure that California is able to take advantage of co-benefits such as economic growth and reductions in criteria pollutants -- both objectives of AB 32 -- among other public policy goals. Placing geographic limits on offsets is one way to guarantee that offset projects used for compliance within state borders meet California's rigid standards for "additionality" and verification. Some members raised questions as to whether or not placing geographic limits on offsets could be designed in a way that does not violate the Commerce Clause. More research is needed on this issue.

Clear Price Signals: By providing increased flexibility for compliance, offsets can lower price signals. Limits on offsets based on geography tend to mitigate this effect somewhat. Such offset limits also help reveal the true cost of GHG emissions reductions within each capped sector of the economy.

F. Banking

Banking allows entities who over-comply in early phases of a cap and trade program to save allowances for use in future compliance periods. If costs are projected to rise in the future (a fair assumption given that allowances will be increasingly scarce as GHG emissions reduction targets ratchet up), banking gives firms the ability to achieve compliance at lower cost by making investments in the current period and banking allowances for use in the later, more expensive period. That said, policymakers have the option to place restrictions on the quantity of allowances that a particular entity can bank as well as the length of time for which allowances can be "banked."

Early Action: Banking encourages early action by allowing firms who undertake early reductions to save allowances for later use. Some degree of banking is required if policymakers want to encourage early action, as firms that are not allowed to bank credits

generated through early action have little incentive to make early reductions in GHG emissions. The early action benefits of banking will be limited to the extent that banking is limited.

Innovation: Banking is also necessary for innovation, to let companies take advantage of lumpy investments in step-change emission reduction technologies and measures. Some members argued that time and quantity limits on banking would limit this innovation incentive. However, others noted that the buildup of a large bank in the early years could decrease the pressure to innovate in later periods. Limits might therefore be helpful to prevent the banks of offsets from growing too large to thwart near- and long-term innovation.

Clear Price Signals: Banking is one way to address price fluctuations and stabilize the market. The ability to bank allowances effectively creates a price floor because saved allowances hold future value. It is safe to assume that allowance owners will not sell them at unusually low prices. Banking can also help prevent allowance price spikes by decreasing relative demand for allowances when prices are high due to the use of banked allowances by firms who would otherwise have to buy them on the market. Some ETAAC members felt that these benefits would be restricted to the extent that limits are placed on banking. Other ETAAC members argued that limits on banking are necessary to force allowance sales, thereby providing liquidity and price containment. Since allowance prices are generally expected to increase in the future, firms may not be inclined to sell allowances that are increasing in value so long as they can bank them indefinitely.

G. Borrowing

This policy allows entities to "borrow" allowances from future compliance periods for use in the current compliance period. While banking theoretically encourages over-compliance and early action, borrowing can have the opposite effect: allowing capped entities to delay compliance.

ETAAC believes that borrowing should be limited to very specific circumstances. For example, conditional borrowing, triggered by certain market conditions, could serve an important role as a cost containment mechanism. Beyond this limited application, however, borrowing is problematic in practice. Many of the benefits that borrowing offers in terms of flexibility over time can be achieved instead through the use of longer compliance periods.

Early Action: Borrowing discourages early action by allowing capped entities to delay compliance. Unrestricted borrowing would provide a strong disincentive for early action. Limits on borrowing can reduce this effect to a degree, but even a restricted borrowing ability is likely to reduce early action.

Innovation: By allowing firms to delay compliance, borrowing delays technological innovation and the diffusion of advanced solutions. A few ETAAC members felt that limited borrowing might be necessary for innovation in order to encourage longer-term

investments. The use of a longer compliance period could serve the same purpose, however, and eliminate the need for borrowing.

Clear Price Signals: Borrowing can help smooth prices by providing flexibility over time. But this can also be achieved through banking and the use of a longer compliance period. Conditional borrowing, triggered by adverse market conditions, could address price spikes.

H. Cost Containment Mechanisms

Cost containment comes from flexibility and good program design. A broad scope, offsets, banking, and proper use of auction revenues, should all help keep compliance costs down to reasonable levels for capped entities. Nevertheless, no market is ever perfectly designed for *all* situations. The emerging market for carbon and other GHG emission allowances could benefit from a fast-acting cost containment mechanism that could address price volatility in a timely fashion. Possibilities include a static "safety valve" or perhaps a more dynamic "market maker" that could actively manage the carbon market through the buying and selling of credits. Borrowing could also be used as a cost-containment mechanism, conditioned on the price of carbon. See G above for a discussion of borrowing.

A well-designed market maker would be preferable to a rigid price-based safety valve for all three criteria analyzed. The proposed California Carbon Trust (see Chapter 2, Financial Sector, section II A) is one example of such a market maker. It is important to note that the rules for intervention in the market would have to be clearly defined; more research is needed on how active market management might impact costs and innovation. The Committee received considerable public comments both in favor of and against the idea of an active market maker.

Early Action: A price-based safety valve would reduce incentives for early action by eliminating one reason to undertake early reductions: the threat of unusually high prices for mitigating GHG emissions in the future. This problem could theoretically be addressed by setting the safety valve trigger price at a high enough level to maintain the threat of high prices and therefore incentives for early action. The same argument could be made with regard to a dynamic market maker that has cost containment as one of its goals. Nevertheless, such an entity could be also designed in a way that encourages early action through other means.

Innovation: An explicit safety valve would frustrate innovation by setting an upper limit on the cost of reductions, thereby confining the return to investors in emissions reduction technologies. An active market maker would be able to monitor trends in both costs and investments in low-carbon technologies, allowing for more well-informed intervention.

Clear Price Signals: A safety valve would create an upper bound for the price of carbon and other GHG emissions, but would not create clear, stable prices. A market maker that could actively monitor trends and intervene as necessary would be better able to smooth prices, providing consistent and clearer price signals for investors. Again, ETAAC notes

that the guidelines for intervention by the market maker would have to be carefully designed and clearly articulated.

[1] McKinsey, *Reducing US Greenhouse Gas Emissions: How Much at What Cost*?, November, 2007 http://www.conference-board.org/publications/describe.cfm?id=1384

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9. APPENDICES

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APPENDIX I: Brief Biographies of ETAAC Members

Alan Lloyd (Chair)
Dr. Lloyd is the President of the International Council on Clean Transportation. He served as the Secretary of the California Environmental Protection Agency from 2004 through February 2006 and as the Chairman of the California Air Resources Board from 1999 to 2004. Prior to joining ARB, Dr. Lloyd was the Executive Director of the Energy and Environmental Engineering Center for the Desert Research Institute at the University and Community College System of Nevada, Reno, and the Chief Scientist at the South Coast Air Quality Management until 1996. Dr. Lloyd's work focuses on the viable future of advanced technology and renewable fuels, with attention to urban air quality issues and global climate change. A proponent of alternate fuels, electric drive and fuel cell vehicles eventually leading to a hydrogen economy, he was the 2003 Chairman of the California Fuel Cell Partnership and is a co-founder of the California Stationary Fuel Cell collaborative. He earned both his B.S. in Chemistry and Ph.D. in Gas Kinetics at the University College of Wales, Aberystwyth, U.K.

Bob Epstein (Vice-Chair)
Dr. Epstein is an entrepreneur and engineer with a Ph.D. from the University of California at Berkeley. He is currently the Co-Founder of Environmental Entrepreneurs, Chairman of the Board at GetActive Software, Director of New Resource Bank, Director of Cleantech Capital Group, Board Member of the Merola Opera Program, and Trustee of the Natural Resources Defense Council. Dr. Epstein co-founded Environmental Entrepreneurs (E2), a national community of professionals and business people who believe in protecting the environment while building economic prosperity. It serves as a champion on the economic side of good environmental policy by taking a reasoned, economically sound approach to environmental issues. Through active support of Natural Resources Defense Council, E2 works to influence State and national environmental policy.

Lisa Bicker
Ms. Bicker is President of the California Clean Energy Fund (CalCEF), a private nonprofit corporation formed to accelerate investment in California's clean energy economy. Before joining CalCEF, she was a Co-Founder and Chief Executive Officer of TruePricing, Inc. an energy technology company. Prior to that, Ms Bicker served as Chief Operating Officer of NewEnergy, Inc., a high-growth, retail electricity provider which is now the largest retail electricity provider in the United States. Ms. Bicker has also served as General Counsel to California Council for Environmental and Economic Balance, a non-profit advocacy group. She has a B.A. from the University of California at Davis and a J.D. from the University of San Francisco. She is a member of the California State Bar and several industry associations.

Jack Broadbent

As the Executive Officer/Air Pollution Control Officer, Mr. Broadbent is responsible for directing the Bay Area Air Quality Management District's programs to achieve and maintain healthy air quality for the seven million residents of the nine county region of the San Francisco Bay Area. Mr. Broadbent joined the Air District after serving as the Director of the Air Division at the U.S. Environmental Protection Agency, Region IX, where he was responsible for overseeing the implementation of the Clean Air Act as well as indoor air quality and radiation programs for the Pacific Southwest region of the United States. Previously, Mr. Broadbent was the South Coast Air Quality Management District's Deputy Executive Officer, where he directed the development of a number of landmark programs that contributed to significant improvements in air quality in the Los Angeles region. Mr. Broadbent holds a Master's degree in Environmental Administration and a Bachelor of Science degree in Environmental Science, both from the University of California at Riverside.

Cynthia Cory
Ms. Cory is the Director of Environmental Affairs, Government Affairs Division, for the California Farm Bureau Federation (CFBF), a non-profit agricultural trade association with more than 91,500 members in 53 counties in California. She has been associated with the agricultural community for over thirty years; the past seventeen years have been at CFBF working on State and Federal matters including air quality, biotechnology, climate change, transportation and renewable bioenergy issues. Ms. Cory has a M.S. in International Agricultural Development and a B.S. in Agronomy. She is also a member of the USDA Agricultural Air Quality Taskforce and serves on several advisory committees including the Governor's Environmental Advisory Task Force, the California Energy Commission's Climate Change Advisory Committee and their Biodiesel Working Group.

Alex Farrell
Dr. Farrell is an Assistant Professor in the Energy and Resources Group at the University of California at Berkeley and Director of the Transportation Sustainability Research Center. He has a degree in Systems Engineering from the U.S. Naval Academy and served as a nuclear engineer onboard a submarine. After that, Dr. Farrell worked for the world's largest hydrogen supplier, Air Products and Chemicals, Inc. He received his Ph.D. in Energy Management and Policy from the University of Pennsylvania and then worked as a research fellow at Harvard, and a research engineer at Carnegie Mellon University, where he remains part of the Climate Decision Making Center. For the last decade, Dr. Farrell has conducted research on energy and environmental policy and has published over two dozen peer-reviewed papers on these topics. He has served on advisory committees for the National Academy of Engineering, the National Science Foundation, and has consulted for various public and private organizations.

Bill Gerwing
Mr. Gerwing is the BP America General Manager of Regulatory Affairs. He is responsible for regulatory issues management process, government regulator and non-government organization stakeholder engagement strategy, and leads advocacy efforts on emerging US climate change policy and regulations. Mr. Gerwing has twenty five years

of knowledge and experience within the Health, Safety, and Environment (HSE) fields, gained through a number of diverse assignments with the corporate and operating business units within BP and Amoco. In 2003, he was appointed as the Director of HSE for BP's Western Hemisphere business and was then named to his current role focused on US activities in 2006. Mr. Gerwing represents BP on PEW's Business Environmental Leadership Committee (BELC), API Climate Change Steering Committee, and a variety of external stakeholder forums to advance policy development on climate issues.

Scott Hauge
Mr. Hauge is the President and owner of CAL Insurance & Associates, Inc., which was founded in 1927 and currently has 27 employees. The agency specializes in providing insurance for small to medium sized businesses. He has been a leading advocate in paving the way for small and medium sized businesses by introducing government legislation that has affected business on local, State and national levels. Mr. Hauge is renowned for his knowledge of how to best protect and serve the business community. He is currently a member of over 20 boards and commissions in San Francisco and California. He is the founder of the San Francisco Small Business Advocates and most recently, Small Business California.

Jim Hawley
Mr. Hawley is the Vice President and General Counsel of Technology Network (TechNet), a California political and legislative strategy group, working with senior executives and government relations staff of California-based technology companies. He directed successful TechNet lobbying efforts related to green technology, litigation issues, e-commerce regulation, corporate taxation, and broadband deployment. Mr. Hawley has a B.A. Magna Cum Laude in political science from Amherst College, a JD from Georgetown University Law Center and an active member of the California Bar Association.

Patti Krebs
Patti Krebs is the Executive Director of the Industrial Environmental Association, a Southern California public policy trade organization that represents manufacturing, technology and research and development companies on a wide variety of legislative, regulatory and policy issues that affect their facilities and operations.

Patti currently serves on the San Diego Association of Governments Energy Working Group, the Port of San Diego's Maritime Advisory Committee, the San Diego Regional Airport Authority Technical Advisory Group and has been instrumental in the organization and founding of the San Diego Regional Sustainability Partnership. She is a past member of the Board of Directors of San Diego Transit Corporation, the San Diego Natural History Museum and the San Diego Symphony. She has served on numerous Statewide technical boards and commissions including the State Water Resources Control Board Advisory Group on TMDLs and the Air Resources Board Neighborhood Assessment Group.

Patti has a bachelor's degree in Communications from San Diego State University.

Jason Mark
Jason Mark is the U.S. Transportation Program Officer at the Energy Foundation, a private foundation which promotes a sustainable energy future through increased energy efficiency and renewable energy. From 1995 to 2006, Mr. Mark worked for the Union Concerned Scientists (UCS), ultimately as the national Director of the Clean Vehicles Program and as the organization's California Director. He was the lead author on many UCS reports in the transportation and energy field. Before joining UCS, Mr. Mark worked as an independent consultant on transportation policy analysis as well as at the National Renewable Energy Laboratory and the Center for Energy and Environmental Studies at Princeton University. He holds a bachelor's degree in mechanical engineering from Princeton University and a master's in energy and resources from the University of California at Berkeley.

Joan Ogden
Dr. Ogden is Associate Professor of Environmental Science and Policy at the University of California, Davis and an Associate Energy Policy Analyst and Co-Director of the Hydrogen Pathway Program at the Institute of Transportation Studies (ITS-Davis). Her primary research interest is technical and economic assessment of new energy technologies, especially in the areas of alternative fuels, fuel cells, renewable energy and energy conservation. Since 1994 she has studied alternative strategies for developing a hydrogen infrastructure for transportation applications. Ogden and her colleagues have developed an extensive set of data on hydrogen and fuel cell technologies, and tools for modeling infrastructure performance and costs. She is now active in the H2A, a group of hydrogen analysts convened by the Department of Energy to develop a consistent framework for analyzing hydrogen systems. She served on the Blueprint Advisory Panel for the California Hydrogen Highway Network. Dr. Ogden received a Ph.D. in theoretical plasma physics from the University of Maryland, with a specialization in numerical simulation techniques. She was a research scientist at Princeton University's Center for Energy and Environmental Studies and her recent work centers on the use of hydrogen as an energy carrier, particularly hydrogen infrastructure strategies, and applications of fuel cell technology in transportation and stationary power production.

Amisha Patel
Ms. Patel joined the California Chamber in June 2004 as a legislative assistant in the air and waste, health care, housing and land use, and education policy arenas. She was promoted to a policy analyst position at the start of 2006, tracking and lobbying on energy, government procurement, outsourcing and environmental issues, as well as air and waste management. She was named policy advocate for energy and climate change issues in October 2006. Before coming to CalChamber, Ms. Patel garnered Series 7 and 63 broker's licenses while working at E*Trade Financial. She also served as a public policy intern at the Sacramento Metropolitan Chamber of Commerce. Ms. Patel graduated from the University of California, Davis with a B.A. in political science/public service and a double minor in economics and communications.

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Dorothy Rothrock
Ms. Rothrock is Vice President of Government Relations for the California Manufacturers and Technology Association since 2000. Previously, she consulted on energy and telecommunications regulatory issues for industrial energy users, policy advocates, and economic research firms. Ms Rothrock graduated from University of Oregon and Lewis and Clark Law School, joining the Oregon Bar in 1980 and the California Bar in 1997.

Jan Smutny-Jones
Mr. Smutny-Jones is Executive Director of the Independent Energy Producers Association (IEP) and has represented IEP since 1987. He was a principal in the California Memorandum of Understanding and a key party in the restructuring legislation. He has served as Chair of the Governing Board of the California Independent System Operator, and as a member of the Governing Board of the California Power Exchange and the Restructuring Trusts Advisory Committee. Mr. Smutny-Jones is a graduate of Loyola Law School and is a member of the American, California State and Sacramento County Bar Associations. He did his undergraduate work at California State University, Long Beach, and has a certificate in Environmental Management from the University of Southern California.

Andrea Tuttle
Andrea Tuttle has 30 years experience in California resource policy issues. She is former Director of the California Department of Forestry and Fire Protection (CDF), and served on the California Coastal Commission and the North Coast Regional Water Quality Control Board. She was principal consultant to the Select Committee on Forest Resources in the California Senate, and has consulted on sustainable forest management in Malaysia. She currently teaches forest and fire policy in the College of Natural Resources at UC Berkeley and is a board member of The Pacific Forest Trust. She is a strong advocate for retaining working forestlands for their environmental, economic and social values, and incorporating the role of forests in a climate strategy. She has a Ph.D. in Environmental Planning from UC Berkeley and an MS in biology from the University of Washington.

Fong Wan
Mr. Wan is Vice President of Energy Procurement for Pacific Gas and Electric Company (PG&E), and is responsible for gas and electric supply planning and policies, market assessment and quantitative analysis, supply development, procurement and settlement. Mr. Wan joined PG&E in 1988 and moved to Energy Trading in 1997. He served as Vice President, Risk Initiatives for PG&E Corporation Support Services, Inc and as Vice President, Power Contracts and Electric Resource Development. Mr. Wan has a Bachelor of Science degree in chemical engineering from Columbia University and a M.B.A from the University of Michigan.

Jonathan Weisgall
Mr. Weisgall is Vice President for Legislative and Regulatory Affairs for MidAmerican Energy Holdings Company, a subsidiary of Berkshire Hathaway. He also serves as

Chairman of the Board of Directors of the Center for Energy Efficiency and Renewable Technologies and President of the Geothermal Energy Association. He is an Adjunct Professor of Law at Georgetown University Law Center, where he has taught a seminar on energy issues since 1990, and he has also guest lectured on energy issues at Stanford Law School and the Johns Hopkins Environmental Science and Policy Program. Mr. Weisgall earned his B.A. from Columbia College and his J.D. from Stanford Law School, where he served on the Board of Editors of Stanford Law Review.

John Weyant
Dr. Weyant is Professor of Management Science and Engineering, a Senior Fellow in the Institute for International Studies, and Director of the Energy Modeling Forum (EMF) at Stanford University. Established in 1976, the EMF conducts model comparison studies on major energy/environmental policy issues by convening international working groups of leading experts on mathematical modeling and policy development. Prof. Weyant earned a B.S./M.S. in Aeronautical Engineering and Astronautics, M.S. degrees in Engineering Management and in Operations Research and Statistics all from Rensselaer Polytechnic Institute, and a Ph.D. in Management Science with minors in Economics, Operations Research, and Organization Theory from University of California at Berkeley. Dr. Weyant was also a National Science Foundation Post-Doctoral Fellow at Harvard's Kennedy School of Government. His current research focuses on analysis of global climate change policy options, energy technology assessment, and models for strategic planning.

Rick Zalesky
Mr. Zalesky is Vice President of the Biofuels and Hydrogen business for Chevron Technology Ventures Company, LLC. In this role, he has responsibility for the commercialization of infrastructure development, production and supply, as well as all current technology initiatives. Mr. Zalesky joined the company in 1978 holding a variety of management positions of increasing responsibility in the downstream in refining, marketing, and technology. He is Chevron's representative on the Fuel Operations Group of the FreedomCAR and Fuel Program of the Department of Energy and a member of the UC Davis External Research Advisory Board. Mr. Zalesky is a graduate of the Georgia Institute of Technology, with a bachelor's degree in Civil Engineering.

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APPENDIX II: ETAAC Meeting Dates and Venues

Date	Venue	Focus
March 1, 2007	Cal-EPA Headquarters, Sacramento	Brought the Committee members together for the first time, and began to develop plans for meeting the ETAAC goals.
May 31, 2007	South Coast Air Quality Management District Headquarters, Diamond Bar	Provided Federal, local, and other State agencies the opportunity to present to the Committee.
August 14, 2007	Cal-EPA Headquarters, Sacramento	Discussed the information gathered to date and how it will be incorporated into the Committee's report to the ARB
September 6, 2007	Stanford University, Stanford	Provided national laboratories, academia, and technology providers the opportunity to present to the Committee.
October 16, 2007	Cal-EPA Headquarters, Sacramento	Discussed draft report status, provided comments and revisions to staff, and voted on releasing for public review period.
November 29, 2007	Campus of University of California at Merced, Merced	Reviewed the draft final report. Received public comments.
December 13, 2007	Cal-EPA Headquarters, Sacramento	Reviewed the draft final report. Received public comments.
January 25, 2008	Cal-EPA Headquarters, Sacramento	Reviewed the draft final report. Received public comments.
February 11, 2008	Cal-EPA Headquarters, Sacramento	Reviewed the draft final report. Received public comments. Voted on adoption.

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APPENDIX III:
Inventory of Existing State Funding Sources to Reduce GHG Emissions

The programs listed here fund activities to deploy technologies that can reduce GHG emissions. Some of the programs are directed specifically against such emissions. Others -- such as the Carl Moyer Program -- are directed at other State air emission challenges, but which can cut GHG emissions as a co-benefit.

Some of the programs offer grants; others offer contracts based on an open bidding process or other competitive disbursement instruments. Some of the entities listed in this Appendix are directories of grant and contract programs. Except as specifically noted, the information shown here was obtained from the web sites cited for each of these programs.

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Program: **Advanced Technology Program** (www.atp.nist.gov)

Sponsor: National Institute of Standards and Technology (NIST)

Funding source: NIST

Sectors supported: New technology across all industrial sectors

Activities supported: Research and early R&D

Geographic limits: None

Funding: ~$155 million per year

Grant amount: ~ 2.5 million, avg.

Grants as percent of applications: 11 percent

Overview

ATP supports research and basic development of new technologies by sharing the cost and the risk with companies when risks are too high for the private sector to bear alone. Research priorities for the ATP are set by industry. For-profit companies conceive, propose, co-fund, and execute ATP projects and programs in partnerships with academia, independent research organizations and Federal labs.

The ATP has strict cost-sharing rules. Joint Ventures (two or more companies working together) must pay at least half of the project costs. Large, Fortune-500 companies participating as a single firm must pay at least 60 percent of total project costs. Small and medium-sized companies working on single firm ATP projects must pay a minimum of all indirect costs associated with the project.

Each project has goals, specific funding allocations, and completion dates established at the outset. Projects are monitored and can be terminated for cause before completion. The technology areas for grants are:

- Advanced Materials/ Chemicals
- Biotechnology
- Electronics/Computer Hardware/Communications
- Information Technology
- Manufacturing

Measures of Effectiveness

N/A

ATP uses complex, "cutting-edge" econometric analyses to assess effectiveness.[1] It uses at least four metrics in its analyses:

- Commercialization -- number of new products and acceleration of reaching the market
- Creation & dissemination of knowledge -- numbers of patents and papers related to the supported product
- Stimulation of additional funding for the product
- Benefit: Cost. "Benefit" is a prospective estimate made in a complex economic analysis. "Cost" is the award by ATP.

ATP spends $2 to $5 million annually for the assessments, which in part are done by contractors. Data are obtained via formal surveys of grantees for six years after projects end. Many of ATP's analyses are comparisons of the above metrics between companies that have received awards and applicants that have not received awards. (That is: they gather data from both classes.)

In a study of 100 ATP projects[2], 122 new commercial products were identified among 64 grantees. In case studies of the first 120 ATP projects[3], 41 percent showed "strong" or "outstanding" performance vs. ATP objectives. 46 percent of awardees reported reduction of R&D time by at least 2 years, and 60 percent expected to reduce their times to market by the same amount. ATP funding was critical to16 percent of the projects. 1/3 of the awardees reported increased external funding due to their awards. Over 14 years, the overall benefit: cost figure is 8:1.

DRAFT

Program: **California Clean Energy Fund** (www.calcef.org)

Sponsor: California Clean Energy Fund (CalCEF)

Funding source: PG&E bankruptcy settlement

Sectors supported: New technology (renewable fuels, energy efficiency & storage)

Activities supported: Venture capital

Geographic limits: PG&E service territory

Funding: $30 million (total)

Grant amount: N/A

Grants as percent of applications: N/A

Overview

CalCEF is a non-profit organization that makes equity investments in emerging clean-energy technology companies. Funds are invested in private companies that are creating technologies or products that should reduce reliance on non-renewable fuels. These include companies that focus on renewable energy, better energy efficiency, and energy storage. They also include companies that provide products and services, such as software, that are designed to enhance some aspect of the clean-energy sector. CalCEF acts as a critical funding source for emerging clean-energy companies that are too young to access traditional venture capital.

The Fund arises from the PG&E bankruptcy settlement negotiated by the California Public Utilities Commission. CalCEF invests in companies located in PG&E's service territory, and elsewhere, that are developing technology or products that could benefit constituents residing within the service territory.

Measures of Effectiveness

N/A

DRAFT

Program: **California Solar Initiative (**www.gosolarcalifornia.ca.gov/)

Sponsors: CPUC

Funding source: Rate-payers of PG&E, SDG&E and SCE

Sectors supported: Electricity (photovoltaics)

Activities supported: Incentives (subsidy for installation of, or production by, solar power in commercial buildings and existing homes)

Geographic limits: Service territories of PG&E, SDG&E, and SCE

Funding: $2.16 billion over 10 years (2007-2016)

Grant amount: For >100 kW: $.03 - $.50 / kW-hr; for <100 kW: $0.20 - $3.25 / W

Grants as percent of applications: First come, first serve

Overview

CPUC's California Solar Initiative, provides subsidies for installing or using photovoltaic power systems in existing residential homes and existing and new commercial, industrial, and agricultural properties. All utility customers who do not receive subsidies for distributed generation, do not pay at interruptible power rates, and do not resell power are eligible.

Measure of Effectiveness

The goal for the program is 3,000 MW of new photovoltaic capacity installed by 2017. It is too early to attempt to measure progress toward the goal. For systems larger than 100 kW in size, payments will be made based on performance, i.e. per kilowatt-hour generated.

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Program: **California Solar Initiative R&D**
(www.cpuc.ca.gov/static/energy/solar/070216_csi_rddplan.htm)

Sponsor: CPUC

Funding source: Electric utility ratepayers

Sectors supported: Electricity (production technologies; grid integration, storage & metering; business development & deployment)

Activities supported: Mostly demonstration projects; also R&D and deployment incentives

Geographic limits: California

Funding: $50 million over 10 years

Grant amount: No experience yet

Grants as percent of applications: No experience yet

Overview

The CPUC will initiate a program to promote photovoltaic distributed generation. The intended outcomes are to:

- Move the market from the current retail solar price of $9/watt or about 30 cents/kWh to levels that are comparable to the current retail price of electricity.
- Install increasing volumes of solar distributed generation projects that build from the current range of 40+MW per year to 350 MW or more per year.

The *proposed* allotments of the funds are:

- Research – 20 percent (to be committed to a particular project)
- Research & Development -- 10 to15 percent
- Demonstration -- 50 to 60 percent (to be directed to projects that have already been accepted for DOE or PIER R&D grants.)
- Deployment -- 10 to15 percent (to be directed to technologies and measures subject to CPUC's regulatory processes and standards)

Measures of Effectiveness

No projects have been funded yet.

DRAFT

Program: **Carl Moyer Memorial Air Quality Standards Attainment Program** (www.arb.ca.gov/msprog/moyer/moyer.htm)

Sponsor: State of California (administered by air quality management districts and CARB)

Funding source: Vehicle registration fees, State grants

Sectors supported: Transportation (private and public sector); Agriculture

Activities supported: Incentives for clean engines to reduce PM, ROG and NOx

Geographic limits: California

Funding: $140 million per year

Grant amount: Buses, farm equipment, agricultural pumps (an average of $12,000 per unit); Marine vessels, construction equipment ($50,000 per unit)

Grants as percent of applications: N/A

Overview

The Carl Moyer Program provides subsidizes the incremental cost of cleaner-than-required engines and equipment. ("Cleaner" is in reference to emissions of ozone precursors and PM. GHG emissions are not addressed. However, to the extent that fuel economy is improved by replacing or retrofitting old engines, the program indirectly provides reduced CO_2 emissions.) Eligible projects include cleaner engines for on-road and off-road vehicles, marine vessels, locomotives, and stationary agricultural pumps, as well as for forklifts, airport ground support equipment, and auxiliary power units. The program also supports light-duty vehicle scrapping. Grants are based on the cost-effectiveness of the capital cost of achieving super-regulatory emission reductions. Determinations vary by air-quality management district.

Measures of Effectiveness

The Carl Moyer Program measures reductions of criteria and toxic pollutants achieved in excess of reductions that are occurring from regulatory compliance. Grants are based in part upon the emission reductions to be achieved according to prescribed procedures of calculation. Those reductions must cost less than prescribed amounts, per ton of reduction.

Calculations and statistics for cost per ton have not been kept for reductions of GHG emissions that have been incidental to reduced criteria and toxic emissions.

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Program: **Driveclean.CA.gov** (www.driveclean.ca.gov/en/gv/driveclean/demoprog.asp)

Sponsors: Directory of several government agencies

Funding source: Particular to the agency providing the incentive

Sectors supported: Transportation

Activities supported: Incentives to purchase and use EVs, hybrids and CNG vehicles

Geographic limits: Particular to the agency providing the incentive

Funding: Particular to the agency providing the incentive

Grant amount: Particular to the agency providing the incentive

Grants as percent of applications: No data available

Overview

Incentives offered for purchasing EVs, hybrids and CNG vehicles; fueling infrastructure; and vehicle parking. Funding is available from Federal, regional and local governments.

Measures of Effectiveness

N/A

DRAFT

Program: **Grants.gov** (www.grants.gov/search/category.do)

Sponsor: Multiple Federal agencies

Funding source: Particular to the granting agency

Sectors supported: Agriculture, electricity, new technology, transportation.

Activities supported: Particular to the granting agency

Geographic limits: US

Funding: Particular to the granting agency

Grant amount: Particular to the granting agency

Grants as percent of applications: Particular to the granting agency

Overview

This is a directory of all Federal grant programs, including the Federal Department of Energy (DOE).

Measures of Effectiveness

N/A

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Program: **Innovative Clean Air Technologies (ICAT) Grant Program**
(www.arb.ca.gov/rsearch/icat/icat.htm)

Sponsor: CARB

Funding source: Research Division of CARB

Sectors supported: New technologies, including those that reduce GHG emissions

Activities supported: Demonstrations

Geographic limits: Supported technologies must be useful in California

Funding: Up to $1 million per year

Grant amount: $200,000 average

Grants as percent of applications: 5 percent to 10 percent

Overview

ICAT co-funds practical demonstrations of innovative technologies that can reduce air pollution, including GHGs. Its purpose is to advance such technologies toward commercial application in California, thereby reducing emissions and helping the State's economy. ICAT seeks technologies that are not yet marketed but are substantially ready for practical demonstrations of their utility to potential users. It focuses on co-funding such demonstrations. It does not support RD&D that is not intrinsic to performing a particular demonstration, or marketing activities.

Measures of Effectiveness

The following table compares statistics from ICAT and four grant programs by various State and Federal agencies. The statistics can be viewed as measures of the effectiveness of grant funds or of the quality of the technologies that were selected for support.

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Table 1. Program Evaluation Statistics

	Annual Grants (MM$/yr)	Sample Size	Commer-cialization Rate	Time to Sale#	Benefit Cost ^	Annual Revenue / $ Granted	Grants leveraged funds	Grants critical to projects
SBIR		100's	25% *	~4 yrs				
ATP	145	100's			8:1		33%	16%
PIER	62	34			1.3 to 3.4:1			
CalTIP	~5	75	31%	2 yrs		3 /yr	>38%	31%**
ICAT	*~0.9*	*15*	*53%*	*1.7 yrs*		*1 /yr ^^*	*37%*	*50%*

* >$300,000 revenue
\# Defn of "Time 0" varies.
^ Defn of "benefit" varies.
** derived by staff from data in CalTIP report
^^ $1.2 million revenue in 2004 among 6 grantees who received $1.1 million in grants

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Program: **New Solar Homes Partnership**
(www.gosolarcalifornia.ca.gov/nshp/index.html)

Sponsor: CEC

Funding source: CEC

Sectors supported: Electricity

Activities supported: Incentives for installation of solar photovoltaics in new homes

Geographic limits: Service areas of PG&E, SDG&E, SCE and Bear Valley Electric

Funding: $400 million over 10 years

Grant amount: No experience yet

Grants as percent of applications: No experience yet

Overview

The CEC will manage a 10-year, $400 million program to encourage solar in new home construction. The program will target single family, low-income, and multi-family housing markets. Eligible projects include single- and multi-family developments where at least 20 percent of the project units are reserved for extremely low, very low, lower, or moderate income households for a period of at least 45 years. Strict standards for energy efficiency will be applied. Depending on the total installed photovoltaic capacity in the State, the proposed subsidy will be $0.25 to $2.60 per watt.

Measures of Effectiveness

The goal for the entire CSI program is 3,000 MW of new solar photovoltaic capacity installed by 2017, and the New Homes Solar Partnership is the subset of this program managed by the CEC. It is too early to report any measurable progress toward the goal.

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Program: **Public Interest Energy Research Program**
(www.energy.ca.gov/pier/index.html)

Sponsor: CEC

Funding source: Investor-owned utility ratepayers

Sectors supported: All sectors

Activities supported: RD&D

Geographic limits: US

Funding: $62 million per year

Grant amount: Varies by program area

Grants as percent of applications: N/A

Overview

PIER supports energy RD&D projects that will bring environmentally safe, affordable and reliable energy services and products to the marketplace. The PIER Program partners with other RD&D organizations that include individuals, businesses, utilities, and public or private research institutions. PIER supports these RD&D program areas, some with contracts and others with direct grants:

- Buildings End-Use Energy Efficiency
- Climate Change Program
- Energy Innovations Small Grant Program
- Energy-Related Environmental Research
- Energy Systems Integration
- Environmentally-Preferred Advanced Generation
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Natural Gas Research
- Renewable Energy Technologies
- Transportation Research

Technologies supported by PIER address the following goals:

- Reduce the cost (and increase the value) of electricity
- Increase the reliability of the electric system
- Reduce the environmental impacts of electricity generation, distribution and use

- Enhance California's economy
- Demonstrate a connection to the market
- Advance science and technology not provided by competitive and regulated markets

Measures of Effectiveness

The following comments are taken from an *Independent PIER Review Panel Interim Report* published in March 2004:

> *"Since PIER's inception in 1998, a total of about $260 million has been encumbered for research contracts. A review of contracts completed through 2002 revealed a total of 20 commercialized products with projected benefits of $221 to $576 million. The benefits are significant in comparison to the total contract disbursements of about $125 million between 1998 and 2002, resulting in a benefit-to-cost ratio between 2 and 5 to 1…. The Independent Review Panel believes that except for minor issues the current PIER research portfolio is well focused, addresses issues relevant to California as outlined in the Energy Action Plan, meets PIER objectives and is well balanced."*

As illustrated on Table 1 of this Appendix, PIER gets a return of 1.3 to 3.4 dollars for every dollar of PIER funds invested.

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Program: **Low Emission School Bus Program**
(www.arb.ca.gov/msprog/schoolbus/schoolbus.htm)

Sponsor: CARB

Funding source: 2006 Proposition 1b State Bonds

Sectors supported: Transportation

Activities supported: Incentives

Geographic limits: California

Funding: $200 million

Grant amount: No experience yet

Grants as percent of applications: No experience yet

Overview

Proposition 1B, the "Transportation and Air Quality Bond, approved in November, 2006 provides $200 million for replacing and retrofitting school buses. These funds are not available until appropriated by the California Legislature, which is expected to occur after the Legislature reconvenes the 2007-2008 Regular Session in January, 2008.

The terms for making grants under the new program will be proposed by CARB in the near future. Under the previous version of the program (funded at $25 million in 2006), half of the funds were used for new school bus purchases and half were used for in-use diesel bus retrofits. CARB was directed to allocate the new bus purchase funds to replace pre-1977 model year school buses, in order of oldest bus first.

Measures of Effectiveness

No experience yet. However, one useful measure will be the estimated GHG emissions avoided by early retirement of old buses with more fuel-efficient (and, possibly, alternative-fueled) buses.

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Program: **Small Business Innovation Research (SBIR) & Small Business Technology Transfer (STTR)** (www.science.doe.gov/sbir)

Sponsor: Eleven large Federal agencies (DOE is highlighted below); coordinated by the Federal Small Business Agency

Funding source: Federal agency R&D budgets

Sectors supported: All sectors

Activities supported: Basic Research and R&D

Geographic limits: US

Funding: SBIR (2.5 percent of agency research budgets); STTR (0.3 percent per agency)

Grant amount: Research (up to $100,000); R&D (up to $750,000)

Grants as percent of applications (DOE): Research (20 percent); R&D (50 percent)

Overview

SBIR and STTR are U.S. Government programs in which Federal agencies with large R&D budgets set aside a small fraction of their total funding for solicitations earmarked for small businesses. The major difference between the programs is that STTR projects must involve substantial (at least 30 percent) cooperative research collaboration between the small business and a non-profit research institution. Small businesses that win awards in these programs keep the rights to any technology developed and are encouraged to commercialize the technology.

The Federal agencies participating in SBIR and STTR set aside 2.5 percent and 0.3 percent, respectively, of their annual extramural R&D budgets. For the DOE in FY 2005, these set-asides correspond to $102 million and $12 million, respectively.

Each October, DOE issues a solicitation for small businesses to apply for SBIR/STTR Phase I grants. It contains technical topics in research areas such as Energy Production (fossil, nuclear, renewable and fusion energy), Energy Use (buildings, vehicles, and industry), Fundamental Energy Sciences (materials, life, environmental, computational, nuclear and high energy physics), Environmental Management, and Nuclear Nonproliferation. Grant applications submitted by small businesses MUST respond to a specific topic and subtopic during each annual open solicitation.

SBIR and STTR have three distinct phases. Phase I explores the feasibility of innovative concepts with awards up to $100,000 for about 9 months. Only Phase I award winners may compete for Phase II, the principal R&D effort, with awards up to $750,000 over a two-year period. There is also a Phase III, in which non-Federal capital is used by the

small business to pursue commercial applications of the R&D. Also under Phase III, Federal agencies may award non-SBIR/STTR-funded, follow-on grants or contracts for products or processes that meet the mission needs of those agencies (or for further R&D.)

Measures of Effectiveness

SBIR measures "success" in terms of the fraction of “Phase 2” products that provide a minimum of $300,000 in revenue. The recent project success rate is reported to be 25 percent. It often takes four years or so after these grants that revenues begin accumulating.

SBIR also mentions an "environmental metric" that would count "pollutant reductions" and/or cost savings, but that apparently is not put into practice. No general protocol for producing such a metric is presented in the material that CARB staff received.

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Program: **Global Climate and Energy Project (GCEP)**

Sponsor: Stanford University

Funding source: ExxonMobil, General Electric, Schlumberger, and Toyota

Sectors supported: All sectors

Activities supported: Research

Geographic limits: None

Funding: $225 million over 10 years

Grant amount: Average $1.2 million

Grants as percent of applications:

Overview

The Project's sponsors will invest a total of $225 million over a decade or more as the GCEP explores energy technologies that when deployed on a large scale are efficient, environmentally benign *and* cost-effective. Here are GCEP's specific goals:

- Identify promising research opportunities for low-emissions, high-efficiency energy technologies.
- Identify barriers to the large-scale application of these new technologies.
- Conduct fundamental research into technologies that will help to overcome these barriers and provide the basis for large-scale applications.
- Share research results with a wide audience.

GCEP sponsors research at Stanford and other leading universities and research institutions. It does not sponsor research by external institutions, businesses or individuals.

Measures of Effectiveness

N/A

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Program: **Technology Advancement Program (**www.aqmd.gov/tao/About/index.html)

Sponsor: South Coast Air Quality Management District (CSAQMD)

Funding source: Vehicle registration fees, regulatory violation settlements, State Federal grants

Sectors supported: Transportation

Activities supported: R&D, demonstration projects and incentives

Geographic limits: South Coast Air Basin (the greater Los Angeles area)

Funding: $9 to $15 million per year

Grant amount: Ranges from $6,000 to $3 million

Grants as percent of applications:

Overview

The Technology Advancement Program expedites the development, demonstration and commercialization of cleaner technologies and clean-burning fuels. It uses cooperative partnerships with private industry, academic and research institutions, technology developers, and government agencies to cosponsor projects intended to demonstrate the successful use of clean fuels and technologies that lower or eliminate emissions. The supported technologies are chosen to provide emission reductions in the SCAQMD in the context of the district's emission-reduction strategies.

Typically, SCAQMD public-private partnerships effectively leverage public funds, attracting an average of $3 from outside private sources for every public sector dollar contributed.

Measures of Effectiveness

As of 2004, twelve technologies supported by the clean technologies program had become commercialized.

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Program: **Alternative and Renewable Fuel and Vehicle Technology Program (**AB 118)

http://info.sen.ca.gov/pub/07-08/bill/asm/ab_0101-0150/ab_118_bill_20071014_chaptered.html

Sponsor: California Energy Commission

Funding source: Vehicle registration fees

Eligible business and technology areas: See "Overview". Details TBD

Functions supported: TBD

Type of support: TBD

Economic sectors affected: Transportation, energy production

Geographic limits: TBD

Funding: TBD

Grant amount: TBD

Grants as % of applications: No information

Overview

The bill (as yet unsigned) creates the Alternative and Renewable Fuel and Vehicle Technology Program to provide grants, loans, loan guarantees, revolving loans, or other appropriate measures to develop and deploy innovative fuel/vehicle technologies to reduce exhaust emissions of CO_2 from future vehicles. Recipients of the awards can be public agencies, businesses and projects, public-private partnerships, vehicle and technology consortia, workforce training partnerships and "collaboratives", fleet owners, consumers, recreational boaters, and academic institutions. The funding will depend on future legislative appropriations.

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Appendix IV: Background Status Report on Energy Technologies

A. Energy Efficiency -- Next Generation LEDs

Energy efficiency technologies abound in all market sectors and end-uses. The California IOUs' emerging technology programs are closely coordinated with the CEC's PIER program -- as well as universities, national labs, technology providers, consulting firms, and venture investors -- to identify and commercialize new measures to renew the energy efficiency portfolios, i.e. fill the pipeline, as existing technologies achieve market penetration. One of the most promising near-term opportunities for California are advances in Lighting emitting diodes (LEDs).

These advanced lights are solid-State devices that convert electricity to light. LED lights are up to 10 times more efficient than standard incandescent lights (which waste up to 90 percent of their energy as heat) and use 10 percent to 30 percent less electricity than compact fluorescent bulbs (CFLs), the present technology of choice for those looking to become more efficient. Moreover, LED lights are mercury free (unlike CFLs), and are therefore more environmentally-friendly and safer choices for homes and office buildings.

Early applications of LED have been for red exit signs and traffic signals, though they are also used for airport runways, exit signs and other signage, typically displacing neon signs. Red and green traffic light LEDs have already reached commercial maturity. White LEDs are entering niche markets such as retail displays, under-cabinet kitchen lights, and backlighting for liquid crystal displays on laptop notebooks. HP, Apple, and Dell have committed to releasing backlit LED monitor screens in 2007.

Technological Developments

High wattage LED white lights suitable for general illumination are several years from full market commercialization. These lights are expected to reach early adopters by 2008 and reach mass market within the next 5 to 10 years. In addition to energy savings from LEDs, the co-benefits associated with this lighting technology include economic development since significant numbers of LED manufacturers are California companies. As policies and regulations make way for improved LED implementation, this benefits the State not only in energy savings and emissions reductions, but also in spurring job creation.

CO_2 Abatement Potential

The total technical potential from emerging commercial LED lighting in California (2006-2016) is estimated to be 297 MW and 1,312 GWh[3].

Technology-Specific Barriers

Technological: Continuous improvement in lighting quality is needed to expand LED technology applications.

Financial: Although LED prices are dropping, bulbs remain more expensive in up-front costs. In addition, LED lights may also require a redesign of an existing lighting system, yet another additional expense.

Institutional: While LED lights can last 10 to 15 years in normal use -- and make financial sense on a lifecycle basis -- consumers who make purchase decisions based on payback period are reluctant to invest in LED lighting due to higher upfront cost. In addition, the decision makers (e.g. builders and landlords) are not necessarily the end-use customer who pays the electric bills, and thus have no incentive to pay higher cost for energy efficiency unless there are other compelling reasons such as getting LEED-certification.

Regulatory: While not specific to LED lighting, the longer term energy efficiency funding and crediting issue described above applies to all energy efficiency programs and thus indirectly impacts LED savings achievement.

B. Wind Power

Wind power can be harnessed by small on-site electricity generators or large "wind farms" comprised of dozens or even hundreds of large utility-scale turbines operated as a single large generating station.

The total installed capacity of California wind power utility-scale generation is 2,376 MW.[4] The areas with the highest wind potential are in California are the Altamont Pass east of San Francisco, the Montezuma Hills in Solano County near Rio Vista, San Gorgonio Pass near Palm Springs, and the Tehachapi Mountains near Bakersfield. The Altamont Pass and San Gorgonio resources are the mostly fully developed. The Tehachapi resource is the largest in the State, with a total additional undeveloped potential estimated at 4,500 MW. According to the CEC, in-State wind farms produced 4,927 gigawatt hours (GWh) of electricity in 2006.[5] California also imported 443 GWh of wind energy from out-of-State that same year. The CEC map below illustrates California's wind resources.

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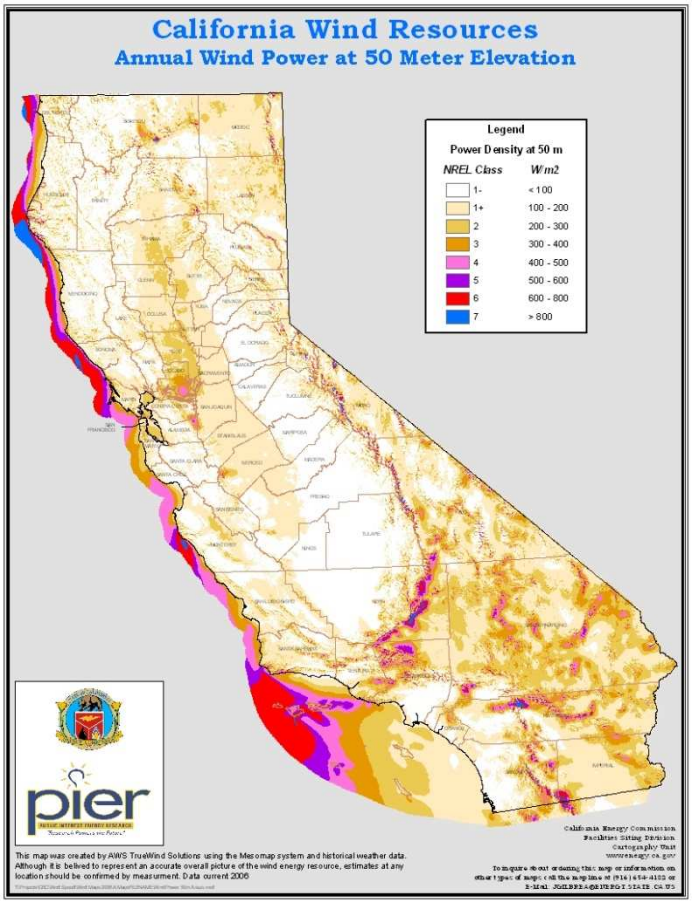


Source: Dvorak, M.J., Jacobson, M.Z., Archer, C.L. (2007): "California Offshore Wind Energy Potential." Proceedings from Windpower 2007*: American Wind Energy Association Windpower 2007 Conference & Exhibition*, Los Angeles, CA: June 36, 2007.

Preliminary data suggest that there exists a huge and untapped potential for more than 100,000 MWs of offshore wind power, particularly off of the Northern California coast. Unfortunately, ocean depths off the California coast have made building towers prohibitively expensive.

Wind is very effective in displacing fossil fuels; however, wind is an intermittent resource. Generation is dependent on when the wind is blowing. Therefore, great care is used in siting wind facilities in areas with high and predictable winds. Given the variable output nature of wind, there is a need to ensure that it is efficiently integrated into the grid. Recently, forecasting tools have been developed to better schedule wind production into the grid.

California's wind resources are driven by the temperature differentials between the cool coastal air and hot inland valley/ desert air. When it is warm along the coast (during peak) there is usually very little wind available. There can also be a challenge at night (off-peak) when many wind areas in California experience high production. The grid needs to accept all of this wind generation in real time. A problem can arise under minimum load conditions, especially when this generation exceeds the supply and

demand balance. Shifting demand to off peak and/or creating energy storage is an effective way of addressing this issue.

There are several studies underway examining how to integrate additional large quantities of intermittent resources into grid operations. The California Energy Commission just released its 375-page *Intermittency Analysis Project: Final Report*. The CA ISO, which manages statewide transmission services, is finishing an integration study looking at the operational impacts of increasing intermittent generation sources such as wind power onto the California grid.

Technological Developments

By 2030, it is estimated that innovations underway to turbine design and size will yield both higher capacity factors and lower costs of construction. (A capacity factor is a measurement of how frequent intermittent capacity generates energy as a function of time.) This is true for both on-shore and off-shore turbines. Capacity factors for on-shore turbines are expected to improve by 5 to 7 percentage points while capital costs are projected to decline by 10 percent by the 2030 time frame. Utility-scale turbines of 1–3 MWs are already commercially available. Larger turbines are expected to be installed in the 2010 to 2020 timeframe.

CO_2 Abatement Potential

Wind power does not emit any greenhouse gases or criteria pollutants. In 2006, wind turbines generated 5.37 million MWhs[6] of power. The CEC has estimated a total technical potential of 99,945 MWs of wind generating capacity (including both high-speed and low-speed wind) in California, which translates into an energy generation potential of 323.94 million MWhs.[7] Wind power developments at California terrestrial sites could offset an estimated 130 million metric tons of CO_2.[8] It is important to note that these figures to not capture the equally large estimates of potential of off-shore wind resources.

Technology-Specific Barriers

Wind development shares the barriers faced by all renewable technologies, described in the Policy Game-Changers Section. There are some barriers that are specific to wind development.

Regulatory: Despite the availability of better wind technology, there exists a lack of progress in replacing aging wind facilities with new technology through repowering. This barrier is closely related to permitting issues. Wind projects face some permitting hurdles that are quite specific to this renewable energy technology. The three main issues include radar interference at military bases, view shed aesthetics, and wildlife impacts on birds and bats. Radar is a relatively new issue that has surfaced in connection to a new generation of digital radar systems. There is a software fix, the cost of which can be abated if spread out across multiple wind projects. View shed issues are typically an issue

when wind development projects are proposed next to or near protected land -- such as a nature reserve -- or near a recreation area. Bird and bat mortality have become a large issue in the Altamont Pass, but not elsewhere.

Generally, study protocols for bird impacts have become standardized and are used at most newly developed wind project sites. The *California Guidelines for Reducing Impacts to Birds and Bats from Wind Energy Development* is in the final drafting stages at the CEC and represents the most thorough survey of the science and the best way to address wildlife concerns. These guidelines, once adopted, will be optional to wind developers. California has not adopted the aggressive wind repowering policies similar to those that have been successful in European Union. Repowering existing sites with aesthetically advanced new technology will enhance reliability as well as reduce avian mortality.

Financial: The federal Production Tax Credit (PTC) provides tax benefits for the production of wind generation which has helped commercialized the technology. However, due to its serial short duration, it has also created a boom and bust cycle that has a demonstrable affect on cost and availability of wind technology. A long term PTC would provide developers and turbine manufactures with a stable market lowering cost and providing a sustainable market.

Institutional: Wind turbine availability is driven by world-wide demand. California wind developers must compete for wind turbines in an international market. Therefore it is imperative that California policies provide for a stable long-term market.

C. Geothermal Steam

Geothermal steam can be used to generate power either in utility-scale plants or in direct use applications, such as space heating and various commercial and industrial heat applications. Another technology to use the earth's heat is geothermal heat pumps, also called "geoexchange."

California has the largest developed geothermal resources dedicated to electricity production in the U.S. at approximately 1,900 MW. CEC studies have shown the potential for an additional 2,900 MW[9] using conventional flash and binary technologies in known resource areas. The US Department of Energy estimates California resource potential at between 12,200 and 15,100 MWs.[10] In 2006, 4.7 percent of California's electric energy generation came from geothermal power plants. This amounted to a net-total of 13,448 GWh generated from in-State geothermal resources.[11] Today there exist fifteen geothermal projects in some form of development, which will amount to an additional 921.3-969.3 MW of capacity.

The major identified geothermal resource areas in the State are: the Geysers north of San Francisco, Northeastern California, Western Nevada, the Mammoth Lakes area, Coso Hot Springs in Inyo County, and the Imperial Valley. The City of San Bernardino has one of the largest geothermal district heating projects in North America. That project heats 37

buildings with fluids sent through 15 miles of pipelines. The CEC map below illustrates the known geothermal resource areas in the State.

Technological Developments

Investing in R&D to improve geothermal power conversion technologies could help expand new renewable energy resources from the following:

- *Lower-Temperature Resources:* Improving the heat-transfer performance for lower-temperature fluids (below 212°F) in order to make lower-temperature geothermal resources more viable. There could also be opportunities to use hot water, available in large quantities of up to 212°F or more from existing oil and gas operations.
- *Higher-Temperature/Supercritical Resources:* Developing plant designs for higher resource temperatures to the supercritical water region could lead to an order of magnitude (or more) gain in both reservoir performance and heat-to-power conversion efficiency.[12]
- *Enhanced Geothermal Systems*: Reservoir technologies focusing on enhanced (or engineered) geothermal systems (EGS) could potentially enable an enormous potential resource for primary energy recovery using heat-mining technology, which is designed to extract and utilize the earth's stored thermal energy.

CO_2 Abatement Potential

Geothermal power production does not emit any GHG or criteria pollutants, except for geothermal systems using water cooling (which may produce limited emissions from the evaporating water, approximately 60 pounds per megawatt-hour of CO_2.[13]) Based on DOE estimates of total potential, the committee estimates that geothermal has the total potential to offset 37 million tons CO2 per year.

Technology-Specific Barriers

Geothermal development shares the barriers faced by all renewable technologies, described in the Policy Game-Changers Section. There are some barriers that are specific to geothermal development.

Technological: Significant advances in exploration technology are needed. Resource assessment work supported by the US Department of the Interior and Department of Energy can help overcome the initial barrier to geothermal development. The US Geological Survey is undertaking a new resource assessment, updating the last assessment which was completed in 1979. The new assessment, however, will not examine new technologies and their potential in California, nor will it examine direct uses, heat pumps, or other non-conventional geothermal resources (like oil field co-production or geo-pressured resources). The CEC should support its own complementary assessment to examine California's geothermal potential in a more comprehensive and up-to-date manner.

Financial: Resource exploration and identification expensive, with an upfront cost of at least $2 million per site, to secure or lease land rights even before exploration. Improved development of exploration tools and technology is needed to lower costs. Roughly one-half of the cost of a geothermal project is estimated by the GEA to be related to subsurface exploration and resource characterization. These costs also raise the greatest risk to investors, and are usually not financeable. Cost-shared exploration drilling by the Department of Energy has successful in the past, and is being proposed for expansion in HR2304 now under consideration in the US Congress.

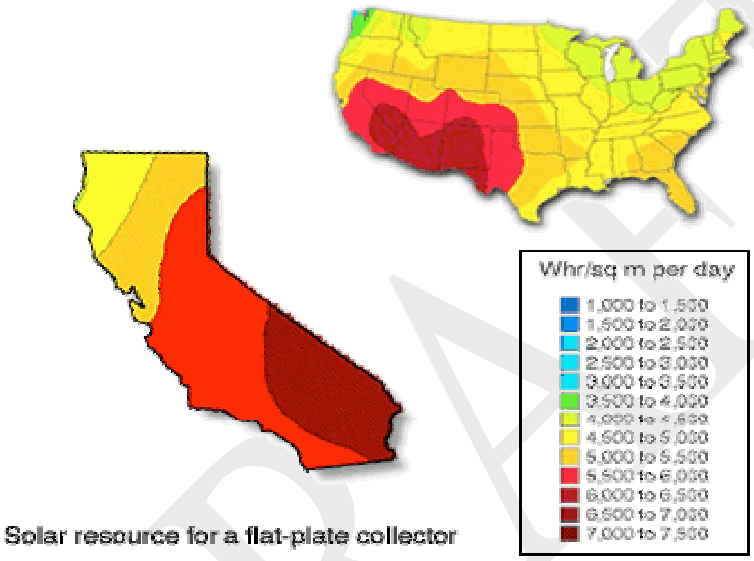
Institutional: There are a wide variety of geothermal resource types in California, but there are a restricted number of capable exploration entities. The Bureau of Land Management (BLM) rarely issues these leases because it is unsure of the geothermal development potential. Since its pre-lease processing requirements of the agency are significant, this has stunted growth of the State's geothermal industry. Moreover, given the BLM's limited resources and growing public demands on the agency, geothermal leases have not been a high priority. A better interface between California and the BLM may help in addressing this issue. Moreover, the Department of the Interior must enhance the ability of the BLM to modernize its leasing practices and capabilities.

California has no effective policy to support geothermal energy development. The CEC Energy Plan has only a few geothermal-specific policies, and the State has no geothermal plan comparable to its biomass, solar and wind initiatives. The California Geothermal

Collaborative, a research and development effort supported by the CEC's PIER Program, has proposed that such a plan be developed focusing on addressing the barriers to developing new geothermal resources in the State.

C. Diverse Solar Energy Applications

The daily load shape of both distributed installations and utility-scale solar plants, matches that of the entire grid roughly 65 percent of the time, making a valuable resource for "shaving the peak", especially during hot months. How much electricity a solar system produces depends on the quality of the solar radiation where the system is located. The figure below[14] shows solar quality for California and the entire United States.



Solar resource for a flat-plate collector

California has hosted the largest concentration of solar generation in the world for almost two decades. California is the clear national leader in solar photovoltaics (PV). And until the construction of the 64 MW Solargenix solar plant in Nevada, was home to the only utility-scale concentrated solar plants in the country. Large opportunities also exist for distributed solar gas-saving technology in California. Consequently, this analysis examines the total solar energy potential throughout the State.

Concentrated Solar Power

According to the National Renewable Energy Laboratory (NREL)[15], technical estimates of concentrating solar power (CSP) potential in California are phenomenal: 877,204 MW of capacity able to generate 2,074,763 gigawatt-hours per year. Throughout the Southwest (AZ, CA, CO, NV, NM and TX), NREL estimates a total technical potential of 6,877,055 MW of solar capacity. Interestingly enough, California has enough CSP potential to provide many times that State's own demand for peak electricity.

Parabolic trough technology has seen incremental improvements and is being used as part of a revival of interest in utility-scale solar thermal power plants. Other technologies originally tested in California in the 1980s and 1990s, such as solar "power towers" are also being revisited with modernized versions proposed to be installed in the Mojave Desert. Newer technologies such as concentrating photovoltaics are also attracting investment and attention. Deployment of all of these technologies in sufficient volume will produce significant CO_2 reductions as the displaced on-peak generation is often the most polluting in California's power supply portfolio.

California is home to 354 MW of parabolic trough systems, divided into nine power plants, called the Solar Energy Generating System (SEGS). These plants began construction in 1985 and construction was completed in 1991. On July 25, 2007, PG&E announced the largest solar power purchase agreement in the world – a 553 MW parabolic trough plant in the Mohave Desert. The plant is scheduled to be constructed and fully operational in 2011.

Located near Barstow, California, the 10 MW "Solar One" generated electricity between 1982 and 1988. A retrofit dubbed "Solar Two" then operated from 1998 to 1999. To date, there is not one commercial power tower facility currently in operation in California, though the new PG&E contract features next generation power tower technology of modular and sufficiently smaller scale design. To date, there are no dish-engine systems in operation in California either, though SCE and SDG&E in 2005 signed power purchase agreements for 500 and 300 MW dish-engine systems, respectively. To date, there are no Concentrated PV systems (CPV) in operation in California, though a few have been proposed in utility RPS solicitations and a few other CPV projects have been announced.

Technological Developments

New versions of each of CSP technologies are under development or construction. New parabolic troughs plants will likely employ molten salt 2-tank storage systems, which will have the ability to retain heat efficiently to produce electricity off-peak for up to 12 hours.[16] Several demonstration power tower plants have been constructed and operated throughout the world. An 11 MW power tower plant, PS-10 opened in Seville, Spain in 2007. New developments of power tower technology and CPV systems are underway. Linear Fresnel systems are in the development stage and are attracting some attention. For all CSP technologies, the key challenge is to improve efficiencies to drive down cost, further technology development, and then manufacture to a larger scale. Better methods for energy storage could accelerate near-term development.

CO_2 Abatement Potential

Solar power production does not emit any GHG or criteria pollutants, and provides valuable peak power. Based on NREL[17] estimates of total potential, CSP has the potential to offset 835 million tons of CO_2 per year.

Technology-Specific Barriers

CSP development shares the barriers faced by all renewable technologies, yet there are some barriers quite specific to these forms of solar energy development.

Technological: Dish-engines have significant maintenance challenges due to many small engines (one per dish), and challenges of using hydrogen as a working fluid. Parabolic trough and power tower systems have to date been cooled using water. Troughs, if wet cooled, require 739 gallons per megawatt-hour for cooling and 37 gallons per megawatt-hour for cleaning the mirrors.[18] Power towers require 739 gallons per megawatt-hour for both cooling and mirror washing.[19] Both power towers and troughs can be dry-cooled with some loss in efficiency (and consequent cost increase). Developing technologies are employing dry cooling in their design with very little loss of efficiency. Dish-engine and CPV systems are air-cooled and only require water for mirror washing.

Financial: The up-front capital cost is greater for concentrating solar systems than other renewable energy sources. Concentrating solar power projects are eligible for a 30 percent Federal investment tax credit through December 31, 2007, at which point the tax credit expires. Property tax credits would help lower the developers' cost and their power prices. Finally, establishment of manufacturing investment credits (MIC) to encourage manufacturing and assembly in California, as opposed to other States.

Institutional: There is a lack of recent, available experience in developing, constructing, operating and permitting concentrating solar plants. Some technology types do not have long-term operating history or have been built in large-scale installations. There also exists a lack of understanding and training for utility procurement officers and decision-makers of the unique attributes and benefits of concentrating solar power. A clear understanding of the technology is an institutional barrier that must be overcome with time and adequate training.

Solar Photovoltaics

PV technology is the direct conversion of sunlight into electricity. Solar radiation is of very high quality throughout most of California. The Central Valley and Southern California receive 5 to 7.5 kWh/m2-day. [20] California has the largest concentration of photovoltaic installations in the U.S. Most systems are distributed on homes and commercial sites. Some large-scale systems do exist, the largest to date being the 3-megawatt installation at Sacramento's retired Rancho Seco nuclear power plant.

California has a long history of policies to support development of the solar industry. At present, there are about 198.2 megawatts of grid-connected PV systems in California.[21] In 2006, the legislature passed Senate Bill (SB) 1, which created a $3.2 billion, 10-year program with guaranteed funding. This program is called the California Solar Initiative (CSI). The CSI awards incentive payments based on actual or expected energy output, and therefore encourages technology innovation and cost reductions.

Technological Developments

The production of electricity from semiconductor cells has increased dramatically worldwide. Advances in silicon have enabled PV technology to achieve efficiencies of between 20 and 22 percent. Despite the recent shortage in silicon -- and subsequent price increase -- manufacturers expect a 50 percent cost reductions in the near term as new polysilicon factories come on-line and as manufacturing processes continue to improve. Manufacturing cost reductions are due to thinner wafers being cut with a thinner saw wire, higher efficiency cells with fewer process steps, smarter panel design with auto-line production, and smarter systems design. Additional cost reductions will come from improvements in crystal growth technology, improvements in cell processing technology, new lower cost silicon refining technologies, and increased manufacturing scale – from 200 MW to 500 MW plant size. [22]

Technological advancement is occurring in thin film PV to improve the efficiency, durability and performance, and reduce costs. Integration of solar PV into building construction can reduce the cost of installation, which is a significant cost barrier to widespread adoption.

CO_2 Abatement Potential

The CSI sunsets in January 2017, at which point it is projected that 3,000 MW of solar PV will be on-line cutting 3 MMT CO_2 per year. The CEC has estimated a technical potential in excess of 74,000 MW of potential solar PV capacity on existing residential and commercial buildings.[23] These figures suggest a substantial untapped potential for a greatly expanded solar PV portfolio with the potential to provide an estimated 74 million tons CO_2 reduction per year.

Technology-Specific Barriers

Technological: The global demand for silicon to make PV panels has skyrocketed over the last few years, from a combination of booming worldwide computer and solar industries. Demand has created a global shortage of silicon, which has contributed to higher costs.

Financial: Solar PV is expensive technology. Customer-owned PV systems purchases are supported by a combination of government or utility-provided incentives including – rebates, tax credits, net metering and exemptions from certain fees – and private investment. Additionally, there is a lot of cost built into "balancing the system". This includes Rule 21 interconnection, net metering, and site-specific installation.

Institutional: There still exists a fairly widely held belief that solar is unattractive or unreliable, though this is changing with time and the growing acceptance of solar and environmental, or "green", building design.

Regulatory: Stability is very important to the future of solar PV in California. The existing policy framework needs to continue into the future and adjust to other potential

future policies. In California, a multitude of incentives exist to support solar PV. Grid-connected solar systems are exempt from exit fees, standby charges, and are eligible for net metering. The authorizing legislation that created the CSI raised the net metering cap from 0.5 percent to 2.5 percent of peak electric demand. In January 2007, the CPUC ordered that renewable energy credits that are attributable to power produced from a distributed PV system fully belong to the owner of that PV system.[24]

Solar PV installations for one building must be connected to one meter as a matter of State policy. This has created problems in multi-unit, multi-meter buildings. For example, the legislature has required individual meters for all dwelling units in multi-unit buildings. The intent of this legislation is so that residential customers receive the correct economic price signals to make energy efficiency decisions appropriately. As a result, each unit currently must have its own inverter and the solar generation must be split into these inverters and interconnected behind each meter, which increases costs for multi-unit dwellings. The CEC, CPUC, as well as the utilities, the solar community and low-income community have been grappling with this issue, though there is no clear solution at hand. Regulators and legislators should investigate ways to get solar benefits to multi-unit dwellings without losing the other benefits of individual metering.

Solar Water Heating and Advanced Solar Thermal

In a solar water heating system, solar energy is collected in a rooftop collector. A typical residential solar water heating system requires around five square meters of unshaded roof space. The solar collector array transfers heat through the heat exchanger to a water storage tank. Hot water is pumped from the storage tank through the manifold to the system components that are calling for hot water, or is stored in a storage tank for later use.

Advanced Solar Thermal (AST) systems collect solar thermal energy through a rooftop collector, just as with solar water heating systems. AST systems are used for space heating and cooling, process heating and cooling, district heating and cooling and large-scale domestic hot water. Solar-heated water is either used in a space heating or industrial process application, or run through a chiller to create solar space and process cooling. Solar cooling can be used in lieu of a cooling system powered by electricity, providing a huge opportunity to cut electric air conditioning demand in the hot summer months. AST systems can also provide domestic hot water as a by-product of any cooling or heating system, or as a large-scale hot water-only system.

Solar Hot Water and Advanced Solar Thermal in California

NREL estimates that, in California, 65 percent of residential and 75 percent of commercial buildings could be outfitted with solar collectors for hot water systems and for AST systems.[25] Solar radiant space heating and hot water systems used to be prevalent in California before customers had access to gas for heating in the early to mid-20th century. There is a small distributed solar water heating industry in California. Summertime cooling loads make up a substantial portion of the total peak demand during

summer months, particularly in Southern California. The potential to offset this load with AST cooling systems is huge. Despite the potential, only a few AST systems currently exist in California.

Technological Developments

Solar hot water and AST systems are commercially available, constructed using readily available off-the-shelf technology, and deployed throughout the world. China, Japan, India, Korea, Israel and the European Union use solar thermal extensively both for solar hot water and AST. The 46 million solar hot water systems around the world have a combined capacity of about 88 GWth.

CO_2 Abatement Potential

NREL released a study[26] in March 2007 of the potential for solar hot water only systems to reduce demand in residential and commercial buildings in the U.S. The calculated technical end-use energy and GHG savings potential for both residential and commercial sectors in California was estimated to add up to 116 trillion Btu and 7.8 to 8.6 MMT CO_2. The advanced solar thermal industry currently estimates 15 to 35 MMT CO_2 reduction potential from AST systems.

Technology-Specific Barriers

Financial: Power is still relatively cheap which has had the effect of dampening demand for alternatives. A major financial barrier is also a regulatory barrier, which is the absence of a State program or incentives to spur the development of a distributed solar thermal industry in California. The only incentive that exists currently is a $3 million solar water heating only pilot that is currently being administered by the California Center for Sustainable Energy.[27]

Institutional: A major barrier for AST is simply a lack of awareness and familiarity of the technology. People just don't know about it. By the early 1990's, the AST market was rapidly developing in Europe, but far less so by a handful of companies in the U.S. The AST is now positioned to rapidly develop the U.S. market using time tested technology designed and installed by proven performers.

Regulatory: There are no programs or incentives in California to support solar hot water or AST systems, apart from the CCSE pilot and an authorization under CSI that has not yet been implemented.[28] California's renewable, energy efficiency policy and environmental energy policy is focused on electricity and not gas. Solar hot water and AST systems do not qualify for the RPS, the CSI , the Self-Generation Incentive Program or energy efficiency programs. Further, the funds for electric efficiency, renewable electricity, and distributed generation programs are collected predominantly from electric rates. AST systems save both gas and electricity, which makes them extremely valuable, but there is confusion over how to administer the funding for such a program.

D. Fuel Cells

Fuel cells operate on natural gas, methane, diesel, syngas, hydrogen and other fuels. They range in size from tiny -- several kilowatts capacity -- to as large as 1 MW. There are some utility-scaled fuel cell stack projects of greater than 20 MW.

These stationary fuel cells "electrochemically" generate clean, base load electricity and heat without combustion or moving parts. Heat generated in a fuel cell can be recovered and used in combined heat and power/cogeneration applications, which can double the total energy efficiencies of fuel cell projects. Currently, fuel cells are primarily used to generate electricity and heat that can be used at consumer sites or in district or campus applications. Fuel cells also offer near-term hydrogen fuel production opportunities.

In California and the United States, fuel cells operate as utility-owned power plants or on-site distributed generators. California has installed almost 15 MWs of fuel cells since 2003; about half of the installed capacity is customer generators; the balance is utility and waste water treatment facility power plants. Another 4 MW of fuel cell capacity is under current negotiations.

Technological Developments

Fuel cells are generally characterized by the electrolyte employed in the device. Fuel cells are also characterized by their running temperature, low- or high-temp. There are dozens of types of fuel cells, with four (4) primary technologies at varying States of commercialization and development:

- Molten Carbonate Fuel Cell (MCFC) – High Temperature
- Phosphoric Acid Fuel Cell (PAFC) – Low Temperature
- Proton Exchange Membrane Fuel Cell (PEMFC) – Low Temperature
- Solid Oxide Fuel Cell (SOFC) – High Temperature

Most fuel cells on the market in the world are molten carbonate or phosphoric acid. Solid oxide fuel cells are on the verge of commercialization while proton exchange membrane fuel cells are expected to be commercialized in the coming decade.

CO_2 Abatement Potential

Renewable fuel cell projects operated under the auspices of the Self-Generation Incentive Program, delivered 1.59 tons of GHG reductions per MWh of operation. There exists substantial deployment potential for large buildings with base load power needs – schools, hotels, hospitals, office buildings, and industrial buildings.

Technology-Specific Hurdles

Technological: Fuel cells require highly-durable, expensive component materials. Cost reduction for these materials is the key technical challenge and commercialization factor for fuel cells. Fuel cells require fine tuning and calibration, and periodic cell changes. Lack of workforce training for utility employees on technology operations and best applications is a barrier.

Financial: Fuel cells are still relatively expensive, as compared to other fossil generators, to make, install and operate. The technology's cost-competitiveness would improve if certain variables, such as an accurate accounting of distribution benefits and greenhouse gas abatement, were properly valued. Further, fuel cell operators that use natural gas must absorb the cost and volatility risk, as the cost of the fuel cell is estimated gas price plus capital cost. The key factors are bringing down the price of component materials, reducing the customer capital costs for installations, providing cost recovery for natural gas and other fossil units, and expanding the availability of renewable fuels.

Institutional: There exists a lack of familiarity with technology by utilities, decision-makers and customers. Fuel cells provide superior use of fuel, total efficiencies, multi-faceted benefits and potential to help create a smart grid, but suffer from fear and suspicion of the technology.

Regulatory: Fuel cells have a number of regulatory issues that all deal with cost-competitiveness of the technology. Self-Generation Incentive Program (SGIP), created in 2001 provides funding for fuel cells and other clean DG. Rebates are limited to the first installed megawatt of a maximum total project size of 3 MW. This restriction is too low to incent economies of scale and wide-scale deployment. Increasing this cap would enable a greater market transformation for fuel cell technology. Renewable fuel cells are also eligible for net metering. The current net metering cap in California law, of 2.5 percent of total peak demand, is potentially too low to incent the acceleration of installations.

E. Biomass/Landfill/Methane Digestion

Biomass is defined by Federal statute (7 USC 7624 303) as "any organic matter that is available on a renewable or recurring basis, including agricultural crops and trees, wood and wood wastes and residues, plants (including aquatic plants), grasses, residues, fibers, and animal wastes, municipal wastes and other waste materials." As such, biomass feedstock is very diverse, as are technologies for converting the feedstock to usable energy. Biomass resources can be used for: renewable power generation, production of biofuels such as ethanol and biodiesel, and bio-based plastics and chemicals. Another key co-benefit provided by biomass plants is that most are able to provide firm base load capacity as well as energy.

The three primary sources of biomass for energy in California are agriculture, forestry, and municipal wastes. All together, these biomass generators contribute approximately 2 percent of California's electric supply. Two-thirds of California's biomass power capacity is from direct combustion of solid biomass in boiler-steam turbine plans of 5-50

MW. The remainder is generated by the combustion of landfill gas and biogas in smaller plants typically in the 1-10 MW range.

California leads the nation in the consumption of ethanol. In 2004, California consumed almost 25 percent of all ethanol produced in the US; however, less than 5 percent of the consumed ethanol was produced in California. Given that California produces more lignocellulosic biomass relative to other sources for biofuel, technologies that use lignocellulosic biomass appear more attractive for in-State production. However, these technologies are also the least mature and are still in the commercialization phase. Almost all of the current ethanol supply is created from corn, with most of it grown in the Midwest.

There is no single market driving biomass development. New markets will offer additional outlets for biomass, but will also increase competition and influence price for more readily available and higher quality supplies.

CO_2 Abatement Potential

Significant room exists for increased bioenergy use in California. To date, only 15 percent of the technically recoverable potential of biomass wastes and residues from agriculture, forestry and municipal waste are currently being converted into useful energy products. Dedicated energy crops could also add to this resource potential in the future.

Out of available technical potential of 39 MDT, 4-5 MDT of solid biomass resource was used in 2005. In addition, an estimated 90 BCF of landfill gas and biogas containing as much energy as 3 MDT of additional solid mass was technically available in 2005. (Available technical potential refers to the fraction of theoretical or gross potential that is considered to be recoverable on a sustainable basis.) The theoretical potential for California's entire biomass inventory is estimated to be over 90 MDT per year.

The electricity generation from biomass could potentially reach 60,000 GWh per year by 2017, or 18 percent of projected statewide electricity consumption of 334,000 GWh, if the technical potential is fully developed. The potential for producing biofuels from California's biomass resources depends on the type of biofuel and the conversion technology. California's cellulosic resource could conceivably support over 2 billion gallons of ethanol per year, approaching 3 billion gallons by 2020.[29]

Technological Developments

There are several pathways for converting biomass to usable energy[30]:

Biological Conversion

Source	Conversion Process	Primary Energy Product
Agricultural crop	Fermentation of sugars	Ethanol
Any lignocellulosic*	Cellulose to sugars, then	Ethanol

biomass	fermentation	
Landfill gas, animal manures, food and other organic residues, biogas from wastewater treatment process	Anaerobic digestion, cleaning separation	Pipeline quality gas, CNG, LNG, hydrogen (via reforming)

Thermal Chemical Conversion

Source	Conversion Process	Primary Energy Product
Any lignocellulosic* biomass	Gasification/syngas processing	Fischer-tropsch liquids, mixed alcohols via catalytic synthesis, dimethyl ether, ethanol via syngas fermentation, methanol, hydrogen, methane
Any lignocellulosic* biomass	Pyrolysis and upgrading	Upgraded bio-oils (generally non-transport fuel)

Physiochemical Conversion

Source	Conversion Process	Primary Energy Product
Bio-oils (waste oils/fats, ag crops)	Transesterification or hydrogenation	Biodiesel

*Lignocellulosic or cellulosic biomass refers to biomass that is not food or feed, and the non-food component of traditional agricultural crops such as rice straw and corn stover.

CO_2 Abatement Potential

- *Anaerobic Digestion:* California has 1.7 million cows on 2,100 dairies, 75 percent located in Northern California, half of them in San Joaquin Valley. Less than twenty of California's dairies are generating methane for electricity production. These dairies provide an opportunity for load-serving entities such as public and private utilities to produce base load renewable energy without the need for electric transmission reinforcements. Capturing the methane from dairies has high abatement potential due to the GHG characteristics of methane, which has 23 times the effect of CO_2 as a climate change pollutant.

- *Landfill Gas:* The last comprehensive survey of California landfills was performed in 2002, at which time the total electrical generation capacity from the 51 then existing landfill gas to electricity (LFGTE) projects in California was about 211 MWe. The electrical potential from an additional planned 26 landfills was about 39 MWe. In 2002, 70 landfills in California were flaring the landfill gas they produced. The remaining 164 landfills either did not have landfill gas

control systems or were venting the landfill gas to the atmosphere. These 164 landfills have the potential for producing approximately 31 MWe of electricity while reducing the GHG effect of the methane emissions. Additionally, some of the existing LFGTE projects are operating below their rated electricity generation capacity. About 45 MWe of electrical potential could be added by expanding existing landfill gas to energy projects in California.

Technology-Specific Barriers

Technological: While existing bioenergy generation technologies are well established, new emerging technologies such as gasification, pyrolysis and lignocellulosic ethanol have yet to be fully demonstrated and commercialized. Due to feedstock variation, the new technologies being developed need to be able to handle a variety of feedstock quality. Adequate environmental data often do not yet exist for many new biomass industries or they have not been fully evaluated by regulatory agencies, leading to uncertainties and delays.

Financial: Due to their small size, biomass power plants have relatively high capital and non-fuel O&M costs compared to fossil fuel plants using similar technologies. In addition, the plants are sensitive to biomass feedstock costs. The cost of collecting and delivering biomass to the point of use is often high and reduces the competitiveness of biomass energy systems compared with other renewable technologies that do not incur fuel costs. The benefits of bioenergy options are also not adequately recognized or valued in the market. And the cost of siting and permitting for new projects can be prohibitive, given the lengthy and complex process. In the final analysis, biomass projects are capital intensive, and the uncertainty of California's long-term commitment to and availability of bioenergy -- coupled with uncertainties associated with new technologies such as gasification or cellulosic ethanol technology -- make financing difficult.

Institutional: Biomass projects require an infrastructure to collect, process, transport and store feedstock, and to distribute biofuel products. Furthermore, there needs to be cooperation and collaboration among various industries, from agriculture, forest products, to electric power, waste management, chemicals, oil and gas, and the automobile industry. There is a lack of public awareness of the benefits of bioenergy, and there may be some negative perception of biomass facilities as "incinerators".

Regulatory: Different aspects of biomass development, management and use are governed by various State agencies, which may have unintentionally overlapping and conflicting regulations and policies. Potential developers find difficulty in securing long-term contracts for biomass, especially from public lands agencies and in areas with fragmented Federal, State, and local ownership patterns.

The State currently lacks a comprehensive system for assessing the overall, lifecycle cost and benefits of bioenergy options. Furthermore, the industry is fragmented and composed of a diverse group of fuel providers, producers and users. Each segment of the industry faces different regulatory issues and challenges.

The Federal production tax credit is lower for biomass than that for wind, solar and geothermal projects. Federal programs have only just recently begun to support biofuels other than ethanol. At both the Federal and State levels, bioenergy subsidies lack regulatory certainty, which acts as a barrier to private sector investment. To qualify for diversion credit, a gasification facility must meet stringent criteria, as set out in AB 2770, a bill signed into law in 2002. The criteria includes using absolutely no air or oxygen in the conversion process. Gasification however, does require some air. Gasification of municipal solid wastes is therefore greatly inhibited by the language of the law. The diversion credit rules of the waste management laws also inhibit the use of municipal solid waste. Current laws allow diversion credit for many activities, but generally exclude energy conversion from these credits. Pending legislation (SB 1020) may change this State policy.

On top of all that, landfill operators are required to destroy methane emissions from their facilities. They usually simply flare the gas. The flaring sets the baseline for NO_x emissions for the operation, which are stringently controlled. NO_x emissions from internal combustion are higher than from flares and currently statute requires that the NO_x emissions must be immediately reduced on-site. Capturing these methane emissions would offset other gas use, and therefore be a more efficient use of energy. Yet there is currently no credit given for such offsite NO_x reductions.

F. Ocean Wave Power

Wave Energy Conversion ('WEC') devices are deployed on the surface of water and operate like wind turbines in aggregated "wind farms." These potential energy farms could operate in varying depths (between 60 and 600 feet). At present, wave energy is a pre-commercial, nascent technology. Systems to convert wave energy to electricity are often categorized by their location in the sea, particularly the depth of water, because this has a bearing on the wave height and therefore the amount of energy. Offshore wave energy converters are designed for sites that are tens of meters deep while near-shore while shoreline systems are intended for shallow water and are actually built right on the coastline.

EPRI has evaluated and screened California's potential sites for wave power. Other feasibility studies have also been launched. PG&E has already filed two FERC preliminary permit applications (40 MW each) at Eureka in Humboldt County and Fort Bragg in Mendocino County. If approved, multiple wave energy conversion devices will be arranged in arrays, with leading devices floating on the water surface. The projects will be 0.5-10 miles offshore, connected to land via an underwater cable.

CO_2 Abatement Potential

An average of 37,000 MW of clean energy dissipates on California's 1,200 kilometers of coastline every day. Using current technology, a maximum of about 20 percent of that energy potential could be converted into useful electricity. If developed, these wave

energy systems would yield an average power of about 5,500 MW or an annual electrical energy output of 48,000 GWh. Despite this promise, global installed capacity is estimated to be less than 4 MW as of the end of 2006, with none of that off of US coastlines.

Technology-Specific Barriers

Technological: At present, most procedures and vessels used to develop this form of ocean energy come from the offshore oil and natural gas sector and share a tremendous amount of experience with construction and operation in heavy seas. Unfortunately, most of these technologies are expensive, though trends indicate that companies are trying to come up with simpler, cheaper ways of installing and operating their wave power conversion devices, relying upon small vessels and specialized equipment. Often, this means a re-design of the device and its mooring system is necessary to allow for better operation and handling.

Financial: While the lower capital cost of a wave machine (compared to a wind machine) more than compensates for the higher O&M cost for the remotely located offshore wave machine, a challenge to the wave energy industry is to drive down O&M costs to offer even more economic favorability and to delay the crossover point (greater than 40,000 MW). EPRI estimates that wave energy will first become commercially competitive with the current 40,000 MW installed land-based wind technology at a cumulative production volume of 15,000 or less MW in Hawaii and northern California, about 20,000 MW in Oregon and about 40,000 in Massachusetts.

Institutional: The cost for a small demonstration site to test the first few wave energy devices could be tested is heavily dependent on electrical interconnection costs. A second important consideration is the availability of good local port infrastructure. Many ports in Northern California are small fishing ports with harbor entrances that are only dredged to about 4m and some of them without any breakwater, making navigation in and out of the port difficult when large waves are present. A third consideration is the availability of good local grid infrastructure, which would allow a significant amount of electricity to be fed into the grid. Most coastal towns in Northern California are connected by 60 kV transmission links and usually offer no more than 50 MW of available capacity.

Regulatory: There is a lack of U.S. Federal government support. The U.S. government is and has supported the development and demonstration of all electricity technologies except for ocean wave energy. Moreover, there is a lack of Federal production subsidies. The renewable production tax credits do not include wave energy as an eligible technology. Regulatory uncertainty lends itself to the uncertainties of permitting an offshore project, and the private investment communities are likely to invest in projects with less risk. In addition, permitting an offshore project itself is a daunting task, with many regulatory issues, making it difficult to license a project.

G. Additional Solutions for *All* Renewable Technologies

Simplify Renewables Pricing: The pricing structure under the RPS is a two-step process. The CPUC sets a market price referent (MPR) each year that is based on the cost of a proxy combined cycle natural-gas fired power plant. No other values are included in this proxy calculation, such as avoidance of GHG emissions or other environmental attributes. Up until recently, any costs above the MPR were supposed to be made in payments, called Supplemental Energy Payments (SEPs), from the Public Goods Charge paid by ratepayers on their utility bills. The SEP process carries substantial uncertainty as to whether projects that require SEP payment awards would be able to obtain project financing. As a result, most of the funds earmarked for this purpose have not been accessed.

With the passage of SB 1036, the CPUC is now authorized to allow utilities to recover above market costs for renewable energy, thus removing the fiscal concerns regarding above market cost recovery. Nevertheless, the current MPR and RPS pricing process is still too complicated. The issue of how to best determine the market price for carbon free energy is still up for debate. The ETAAC energy subgroup recommends that the State revisit the structure of RPS pricing and determine how the structure could be simplified.

Unbundle Renewable Energy Credits: RECs have several values and functions: a tracking and reporting mechanism, a tradable/sellable commodity; a market price valuing the benefits provided by non-carbon renewable energy sources. California's RPS program requires that utilities and other the Load Serving Entities (LSEs) covered under the RPS law meet their requirements with delivered energy, not with RECs. In other words, the REC must be "bundled" with the delivered energy and cannot be traded or sold as a separate commodity. The benefit of allowing for "unbundled" RECs is multiple-fold. Such a policy helps address geographic transmission needs in constrained areas such as San Diego. It would encourage development of renewable energy projects beyond any individual utility's RPS requirement, which could then be sold into regions such as San Diego that do not yet have ready access to renewable energy procurements due to transmission constraints.

In an ideal world, LSE's should be able to use unbundled RECs to comply with the RPS. SB 107, signed into law in 2006, gave the CPUC the statutory authority to consider unbundling RECs for RPS compliance once the REC tracking system known as the Western Region Energy Generation Information System (WREGIS) was off the ground. WREGIS, which will verify and transfer RECs between the sellers and buyers, was launched in June 2007, greatly simplifying REC transactions.

Unbundled RECs are used in other States to meet RPS obligations. The following markets track and perform RECs transactions for both State-mandated and voluntary renewables purchases: Pennsylvania-Jersey-Maryland (PJM), the New England Power Pool (comprised of Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island and Vermont), and the Electric Reliability Council of Texas (ERCOT). The CPUC has solicited public comments on unbundled RECs and held workshops this past September. The CPUC expects to decide on whether to use unbundled RECs for the purpose of RPS compliance by the end of 2008.

Production Tax Credit and Investment Tax Credit: The current Production Tax Credit (PTC) of 1.9-cent per kilowatt-hour (kWh) for the first ten years of a renewable energy facility's operation is set to expire on December 31, 2008. The Investment Tax Credit (ITC) for renewable energy installations will also expire on the same date. Between 1999 and 2004, the PTC had expired on three separate occasions. The PTC's "on-again/off-again" status, coupled with the uncertainty over continuation or expiration, contribute to a boom-bust cycle. This counterproductive cycle plagues the wind industry and negatively impacts development of other renewable resources.

Tax issues, such as who will own the PTC, can affect the financial attractiveness of a project, too. The PTC has thwarted landfill gas projects, for example, especially by companies that have adequate taxable income to take advantage of the PTC. Clean, non-carbon power plants that might otherwise show negative cash flow can become profitable with the PTC.

The ITC for solar PV technologies also experiences "on again/off again" issues, making it difficult for investors and real estate developers to plan their solar projects. At present, the ITC is a 30 percent tax credit for homeowners, capped at $2,500. For businesses, the 30 percent credit is uncapped. While the homeowner ITC expires in 2007, businesses can only take advantage of the ITC through the end of 2008. Unless re-authorized, the lack of an ITC is a significant barrier for large commercial scale solar PV projects.

H. Enabling Technologies: Energy Storage

Energy Storage is the key to California achieving higher penetrations of variable output renewable energy such as solar and wind power in California's supply portfolio. Other types of renewables – such as geothermal and biomass – are base load resources and therefore do not require storage. Some CSP projects will likely be built with heat storage to generate off-peak electricity. The ability of today's primitive electricity grids to absorb intermittent wind power has unnecessary limits. Unless upgraded with storage features, the full potential of wind power will never be reached. Energy storage resources can firm, balance and integrate intermittent renewables into a larger network. Pumped water, compressed air, or battery storage each firm-up wind power, storing energy that can be scheduled to meet customer demand at another time.

Energy storage could cut dependence upon natural gas-fired peaker plants to firm up wind energy. Peakers are a less efficient than wind turbines emit CO_2. Capturing and sequestering CO_2 from a variable output, peaking generation source is far more difficult than for base load natural gas power plants. Energy storage provides emergency power supply and backup and remote area power supply as co-benefits. Coupled with advanced power electronics, storage systems can reduce harmonic distortions and eliminate voltage sags and surges.

Storage technologies are particularly attractive for wind power, in effect overcoming the intermittent and frequently off-peak production profile of wind power. This then avoid

penalties for wind generation falling short of forecasts and enables grid operators to utilize generation that exceeds generation forecasts. With storage, wind power can increase capacity credits, reduce grid connection ratings and boost overall market penetration. Storage can be on-site or at centralized at utility facilities such as the Helms Pumped Storage plant. Utility-scale central storage is much cheaper than on-site storage, but it requires transmission services to transport intermittent generation to the storage site or to meet required demand at load centers.

Technology-Specific Barriers

Financial: The high price of batteries discourages independent wind farm developers from embracing a battery/storage component because it would drive the wholesale electricity prices above competitive rates. Prices of batteries are expected to come down within a decade.

Regulatory: Currently there is a lack of policy recognition that energy storage is a necessary component to successfully using high penetrating levels of intermittent renewable energy. The CA ISO has stated it has a difficult time planning for and integrating inherently intermittent energy sources such as solar and wind, some of which occurs during minimum load conditions. Storage alleviates much of this problem by firming and shifting the resource.

I. Enabling Technologies: Plug-in Electric Vehicles

Plug in hybrid and dedicated electric vehicles (PHE/EV) offer a key way to increase renewable energy consumption and to balance electricity loads around-the-clock. Plug-in hybrid electric and electric vehicles provide an opportunity clean up the transportation sector with electricity generated from renewable resources. It is likely that light-duty PHEV/EVs will reach 200,000 new vehicles sold per year within the coming decade.

The PHEV/EVs are also valuable in that they perform a storage mechanism. PHEV/EVs can also be plugged in at night time to recharge when electricity is both cheaper and cleaner. They could also be plugged in during the day time to provide valuable ancillary services to the grid at potentially significantly lower costs than other current options. This two-way energy distribution requires a more advanced electric grid – the Smart Grid – than is in place today. The Smart Grid (described in section below) would be a key advance allowing California to get the most value from society's growing investment in PHEV/EV technology.

Running cars on electricity from today's U.S. power grid (which is about 50 percent coal-fired) instead of liquid gasoline or diesel fuels cuts overall GHG emissions from 22 percent to 61 percent. Why? Because most battery-charging takes place overnight, when power demand drops dramatically and utilities have excess generating capacity, an effect known as "valley filling." A December 2006 study by the U.S. Department of Energy's Pacific Northwest National Laboratory (PNNL) concluded that such off-peak utility generation and transmission could power 84 percent of the 220 million vehicles in the

United States if PHEVs. In its detailed nationwide analysis of (GHG) impacts of plug-in hybrid electric vehicles, EPRI also concluded that switching to PHEVs can reduce GHG emissions significantly, potentially reaching a maximum cumulative reduction of 612 million metric tons by 2050 (High PHEV fleet penetration, Low electric sector CO_2 intensity case).

The actual GHG reductions attached to a comprehensive PHEV/EV program depends upon how clean the regional electricity grid is. (This fact means plug-in hybrids will be cleaner than hybrids! A plug-in with a 40-mile range could cut carbon dioxide emissions about one-third compared to a gas-electric hybrid.) Since California has a cleaner electricity supply than the rest of the U.S., the contribution of a robust PHEV/EV effort to storing renewable energy would no doubt be significant. California could also provide a superb model for a national-scale PHEV/EV program.

Technology-Specific Barriers

Technological: Continued improvement is needed regarding capacity, durability and enhancement of current grid infrastructure to enable multidirectional flows of both power and the data necessary to monitor and manage the power.

The battery types for PHEV/EV include nickel-metal hydride (NiMH), currently used in conventional hybrids, and lithium-ion (Li-ion). Li-ion batteries are smaller and lighter than NiMH, though they cost more and may not be as safe or durable. When operating on liquid fuels, the heavier batteries can pose a weight penalty. Additional R&D is need for longer-lasting batteries and greater electric-only range.

The traditional problem with lithium-ion batteries is that they heat up too much (known as “thermal runaway”), but some battery manufacturers are using nanotechnologies and new materials such as phosphates to address the heat problem and reduce weight as well. The challenge and opportunity is scaling up lithium-ion technology to store and deliver enough power to run a car, while controlling thermal runaway. Durability is also a problem with the lithium-ion battery, as it tolerates only 750 cycles of discharge and recharge, or about two years of service, before deterioration of the terminals carrying power reduces charge capacity by 20 percent. Nano-batteries promise to boost these numbers to 9,000 cycles and a 20 year lifespan.

Financial: The operating costs of PHEV/EV in electric-only mode are much lower than liquid fuel vehicles, but the upfront costs for a PHEV/EV are much higher. At present, the price premium is in the $7,000-10,000 range. Much of the higher upfront cost can be traced to batteries.

Institutional: The actual fuel and climate benefits from PHEV/EV depend on a variety of factors, such as the amount of time the vehicle is operating in electric mode, the generation mix of electricity used to produce the electricity, time when the user is charging the car, and whether the excess capacity in the grid can be used.

Regulatory: Fuel electricity for PHEV/EV requires a special treatment compared to other electricity because it represents a potential cross-sector transfer of emissions. As electric transportation load grows, emissions that would otherwise have been the responsibility of the transport sector will shift to the electric sector, even though the overall impact to the environment is positive. An AB32 GHG emissions cap for the electric sector, absent mitigating measures, will make this otherwise desirable shift a liability for the complying entities. This will serve as a powerful disincentive for the energy sector to take actions that encourage the use of electricity to support the transportation sector. In order to reduce this disincentive, it is important that a policy be implemented that makes complying entities neutral with regard to incremental transportation load and emissions cap compliance under AB 32.

K. Enabling Technologies: A Smart Grid

The widespread deployment of PHEV/EV, distributed generation and end-use efficiency devices requires a "smart" and interactive grid taking advantage of State-of-the-art communication infrastructure. Today's transmission system was only designed to transmit energy from central generating source to the point of consumption. This delivery system stands to benefit radically from evolution of the Internet and modern material sciences. A modernized grid would also improve operational security and allow increasing amounts of distributed resources to be developed near points of consumption. This would diminish overall system energy losses and thereby multiply carbon savings. If PHEV/EV become common place and distributed solar PV applications become standard applications, the energy grid must become interactive. The grid will evolve into network in which energy can be both delivered and received. Two-way flow of energy and data would also allow customers to respond to price signals to reduce usage at peak times, when the lowest efficiency fossil-fired units are operating (and GHG emissions reach their highest levels.)

Technology Development

A range of technology exists today that can improve the grid such that reliability and efficiency is improved, and cleaner, distributed energy resources are better integrated, including new smart meters, remote sensors, energy-management systems, better transmission lines, and advanced storage technologies that serve to optimize electricity generation, dissemination, and usage.

NREL has described some of the major characteristics for a smart modern grid, including:

- *Self-healing*: A grid that can rapidly detect, analyze, and respond to problems, and restore service quickly.
- *Empowering the Consumer*: A grid able to incorporate consumer equipment and behavior in its design and operation.
- *Attack-Tolerant*: A grid that stands resilient to physical and cyber security attack.

- *21st Century Power Quality*: A grid that provides a quality of power consistent with Digital Age consumer and industry needs.
- *Generation Options*: A grid that accommodates a wide variety of local and regional generation technologies, including clean sources such as solar, wind, biomass, geothermal, and small-scale hydroelectric.

The electricity carrying capabilities of the grid will benefit from nanotechnology, which could provide "quantum wires" that could conduct electricity up to 10 times more efficiently than traditional copper wire and weigh one sixth as much. NASA has funded a 4-year, $11 million effort to create a prototype at Rice University in Houston, Texas. Alternatively, superconductors used for both energy storage and transmission and distribution wires could provide significant advantages in energy storage and transmission.

Technology-Specific Barriers

Financial: Lack of financial incentives for utilities to invest in new grid infrastructure.

Regulatory: Traditional regulation with uncertainty around cost recovery provides economic disincentive for utilities to invest in new smart grid technologies.

L. Enabling Technologies: Carbon Capture and Sequestration

Carbon capture and Sequestration (CCS) refers to the separation of CO_2 from industrial and power generation sources and transport to storage locations for long term isolation from the atmosphere.

Three technologies are available for carbon capture: pre-combustion, oxy-fuel combustion, and post-combustion systems. At present, none of these three technologies have been commercialized for applications at power plant scale:

- Pre-Combustion systems apply to *Integrated Gasification Combined Cycle* (IGCC) plants. The coal is first gasified into a syngas which is then treated to remove CO_2. The resulting hydrogen gas is mixed and combusted in a gas or hydrogen turbine.
- *Oxyfuel-Combustion* systems utilize high-purity oxygen rather than air in the combustion process, which yields a highly concentrated stream of CO_2 and water vapor. The water vapor is condensed for removal and CO_2 is thus captured.
- *Post-Combustion* systems separate and capture CO_2 after the combustion of fuel in air in conventional and advanced power plants. Solvents are used to remove the low concentrations of CO_2 from the plant's flue gas.

Carbon sequestration is the process of permanently storing captured CO_2 from point sources in geologic formations and terrestrial systems. Carbon sequestration in oil and gas fields, including for Enhanced Oil Recovery (EOR), has been practiced for decades

and is therefore is a fairly mature technology[31]. In EOR, CO_2 is injected into oil reservoirs to reduce the oil's viscosity, i.e. improve the oil's flow rate, and thus enhance oil extraction. The CO_2 in the produced oil is captured and re-injected and ultimately sequestered below the earth's surface. The demand for additional CO_2 is expected to increase as production from existing oil, using conventional means, declines and oil prices continue to remain high. However, the demand for CO_2 for EOR is significantly less than the amount of CO_2 that is expected to be permanently sequestered to meet long-term target levels[32]. There is significant potential in other geologic sequestration options, such as, saline formations, deep coal seams, basalt formations, oil shales and salt caverns. However, these technology options are still at various stages of research, demonstration and commercialization.

Technological Developments

Pre-combustion capture is widely applied in fertilizer manufacturing and in hydrogen production. The initial fuel conversion in pre-combustion systems is more elaborate and costly; however, the higher concentration of CO_2 in the gas stream and higher pressure make the separation easier. Oxyfuel combustion is still in the demonstration phase. The use of high purity oxygen results in high CO_2 concentrations in the gas stream and thus easier separation. However, it also requires increased use of energy to separate oxygen from air. Post combustion capture of CO_2 in power plants is well understood and used in selected economically feasible, commercial applications; however, the CO_2 in the exhaust is more diluted and thus capture is more costly. Separation of CO_2 in the natural gas processing industry, which uses similar technology, is already mature.

Within each aforementioned system category, there are numerous emerging technologies which offer the potential for major incremental improvements in cost and energy required as compared to commercially available capture technologies. These emerging capture technologies include chemical and physical absorbents, solid dry scrubbing with physical adsorbents or chemical absorbents, cryogenic methods, and gas membrane separation.

In addition, well-drilling technology, injection technology, computer simulation of storage reservoir performance and monitoring methods from existing applications are being developed further for utilization in the design and operation of geological storage projects.

In California, the West Coast Regional Carbon Sequestration Partnership (Westcarb) is conducting a CO_2 storage pilot project in the Rosetta gas field near Thorton, California, testing CO_2 storage within the context of an EOR project. The project will validate the sequestration potential of California Central Valley sediments, focusing on overcoming current monitoring challenges.[33] Monitoring is an important issue to ensure that CO_2 injected into geologic formations remains securely in safe storage.

One interesting sequestration technology in is an emissions-to-biofuels pilot that uses an algae bioreactor system connected to the flue gas of a generating station. The system grows algae by absorbing CO_2 in the exhaust stream. Algae is then processed into

biodiesel and other products. Past successful pilot phases have spurred Arizona Public Service, in conjunction with NREL, to create a larger scale pilot project, ultimately hoping to bring this technology to market scale. Though CO_2 is emitted when the biodiesel is combusted, it displaces emissions that would have resulted when dirtier diesel fuel was burned. One of the challenges of this innovative, sector-crossing technology will be accounting for the avoided GHG emissions. A "Business as Usual" scenario would produce GHG emissions from both the power plant and the diesel engine. The algae bioreactor system reduced the emissions from the combined system and that reduction should either be credited to the power plant or the transport sector, but certainly not both.[34]

A variation on this technology circulates turbine exhaust gas through algae in an open pond (compared to a closed bioreactor) to produce spirulina to be used as a dietary supplement (compared to a biodiesel feedstock), reducing capital costs and eliminating the accounting issues. Testing multiple methods of using the same technology will help determine what variables are the most valuable in creating a sustainable carbon reduction technology.[35]

Other proposals presented to the ETACC energy subgroup would use acceleration or enhancement of naturally-occurring chemical and biological reactions to effect carbon capture and sequestration. One proposal would combine limestone and CO_2 to create a slurry of bicarbonates to be disposed of by dissolving it in the ocean. Two other proposals would create enhanced plankton growth by seeding parts of the ocean with iron particles. The new plankton would absorb CO_2 and become part of the food chain, eventually resulting in carbon-containing organic matter accumulating and sequestering on the ocean floor. These proposals are of interest, but require much more study before implementation in California. The sensitivity and critical importance of the ocean ecosystem require that any actions involving this sensitive environment be carefully researched for irreversible consequences before implementing.[36]

CO_2 Abatement Potential

Technology is available to capture 85-95 percent of the CO_2 processed in a capture plant. After accounting for the energy needed for capture and compression, a plant with CCS could reduce CO_2 emissions by approximately 80-90 percent compared to a power plant without CCS. The IPCC says that CCS has the potential to abate carbon dioxide (CO_2) emissions between 15 and 55 percent of the cumulative mitigation effort needed by 2100.

Technology-Specific Barriers

Technological: Many component technologies for CCS have already been developed, but both the size and number of demonstration projects are very small with respect to the scale that will be necessary to mitigate significant future CO_2 emissions. While carbon capture has been successfully demonstrated for industrial processes, the utilization of CCS for large-scale power plants still remains to be implemented. There is relatively little experience in combining CO_2 capture, transport and storage into a fully integrated CCS

system, though various government and commercial efforts are underway around the world, including promising ones in California.

Another major consideration is the highly diverse nature of potential storage sites, which differ widely in their geologic characteristics, potential for economic co-benefits, and geographic distribution. Terrestrial sequestration is low-cost and has environmental co-benefits, but capacity and storage life are limited compared to the geologic option. There could be potential leakage if previously drilled oil and gas wells were not sealed appropriately. Saline formations provide the most promising storage option due to its large aggregate CO_2 storage capacity and minimal number of existing well penetrations. Given that power plants are widely dispersed geographically, deep saline formations will be important reservoirs for CO_2 wherever they can be put to no other beneficial use (such as enhanced oil and gas recovery or injection for coal bed methane production).

A major challenge is the permanence of carbon sequestration, which must be demonstrated to a high level of accuracy[37]. In addition, the stored carbon must be continually monitored, and systems must be in place to verify and mitigate any harm caused by leakage.

Financial: Retrofitting existing power plants with CO2 capture is expected to lead to higher costs and reduced overall efficiencies, though some of the cost disadvantages may be reduced in new and highly efficient plants or where a plant is substantially upgraded or rebuilt.

Geologic sequestration offers large capacity and potential permanence, but capture costs are high and assurance of no adverse environmental impacts is required.

Activities undertaken for CCS purposes generate liability issues. Indeed, the activities involved in CCS could bring about potential liabilities for nuisance, trespass, negligence, breach of statutory duty, and waste disposal issues. Potential legal liability could arise at any stage of the CCS process. The long term nature of the carbon dioxide storage also creates special considerations in terms of liability. Insurance companies can mitigate near-term risks, but insurance companies will not cover long-term (greater than 100 years) risk. Efforts by government to assuage the liability risk would go far in terms of attracting investment.

Energy required for post-combustion CO_2 capture in power plants could reduce net output by 10 to 40 percent.[38] A newly completed NETL study shows that on average, addition of post-combustion CCS technologies reduced a pulverized coal plant's thermal efficiency by 13 percent, hiked capital costs of the facility by 73 to 90 percent and increased the cost of electricity produced by the plant by 60 to 70 percent. Such enormous cost increases clearly highlight the need for investment in RD&D aimed at slashing costs of CCS technologies. After all, CCS is seen as key to the future of current U.S. coal- fired power plants, which are heavy CO_2 emitters, but currently provide about half of the nation's electricity.

Institutional: Carbon capture in itself will not provide value unless the accompanying infrastructure to transport and sequester the captured carbon, as well as monitor and manage the sequestration sites is in place.

Transportation of CO_2 from the point of capture to the point of geologic injection for storage poses fewer technical unknowns, with dedicated CO_2 pipelines already commercially established. Yet it appears there may be deployment barriers in siting issues and the sheer scale of the major new pipeline networks that will be necessary to carry compressed CO_2 from power plants to injection wellhead locations. Currently, there are thousands of miles of CO_2 pipelines in operation in the United States. These pipelines are regulated by the Department of Transportation to ensure integrity and safe operation. To overcome siting obstacles that might impede CCS projects, the State of Texas recently passed HB 1967 to grant common carrier status to CO_2 pipelines; thereby providing the option for right of eminent domain for securing Rights Of Way for pipes linked to gasification projects, including feedstock/coal slurries and any outputs such as methanol, CO_2, H2, etc.

An entirely new gathering and distribution infrastructure will need to be built to compress and safely transport CO_2 dioxide to appropriate geological formations and inject it deep beneath the Earth's surface. The US appears to have the world's greatest CO_2 sequestration potential. However, these formations are not evenly distributed throughout the country. Fully developing a system of permanent CO_2 geologic sequestration sites will require the US to build a vast interstate pipeline system somewhat similar to the natural gas pipeline system that has been created over the last century. Injection wells must be drilled several thousands of feet below the Earth's surface. This will require massive investments in commodities, industrial products and labor.

The public is generally unfamiliar with CCS; thus, education and outreach would be needed to dispel misconceptions and garner public support. Commercialization of CCS technologies will require continued deployment of pre-commercial technologies. Key challenges include the willingness to bear the initial high cost and potential risks of first-generation systems. Developing a track record, as well as continued technical advances to build up the required infrastructure, are also important factors.

Regulatory: Regulatory uncertainties currently pose a barrier for CCS. For example, it is not clear whether underground injection of CO_2 is under Federal EPA or State agency jurisdiction. Some States have begun regulating experimental wells for CCS research. The EPA announced in 2006 that it will issue permits for the DOE Regional Partnership CCS projects under the UIC Code Class V for experimental wells. However, the EPA has indicated that it may reclassify experimental wells for CCS research if and when they are put into commercial operation. A reclassification could impact the costs and permitting hurdles for CO_2 injection projects. This policy change certainly is needed sooner rather than later if commercialization of CCS is to proceed and succeed.

Access and liability issue present another challenge. Different states have different laws regarding land rights and mineral rights. Developers must negotiate varying regulations

and ownership issues regarding land rights and mineral rights in order to gain access to underground storage with each State government. In addition, long-term retention of stored CO_2 will require approval of monitoring techniques and standards at various governmental levels and acceptance by insurers.

Federal and State governments must develop or revise its legal and regulatory framework to support these investments, because CCS raises new legal and regulatory challenges for project developers. These challenges and potential risks are not yet fully understood, nor are uniform standards or government regimes in place to address and mitigate them. Among the key questions to be addressed in the development of a consistent regulatory framework for CCS are: immunity from potentially frivolous criminal and civil environmental penalties; property rights, including the passage of title to CO_2 (including to the government) during transportation, injection and storage; government-mandated caps on long-term CO_2 liability, insurance coverage for short-term CO_2 liability; the licensing of CO_2 transportation and storage operators, intellectual property rights related to CCS, and monitoring of CO_2 storage facilities. California should address the emerging legal and regulatory issues associated with CCS. Until a regulatory permitting legal structure is developed and the issue of liability risk is addressed, it is highly unlikely that large-scale carbon sequestration can be achieved. In this regard, among the options California should explore is that adopted by Texas, which transfers the title (and any liability post-capture) to CO_2 captured by CCS to the Railroads Commission of Texas. Public acceptance will be crucial; potential risks to human health or to ecological systems, and associated mitigation measures, must be quantified and communicated.

M. Next Generation Advanced Gas Turbine Technologies

Clean, flexible, natural gas-fueled resources are necessary to tie diverse portfolio of renewable resources together. California should procure a portfolio of generating resources that can ramp up quickly, have short start up and shut down times, and have fast response for frequency control. Natural gas generation can support intermittent renewable resources.

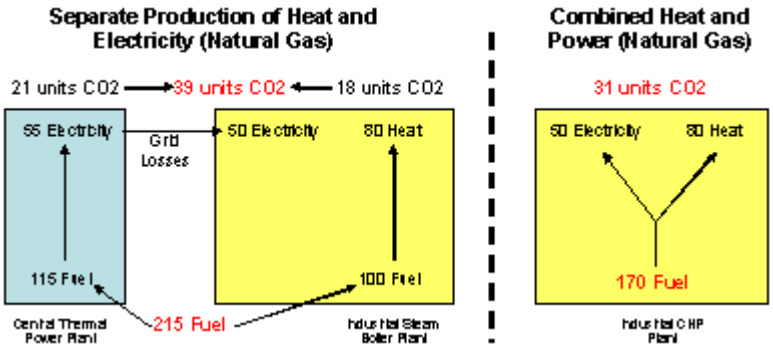
Recent procurement decisions made by PG&E reflect the types of gas-fired assets that are necessary: three highly-flexible combined cycle plants (up to 300 starts per year), three additional simple cycle gas turbines and two reciprocating engine farms. These operations have unprecedented operating flexibility, providing a better air emissions profile than power plants now being retired.

New technologies have been proposed to improve the efficiency of new and existing gas turbines in base load and peaking applications. They face a common hurdle in the energy sector: the cost and risk of trying new technologies. The capital investment is high, so risky new facilities or hardware that add any performance risk are difficult to bring to market.

N. Combined Heat and Power

Combined Heat and Power (CHP) plants -- also known as cogeneraters – are defined as follows: the efficient use of energy in a heat engine or a power station to simultaneously generate both electricity and useful thermal energy for heating, cooling or dehumidification. CHP results in a reduction of CO_2 emissions by avoiding the use of fuel and by using fuel efficiently in the production of electrical and thermal energy.

CHP avoids the use of fuel by combining what would otherwise be stand-alone production facilities – e.g., steam boilers and centralized electrical generation – into a single process. A natural consequence of combining production of thermal and electrical energy can cut GHG emissions by as much as a 20-25 percent.



There are two types of CHP employed in California. "Topping cycle" CHP captures the byproduct heat from electrical generation for domestic or industrial heating purposes. Byproduct heat at moderate temperatures (100 to 180°C) can also be used in absorption chillers for cooling. By capturing the excess heat, CHP uses heat that would otherwise be emitted into the environment. Topping cycle CHP can reach an efficiency of 80 percent or more, compared with the 50 percent efficiency typically found at new, conventional gas-fired base load power plants. The other type of CHP facility is a "Bottoming Cycle" plant are more efficient than conventional gas-fired facilities by virtue of capturing process waste heat to generate electricity. Both types of CHP have a wide range of applications, both large and small.

Historically, California has been a leader in the development and installation of CHP projects. Large scale topping cycle CHP facilities have been installed in California at paper and glass manufacturing plants, food processing, refineries, thermally enhanced oil production operations and other industrial locations. Bottoming cycle plants support other California industrial processes, such as petroleum coke calcining operations. Smaller scale projects can be found at schools, hospitals, prisons and other commercial sites. There are currently over 9,200 MWe of CHP installed at 900 sites throughout California. By 2020, California could add between 2000MWe and 7300MWe of new CHP capacity, resulting in CO_2 reductions of between 1.5 million and 6 million tons per year.

A properly designed and sized CHP system can reduce CO_2 emissions by 20 to 25 percent compared to separate processes for generating electricity and thermal energy. If

these CHP facilities rely upon renewable fuels, additional GHG emission reductions occur.

Small-scale CHP systems already receive numerous incentives, including exemptions from various charges (such as standby for systems under 5 MW), and favorable natural gas transportation rates. Support for Standard Offer contracts under the federal Public Utilities Regulatory Policies Act of 1978 led to large scale CHP development in the 1980s and 1990s.

Despite this historic support, CHP currently faces regulatory tensions and, consequently, commercial barriers. First, an optimal CHP plant sizes to meet the industrial host's thermal, not electrical, load and therefore may have surplus electricity for sale. CHP facilities today face difficulties obtaining power sales agreements with utilities to take limited amounts of non-dispatchable electricity generated by the project, especially as utilities add non-dispatchable, base load renewables. Second, there are policy tradeoffs between efficiency and ratepayer equity resulting in long standing debates between utilities, CHP generators and various classes of ratepayers over standby rates, cost shifting and rate design. Third, the ratepayer equity concerns have led to customer load served by CHP facilities facing material "departing load" charges or exit fees when the facility becomes operational. The cumulative impact of these issues can make the difference between a project that can and cannot meet a required hurdle rate. These challenges may be further exacerbated with the implementation of AB 32 to the extent CHP owners are asked to bear the costs of electricity generation directly, while other industrial sites experience only indirect and diluted carbon mitigation costs.

These are not new issues presenting insurmountable regulatory barriers. California can eliminate these barriers by first creating a viable carbon market, which properly accounts for CHP benefits, and then weighing the tradeoffs between utility portfolio needs, ratepayer equity, and efficiency to address power sales regulations and departing load.

O. Oxyfuel Combustion

If compared to post-combustion carbon capture, Oxyfuel Combustion is the preferred means of capturing carbon from natural gas power plants. CO_2 separation is more costly due to the low concentration of CO_2 in the exhaust in post-combustion systems. With Oxyfuel Combustion, air is excluded from the combustion process such that the products of combustion are nearly pure CO_2 and water. Thus, the CO_2 can be easily isolated simply by cooling the flue gases. The same process could also be applied to fuels such as natural gas, coal syngas, landfill gas and biogases (as well as inexpensive aqueous fuels such as emulsified refinery residues and glycerin from bio-diesel production.)

There are various oxyfuel projects in demonstration phases. In California, a project is underway with Clean Energy Systems (CES) to develop the nation's first natural gas zero-emission power plant (ZEPP) looks promising. The core of CES' process is an oxy-combustor or "gas generator" adapted from rocket engine technology. The gas generator burns gaseous fuel with oxygen in the presence of water to produce a steam and CO_2

mixture at extremely high temperature and pressures. If uncontrolled, the combustion temperatures could reach 6000° F, causing the gas generator to melt. Water is injected to prevent this from happening.

The efficiency of initial demonstration power plants will not be that impressive: only 25 percent to 30 percent. But the opportunity is there to increase the overall efficiency to 60 percent when steam turbines that can handle 3000° F steam become commercially available. One of the biggest challenges associated with bringing this technology to market will be to improve the cycle efficiency by working to develop steam turbine technology capable of cost effectively operating at very high temperatures.

P. Advanced Coal Technologies

Coal currently accounts for more than half of the electricity generated in the United States and more than three-quarters of the electric supply in China. It is also the dominant fuel source for power production in India. Because coal is such an important resource in to so many major economies throughout the world, the development and deployment of affordable, efficient new coal technologies that produce less CO_2 is critical to climate change response strategies designed to avoid global economic instability.

In recent years, Californians have received an estimated one-fifth of its total electricity supply from coal-fired power plants located across the interior West. In addition, California utilities have an equity interest in more than 4,500 megawatts (MW) of coal-fired power generation nameplate capacity located out of state. These coal-fired units provided about 27 TeraWatt-hours (TWh) of electric energy to California in 2003. That same year, an additional 32 TWh of electricity generated by other coal plants in the interior West was estimated to have been sold into the California market.

Governor Arnold Schwarzenegger announced a new partnership in April 2006 with Governor Freudenthal of Wyoming by signing a Memorandum of Understanding (MOU) supporting the development of advanced coal technologies with the goal of improving the availability, diversity and stability of California's electric energy supplies. Since then, a number of utility executives and representatives from the CPUC have met to discuss the advancement of clean coal technologies. Early discussions have centered on California and Wyoming working together to prove the viability of Integrated Gasification Combined Cycle (IGCC) power plants using CCS equipment. If this first of a kind commercial demonstration is successful at its Wyoming site, California could obtain electricity generated by a clean coal technology that would meet its new GHG emission performance standard for electricity generation imports.

Advanced coal technologies, coupled with effective CCS, represent a critical element in an overall energy strategy that seeks to promote both energy security and environmental sustainability. Coal, which is both cheap and abundant, is well-suited to meet the former objective, but, absent CCS, will actually undermine the second goal of reducing GHG emissions. Demonstration projects offer potentially vast public benefits as California and the rest of the nation move to reduce our dependence on foreign energy sources and

address climate change. More broadly, the development of this technology can play a fundamental role in combating climate change globally through technology transfer to nations such as China and India, which remain largely dependent on coal.

Most power plants today use Pulverized Coal (PC) technology, in which the coal is finely ground, mixed with air, and blown into a boiler for efficient combustion. High-pressure steam produced in the boiler passes through a steam turbine, which drives an electric generator. The pressure and temperature of the steam produced in the boiler are often used as shorthand to characterize the design features of these coal-fired plants. Currently, the majority of coal-fired boilers in the United States are sub-critical, which means that the pressure and temperature are below the critical point of water. Subcritical plants are well established and relatively easy to control, with overall energy conversion efficiencies in the range of about 30 percent to almost 40 percent, a calculation based on the higher heating value of the coal.

Technological Development

Higher efficiencies can be achieved by increasing steam temperature and pressure to supercritical conditions. Some 400 supercritical coal-fired power plants are currently operating around the world, including a large US fleet. To prevent premature wear, supercritical plants require careful control of water chemistry and metal temperatures, but today they are just as reliable as subcritical plants. To gain further efficiency, so-called Ultra-Supercritical (USC) plant designs have been introduced in Europe and Asia and are now being developed for the US as well. Steam temperatures in initial USC units will be about 1100F (600°C), with the goal for future designs being 1400°F (760°C) or higher, which translates to an energy conversion efficiency of approximately 50 percent. As USC plant designs cross the 1250°F (670°C) threshold, they will require more expensive nickel-based alloys for high-temperature components. A sustained commitment to materials technology development is needed to produce these advanced alloys, address field fabrication and repair issues, gain approval from industry standards organizations and insurers, and optimize plant designs for their widespread use.

Developmental advances are also under way for two other direct combustion technologies:

- Circulating Fluidized-Bed (CFB) systems are already being selected for new generation capacity, especially where inexpensive, hard-to-burn fuels such as lignite and solid waste are available. CFB plants operate at relatively low temperatures and thus produce less NOx in the boiler than PC plants, avoiding the need for catalytic post-combustion controls. In addition, the aerodynamically suspended “bed” of a CFB boiler is fed with a sorbent (usually limestone particles) to remove SO_2 pollutants. This approach produces a bit more CO_2, however, which puts CFB technology at a disadvantage relative to PC plants under stringent carbon emissions constraints.

- Coal Oxy-combustion – the burning of pulverized coal in pure oxygen separated from air – has emerged as a potential combustion option for the future. The resultant flue gas has a high CO_2 concentration, mixed with water vapor, particulates, residual oxygen, and SO_2. This alternative is attracting increased attention because the high-concentration CO_2 stream would be more amenable to separation for long-term storage. Advances in systems that can properly manage oxygen combustion and CO_2 recycling and purification will require additional development work before full-scale demonstration, and new methods of oxygen production may be needed to make oxy-combustion technology economical.

Q. Integrated Gasification Combined Cycle

Referenced earlier, Integrated Gasification Combined Cycle (IGCC) technology is designed to combine a chemical gasification process with traditional combustion turbine based processes to generate electricity at comparatively high rates of efficiency and low emissions levels. In the IGCC process, the fuel (e.g. coal, petroleum coke, or biomass) reacts with oxygen and steam under high temperature and pressure to form a combustible gas composed mainly of hydrogen and carbon monoxide. This "synthesis gas" is cooled, cleaned, and then combusted in a gas turbine. In a combined (gas and steam) cycle, the hot exhaust from the gas turbine passes though a heat recovery steam generator, which produces steam that drives a second turbine. Because of the heat recovery, IGCC plants can operate at efficiencies approaching 45 percent. IGCC technologies have improved efficiencies compared to traditional PC plants. The overall efficiency of an IGCC plant depends on the particular gasifier technology employed and the type of coal. Improvements in overall efficiency translate into reductions in CO_2 emissions; for every one percent of efficiency gain, a plant produces about 2 percent less CO_2 per kWh. A generic IGCC plant has a CO_2 emissions rate of 1600-1760 lb/MWh as compared to a rate of 2000 lb/MWh for a conventional coal plant.

Use of nitrogen diluents in the gas turbine combustor limits NOx production to about 10 ppm. SO_2 emissions are low as well because of sulfur removal rates greater than 99 percent during synthesis gas cleaning prior to combustion. IGCC has the added advantage of being amenable to the addition of what is known as a water shift reactor downstream of the gasifier to produce a synthesis gas with mostly hydrogen and CO2. Commercial processes from the chemical industry can remove CO2 more economically in this relatively concentrated, high-pressure form than they can remove it from a diffuse flue gas stream at ambient pressure, such as occurs in pulverized-coal (PC) boilers.

Technology-Specific Barriers

Technological: The basic IGCC concept was first successfully demonstrated at commercial scale at EPRI's Cool Water Project from 1984 to 1989. However, IGCC is not yet considered a commercially viable technology for coal at this time, though there are IGCC plants operating in the US and worldwide[39] utilizing a variety of solid fuel feedstock, including petroleum coke. Worldwide, there are four operational coal-based

IGCC electricity generating plants with generation capacity of roughly 250 MW each;[40] however, none of these plants captures or sequesters carbon dioxide. Unfortunately, these coal plants have not consistently achieved capacity factors comparable to readily available supercritical PC plants.

Most of the information on the operation of IGCC technology is based on the use of higher ranked, higher heat content bituminous coal or pet-coke. Lower ranked subbituminous and lignite coals, which feature lower heat content and greater moisture content, can be gasified, but at lower efficiency. The industry needs significantly more experience working with these coals, especially given the quantity of these types of coals in the western US.

The application of IGCC at higher altitudes also presents unique issues that must be addressed given that a large quantity of low rank coals are found in elevations that exceed 4,000 feet. The output of a combustion turbine is reduced approximately 3 percent with every 1,000 feet increase in altitude[41]. For a project operating at 5,000 feet (which would apply to much of PacifiCorp's generating fleet in the Rocky Mountain region), output losses would be a significant 15 percent. In simple terms, this increase in elevation results in a reduction in output, although the capital cost is essentially the same. Relocating power plants to a lower altitude and moving the electrons by wire may seem a reasonable option, but this would move the generation away from many of the most potentially suitable carbon sequestration sites in the US. It would also require moving more coal by rail. It is important to note that supercritical PC plants do not suffer the same output losses at altitude and are therefore considered to be an excellent choice for these applications.

Financial: No large scale, utility-size IGCC plants has been built, and much of the current installed technology is in limited use. As such, vendors are unwilling to provide price and performance guarantees. Many utilities are unwilling at this time to expose their customers to these risks. Electricity from the first group of U.S. IGCC plants is expected to cost about 15- 20 percent more than that from conventional PC units with SO_2 and NOx controls, assuming no CCS requirements. Through active product development by the equipment suppliers, this cost differential may be reduced or eliminated, at least for high-rank coals. For low-rank coals, lignite, further design improvements will be needed to make IGCC more competitive. In addition, an extensive and costly front-end engineering design (FEED) study is required to obtain reasonably accurate estimates of the cost of building an IGCC plant.

R. IGCC with CCS

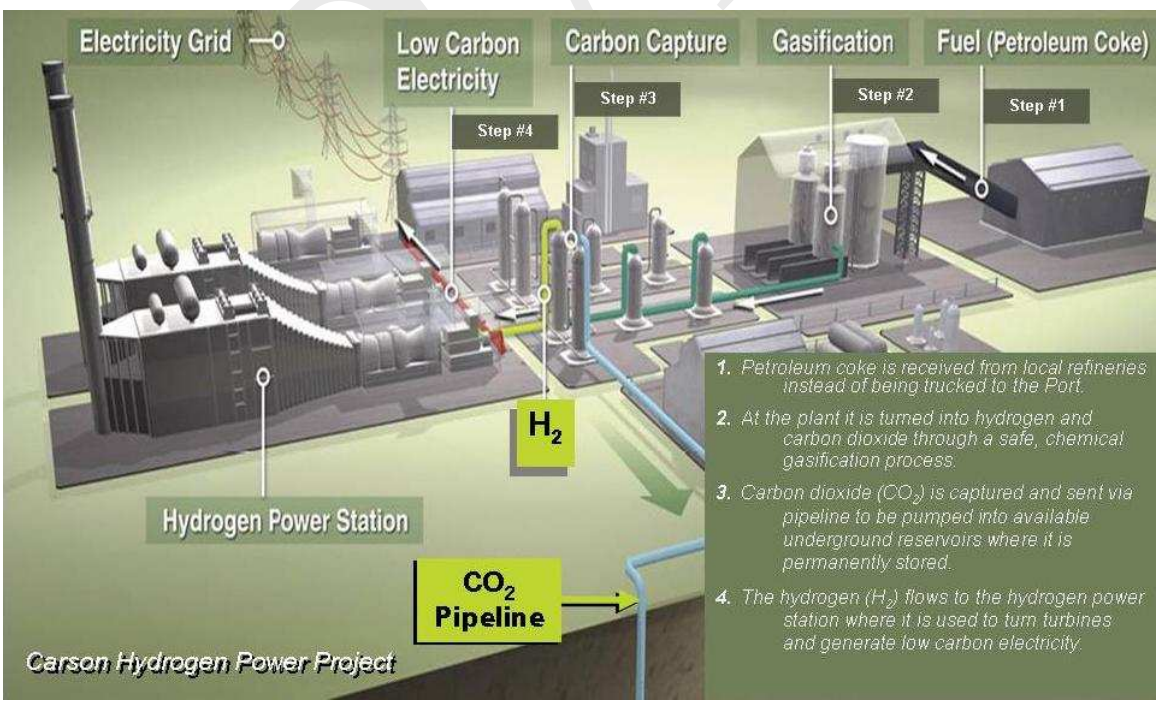
IGCC technology and CCS are two different processes. IGCC describes a highly integrated two-step process: (1) gasification to produce a gas-based fuel that can be burned in a combustion turbine; and (2) power generation. CCS is a potential complementary add-on to this technology that would convert the carbon in the synthetic gas to CO_2, separate and compress it, and ultimately inject it deep beneath the Earth's surface for permanent sequestration. As described in Section L above, CCS is also a two

step process : (1) CO_2 is captured from the air, a fuel or exhaust; and (2) then transferred into a natural sink (trees, algae, carbonate etc.) or injected into geologic formations for long term storage. CCS will play an important role in climate change response strategies given the world's continued reliance on fossil fuel. There are a variety of "pre" and post combustion", mechanical, chemical, and natural carbon capture technologies that are current available or under development. [42]

Technology Development

Hydrogen Energy, a joint venture between BP, Rio Tinto and Edison Mission Group offered a joint proposal to build a new hydrogen power plant for Carson, California. The plant will convert carbon-rich petroleum coke into hydrogen gas and CO_2 through a chemical gasification process. The hydrogen gas will then be used to fuel a combined cycle power plant to generate electricity. Approximately 90 percent of the CO_2 is expected to be captured and sent via pipeline to be pumped into available underground reservoirs for long-term storage, eliminating 4.5 million tons/year of GHG emissions. The plant will be located adjacent to the existing refineries in the Carson area and will utilize the petroleum coke that is produced as a by-product of local oil refining.

Currently, petroleum coke is trucked from refineries in the region to the ports where it is loaded on ships for export to other nations to be burned directly as a fuel. The Carson Project will reduce truck trips and diesel emissions associated with the petroleum coke trade. It will also ensure that the CO_2 emissions associated with the use of petroleum coke abroad or at home is captured and prevented from being released into the atmosphere.



SCE has filed an application with the CPUC requesting permission to assess siting and design for this coal-based hydrogen fired IGCC linked to CCS

Among emerging options for large-scale CO_2 removal are new chemical solvents, alternative physical/chemical separation methods, novel systems based on mineralization processes, and concentration of CO_2 in flue gas via high-oxygen combustion or chemical looping. EPRI is currently evaluating these options and intends to develop appropriate-scale projects to speed the validation and deployment of this promising technology and to improve the economics of integration with coal power plants.

One particularly promising new CO_2 post-capture technology is the chilled-ammonia process. The current monoethanolamine (MEA) process for removing CO_2 from the flue gas of a PC plant has several disadvantages, including low CO_2 loading capacity of the absorbent materials and high energy consumption during absorbent regeneration. The chilled-ammonia process increases loading capacity at lower temperatures by using high concentrations of ammonium carbonate absorbent. It then saves energy by regenerating the absorbent at high pressure. Early data from laboratory-scale equipment indicate that removing CO_2 from a PC plant using the chilled ammonia process may reduce electricity output by only l0 percent, compared with 29 percent for the MEA process. Because of these promising early results, EPRI is working with Alstom to build a 5-MW chilled ammonia pilot test facility, expected to begin operation in 2007 and provide capture test results in 2008. A CO_2 storage test could follow in 2009.

In addition to the technical issues associated with CCS there are a series of legal and regulatory issues which will need to be addressed as to property rights, long term liability, permitting and regulatory consistency. [43] These issue are not unique to California, but are arising on an international scope[44] Texas recently enacted legislation addressing the property rights and long term liability associated with CO2 sequestration.

Applying CCS technology to the CO_2 emissions streams of fossil fuel-based electric generation represents a challenge for the US and the world. The EPRI's February 2007 research paper, *Electricity Technology in a Carbon-Constrained Future*, demonstrates that successfully deploying CCS technology provides the single largest "wedge" of carbon emissions reductions that could be achieved by the electric utility industry in meeting a goal of reducing 2030 emissions levels to 1990 levels. It is clear that broad commercial deployment of CCS technology is the critical component of achieving long-term reductions in GHG emissions, both domestically and internationally. The recent MIT study, *The Future of Coal*, also endorses this course of action: "We conclude that CCS is the critical enabling technology that would reduce CO_2 emissions significantly while also allowing coal to meet the world's pressing energy needs." The Western Governors Association and the US Council of Mayors have both adopted resolutions in support of spurring CCS technology for power generation. In compliance with AB 1925, the CEC is in the process of preparing a report, to be submitted to the California Legislature in November 2007, with recommendations for "how the State can develop parameters to accelerate the adoption of cost-effective geologic carbon sequestration strategies."

Technology-Specific Barriers

Financial: The experimental nature of coupling IGCC with CCS technologies creates added risk and cost during all phases of a any near-term project. While engineering and construction designs for a traditional coal plant cost less than $1 million, an IGCC plant cannot be built without a Front End Engineering Design (FEED) study. Such a study costs $10-$20 million and takes 10 to 14 months to complete. Because commercial-scale IGCC technologies are new, the risk of cost-overruns, construction delays and delays in achieving anticipated reliability levels, are all higher than for a traditional coal plant.

This added risk and cost create financing challenges for an IGCC investment. Assured and timely cost recovery, typically achieved by "pay as you go" proposals, is necessary for large IGCC projects to obtain financing and move forward. For example, the Ohio Public Utilities Commission recently allowed American Electric Power (AEP) to recover an estimated $23.7 million in first-phase IGCC pre-construction costs through a 12-month generation surcharge. AEP proposed a second-phase of recovery during construction to cover financing costs, and a third-phase to recovery the costs of the plant after it becomes operational. Similarly, the Indiana Utility Regulatory Commission approved the requests of two utilities for deferral and recovery of IGCC pre-construction costs. Colorado, Indiana and Pennsylvania all provide full cost-recovery assurances for IGCC and CCS by statute; Colorado additionally includes recovery for replacement power costs associated with unplanned IGCC plant outages.

Regulatory: Before IGCC technology can provide a critical path toward a low-carbon future, it must become economically competitive, reliable, and more broadly applicable to lower rank coals and higher altitude conditions. Policy makers must understand, however, that combining a chemical process (gasification) with a mechanical process (coal-based power generation), and then capturing and sequestering the gasified carbon, is not simple and has yet to be definitively demonstrated anywhere in the world today.

Government support for IGCC/CCS development is needed to help direct the industry toward this higher risk technology investment. This support can take the form of accelerated depreciation; investment and production tax credits; research, development and commercial demonstration funding; performance certainty guarantees; and public-private partnerships to develop, construct and operate commercial scale IGCC plants.

S. Nuclear Power

At present, nuclear power provides about 15 percent of California's total electricity supply. Three reactors supply California: PG&E's 2220 MW Diablo Canyon; San Onofre, a 2254 MW facility operated by SCE; and the 3810 MW Palo Verde reactor in Arizona, which features a 27 percent California ownership share. All three plants began commercial operations in the mid-1980s. Their current operating licenses will expire during the 2022-2027 timeframe.[45] The re-licensing of these nuclear reactors will be determined by the federal Nuclear Regulatory Commission (NRC). The California utilities are in the process of completing relicensing studies, which are expected to be completed in the 2010-2011 timeframe. If the studies prove re-licensing to be feasible

and economic, the utilities will prepare applications for NRC approval. The most likely barrier for relicensing is not any technical challenges, but public resistance.

Nuclear power provides fuel diversity, enjoys low operating costs, and generates virtually no GHG emissions. Nuclear generation is experiencing a "renaissance" as utilities and independent power producers explore its potential in a carbon constrained electric generation market. The Federal government, through the loan guarantees included in Energy Policy Act of 2005, has spurred renewed interest in nuclear power. Throughout the U.S., 21 projects have been announced and are in various stages of the permitting and licensing,[46] though none has yet been constructed.

How much of this capacity actually gets built remains to be seen. The last generation of nuclear power plants to be built experienced significant siting issues, cost overruns and delays. Nuclear proponents argue new technologies lower development risks and associated costs.

The largest barrier to new nuclear development in California is a regulatory one. Under existing California law (Public Resources Code 25524), there is a moratorium on the construction of new nuclear power plants until the CEC finds that there is a federally approved, high-level nuclear waste disposal facility. Yucca Mountain Nevada has been designated by the U.S. Department of Energy as a high-level nuclear waste site. The date for operations has slipped several years with the date now stretching out beyond 2020. Until Yucca Mountain is certified and operational, or unless there is a change of the in California state law, the CEC will be precluded from licensing any new nuclear power plants here in California.

Despite these obstacles, a potential new nuclear power plant is being proposed by the Fresno Nuclear Energy Group, LLC.

Technological Developments

New technologies for nuclear energy generation includes load following, now common in France. An example of new technology is the AP1000, designed to be capable of startup from cold shutdown to hot standby in 24 hours. Likewise, it is capable of cooling down from a reactor critical condition to a refueling operation in 24 hours. Technology advances include enhanced safety features, creating a nuclear island consisting of a proven four-loop reactor cooling system design, four-train safety systems, double containment, in-containment borated water storage, severe accident mitigation, separate safety buildings, advanced 'cockpit' control room, and an undetectable radiation release to the public under any accident scenario. In addition, electrical safety includes full load rejection of 100 percent to 3 percent without a plant trip, four emergency diesel generators, and two smaller, divers SBO D/Gs. New site characteristics include airplane crash protection and explosion pressure wave. Fuel efficiency has also improved to 35 percent (the typical current U.S. plant is 33 percent efficient), and now uses 8 percent less uranium to generate each MW of electricity.

Technology-Specific Barrie

Technological: Long-term waste disposal has been an on-going issue that still needs to be resolved.

Financial: The capital intensity of nuclear generation is daunting, and increases the risk profile for investors. Furthermore, the levelized cost of new plants is hard to estimate, since few plants are being built.

Institutional: Public concerns over plant siting, safe operation and waste disposal pose significant barriers. There are global concerns about the proliferation of nuclear materials. New fears have emerged in the post 9/11 world regarding nuclear plants as targets for terrorists. Finally, lack of qualified labor pool is also a concern.

Regulatory: The California Moratorium is a significant regulatory hurdle. No new nuclear plants may be built in California without a clear repository for waste.

T. Future Game Changers: Making The Case for State Energy RD&D

The ETAAC Energy subgroup Group recommends the State of California make an affirmative commitment toRD&D programs geared toward GHG abatement. The technologies needed to support GHG reductions in the outer years beyond 2020 do not yet exist. While the State of California currently funds a variety of RD&D programs, these programs are not currently focused on measuring GHG reductions. Moreover, the State's individual subsidy programs in most cases are not coordinated with one another, creating inefficiency and missed opportunities for cost-effective GHG emission reductions.

By not just supporting -- but actively promoting clean energy innovation -- the State has the opportunity to seed the California marketplace with promising new technologies that may aid in achieving GHG abatement goals--particularly beyond 2020. 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. Support for clean energy innovation may include such actions as:

- *Support RD&D for GHG Abatement:* Promote the use of public funds to support research of technologies with potentially high GHG abatement value. Consider linking the current individual subsidy programs with a common set of reduction objectives, possibly including a unified approach to State-calculated avoided costs. Accurate and consistent calculation of avoided costs would better ensure that RD&D funding is efficient and attuned to commercialization.

- *Leverage California's Center of Innovation*: Leverage and provide coordination among the existing RD&D efforts of State and Federal labs, private research institutes and universities. Currently there is no single source of information about what the referenced centers of innovation are working on or how their

research priorities are established. A coordinated effort would ensure that market and policy signals reach and influence innovation centers. Further it may enable policy reforms that reflect real technological progress and may help individual efforts achieve scale more quickly.

- *Support Demonstration Finance*: Support first MW installations that prove technical feasibility and enable project financing for emerging technologies. The absence of this kind of financial support is a significant impediment to the maturation of new generation technologies, and is consistently identified by thought leaders as a major gap in the financial architecture of clean energy. A structure that leverages public funds nominally dedicated to efforts such as this – e.g. PIER funds – with private funding at the project level could find the right balance of risk-sharing to accelerate technology maturation.

- *Engage the Private Sector*: Create visible onramps for private sector support for early stage clean energy innovation. Consider a public private partnership that leverages private sector support for public sector objectives. A single, focused entity may be well positioned to act as a coordinator of policy-motivated technology innovation, for example by administering targeted State grant funds for specific technology challenges – i.e. the "golden carrot" approach to goal-setting and reward. Such an entity could also enable the multiple public and private centers of innovation in California clean energy to communicate, share research, seek private funding, and move mature technologies through the procurement processes of the major State energy providers. The entity could also act as the principal agent for external market development and technology transfer to demand centers outside of California.

A host of emerging clean technology opportunities have been identified; however, there is no single "silver bullet" that will provide the technological solution for GHG abatement. Rather, a diverse portfolio is needed that includes energy efficiency, renewable resources and accompanying enabling technologies, improved new and existing generation technologies, development of carbon capture and sequestration systems, and others. In addition, effective policies must be in place to help bring emerging technologies to the market. The State of California needs to implement parallel policy and technology efforts in order to meet its aggressive GHG reduction goals.

Additional Recommendations

Item	**Relates To**
1. To encourage wider adoption of LED lighting, consumer education is necessary to increase awareness of the benefits and availability of consumer-ready LED products.	Energy Efficiency – LED
1. Initiate a study or form task force to assess the potential of using of depleted electric vehicle batteries, with roughly 80 percent State of charge left to provide energy to	PHEV/EV – Storage

residences or commercial buildings.	
2. Develop rebate from ARB to consumers who choose to buy PHEVs perhaps funded via a "fee-bate" assessed on highly polluting automobiles sold in California.	PHEV/EV – Transport
3. Work in concert with the Low Carbon Fuel Standard, to possibly create credits through the sale of electricity as fuel. These credits could be sold to petroleum distributors, and the funds from these sales may go to utility/EV customers or help utilities offset AB 32 emission obligations.	PHEV/EV – Transport
4. Allow Zero Emission Vehicles regulations to set standards for PHEVs.	PHEV/EV – Transport
5. Encourage early implementation of PHEV/EVs by reducing the emission system battery warranty requirements during the start up years through partnerships among utilities, auto manufacturers, and ARB.	PHEV/EV – Transport
6. The California government can play a key role in information-sharing efforts, and making sure there is less of a proprietary effort in smartening the grid. EPRI's IntelliGrid Consortium, with founding members including ABB, the Bonneville Power Administration, Con Edison, Electricite de France, and Hitachi, is working to establish an open standard for smart-grid interoperability. Similarly, the GridWise Alliance, under the guidance of the US Department of Energy and the PNNL is developing supportive open standards and guidelines.	Smart Grid
7. California should actively investigate the upgrades to distribution-level infrastructure that will be needed to support both increased DG penetration by renewables and the power flows associated with a PHEV/EV fleet. Ratemaking treatment for these utility investments should be studied and implemented on the most accelerated timeframe possible, consistent with technical feasibility and the steady market deployment of the technologies in question.	PHEV/EV – Transport; Smart Grid
8. Organize and expand the current level of effort in the science and business of CCS. For example, UC system-wide participation in CCS RD&D can occur through a national research institute, such as DOE's Lawrence Livermore Laboratory[47].	CCS
9. California should investigate, in a collaborative manner, the renegotiation of existing high-polluting import contracts to the effect that California ratepayer funds actively support the near-term testing and development of sequestration sites for GHG emissions associated with California electricity consumption.	CCS
10. Coordinate potential plant capacity additions and retrofits with ongoing program objectives to maximize the	CCS

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commercialization potential of CCS technology	
11. Joint guarantee provided by consuming States and coal producing/generating States for indemnification of the indefinite insurance liability risk associated with the CO2 sequestration of the first few projects as currently there is no insurance available for CO2 sequestration	CCS
12. Collaborate on integrated financing issues associated with CCS issues	CCS
13. In line with SB 1368, provide utilities with rate based reimbursement for all R&D expenditures associated with their collaboration of new and emerging CO2 technologies.	CCS
14. Encourage further development of CCS technologies that use algae to make biofuels.	CCS
15. Fostering interactions between consuming and coal producing/generating States should include: a) Closer collaboration between all utility commissioners b) Support "Capture-Ready" requirements for all new generating facilities. "Capture-Ready" refers to IGCC and PC power plants that are located in immediate proximity to a suitable sequestration site, and existing CO2 pipeline, or a verified pipeline rout to a remote sequestration site and have space on site and any other essential features to allow CO2 capture facilities subsequently to be integrated without extended outages. c) Support construction of new CCS projects including out of State CCS projects with assets dedicated to supply electricity to California.	CCS
16. Investigate incorporating storage into the grid to balance out variable output renewables – solar and wind.	Renewable; Storage
17. Ensure full valuation of CO2, environmental and other benefits. Synchronize different valuations among programs and technologies.	Renewable
18. Continue existing incentives for distributed technologies, and adjust to account for actual energy performance, environmental attributes, and economies of scale.	Renewable
19. State support for development of new technologies for geothermal exploration.	Renewable
20. Accelerate research into material cost-reductions.	Renewable
21. Incentives for clean energy equipment manufacturing facilities in the State, including Manufacturing Investment Credits, property and other tax exemptions, as well as other programs as services such as recruiting, creation of clean energy equipment manufacturing "enterprise zones".	Renewable
22. Workforce training for utility procurement officers,	Renewable

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field operators and other employees on technology characteristics and operations.	
23. Expansion of funding to RD&D incubation centers.	Renewable
24. Change the gasification law to allow diversion credit for gasification of municipal solid waste.	Renewable
25. Incentivize landfill operators to use landfill gas for energy generation.	Renewable
26. Simplify permitting for renewable project developments through coordinated decision-making process between State and Federal agencies such as consolidating permitting activity within interagency coordinating bodies or through master agency agreements, establishing a clearer permitting pathway, and/or fast-tracking permitting efforts.	Renewable
27. Extend timeframe for Production Tax Credit (PTC) and Investment Tax Credit (ITC) – a clear, consistent signal to the market that PTCs and ITCs can be expected over a longer term would increase clean energy investment and projects, and continue momentum in lowering costs and continuing supply of materials for technologies production such as wind and solar.	Renewable
28. Improve transmission access for renewable energy.	Renewable
29. Support Federal funding under section 413 of the 2005 Energy Policy Act for demonstration projects of advanced coal technologies using carbon capture and sequestration, with a focus on those locations and coal types that are the most abundant.	IGCC with CCS
30. Provide specific development goals for the advancement of IGCC technologies that focus on major components that will result in higher availability, increased performance and lower cost.	IGCC with CCS
31. Address legal and regulatory barriers/issues associated with CCS, including regulatory and policy certainty to eliminate all liability for sequestering carbon under scientifically-based Federal standards.	IGCC with CCS
32. Provide financial incentives for permanent geologic carbon dioxide sequestration.	IGCC with CCS
33. Develop a regulatory framework for injection wells and carbon dioxide pipelines.	IGCC with CCS
34. Guarantee assured and timely cost recovery or “pay as you go” for large IGCC projects.	IGCC with CCS

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Appendix V - Background Status Report on Transportation Sector Solutions and Sources

TRANSPORTATION TECHNOLOGIES AND PRACTICES

This appendix was compiled by the Transportation section of the ETAAC as a reference document for strategies that can be used to control greenhouse gas emissions from the transportation sector. It contains summaries of specific technologies and a set of references in endnotes. Material was contributed by both ETAAC members and the public. This inventory is arranged into the following categories:

A. Vehicle and Fuel Technologies
B. Transportation Planning and Incentives
C. Mobility Options
D. Traffic Flow Improvements
E. Goods Movement
F. Other
G. References and Notes

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A. Vehicle and Fuel Technologies

A.1 Conventional Vehicles and Fuels

Many technologies exist that can improve the fuel efficiency of contemporary vehicles that burn fossil fuels in internal combustion engines, thereby substantially lowering GHG emissions, as has been documented elsewhere by CARB and others.[48] Many of these technologies involve improvements to internal combustion engines, hybridization of vehicles, and similar incremental changes. Many have already been introduced into markets outside of the United States, notably Europe. In general, technologies to reduce emissions from conventional vehicles can be integrated fairly easily into new vehicle design and manufacturing, and they require no changes in infrastructure.

Current trends to use lower-grade resources (e.g. Canadian tar sands) for fuel production are leading to fuels which have higher GHG emissions per unit of fuel, although technologies can be developed to limit or to capture and store additional GHG emissions used in resource extraction.[49] These include improved efficiency in oil production and refining, the storage of carbon dioxide in depleted oil fields and reservoirs, and possibly even the capture of carbon dioxide from the air after fossil fuels have been combusted.

- *Timeframe:* Near to long term (growth potential)

- *GHG Reduction Potential:* Potentially very large, especially if carbon storage is feasible.
- *Ease of Implementation*: From very simple to very challenging.
- *Co-Benefits / Mitigation Requirements*: Can reduce the need for petroleum imports. May have negative costs.
- *Responsible Parties:* Federal and state governments, private sector

A.2 Electric Vehicles

Vehicles that draw electricity from the grid have been in development and use for some time and may be an important option in the future.[50] The electric vehicles category (EVs) includes a wide range of configurations, from different plug-in hybrid electric vehicles (PHEVs) to neighborhood electric vehicles (NEVs) to high performance battery electric vehicles (BEVs). Generally speaking, the key challenge for EVs is improved battery technologies since relatively little infrastructure is needed.

Some of the key advantages of EVs are: they have zero tailpipe emissions of GHGs; they tend to be very efficient in terms of energy consumption; they have low operating costs; they diversify the transportation energy supply; and they have the potential to support the electric power system through vehicle to grid (V2G) technologies.[51] However, they are currently very expensive, largely due to battery costs. Other important challenges for EVs include development of low-cost manufacturing technologies, appropriate technologies and methods for charging, and potential infrastructure for rapid re-charging. Because EVs constitute such a wide range of vehicles, the relative importance of these challenges varies greatly with vehicle type.

- *Timeframe:* Mid to long term
- *GHG Reduction Potential:* Potential to eliminate GHG emissions.
- *Ease of Implementation*: Moderately to very challenging.
- *Co-Benefits / Mitigation Requirements*: Can reduce the need for petroleum imports. May have negative costs. Eliminates tailpipe emissions.
- *Responsible Parties:* Federal and state governments, private sector, electricity providers

A.3 Biofuels

Transportation fuels produced from biological feedstocks (biofuels) are currently used in California and may offer important opportunities for GHG emission reductions, but there are also significant concerns about biofuels.[52] Currently, gasoline in California contains about 5.7% ethanol by volume, which implies annual consumption of about 900 million gallons. Much smaller quantities of biodiesel are consumed. A major advantage of biofuels is that they require smaller changes in fuel infrastructure and vehicle technology

than do other low-carbon options. However ethanol does not blend perfectly with fossil fuels, so it requires special distribution infrastructure, which is currently strained at both the national and state levels. In addition, the carbon intensity of biofuels varies greatly with production method, and some of today's biofuels can have higher GHG emissions than fossil fuels. As biofuel production has expanded, concerns about the environmental and social implications of using food crops for such expansion have risen.

Most experts agree that for biofuels to contribute significantly to lowering GHG emissions, advanced (or "second-generation") technologies will be needed because they offer two key advantages over today's biofuels. First, they will enable the cost-effective use of feedstocks such as grasses, trees, wastes, and possibly algae in place of crops like corn and sugarcane. Second, they may yield fuels that are readily blended with (and may be virtually identical to) fossil fuels, minimizing the need for any special infrastructure or vehicles to use biofuels. Recently, the U.S. Department of Energy sponsored six pilot plants to produce cellulosic ethanol, one of the earliest of the second-generation biofuels. This technology offers the first advantage, but not the second.

- *Timeframe:* Near to mid term
- *GHG Reduction Potential:* Unclear, but possibly large with technology improvements.
- *Ease of Implementation*: Very easy to somewhat challenging.
- *Co-Benefits / Mitigation Requirements*: Can reduce the need for petroleum imports. May have negative costs.
- *Responsible Parties:* Federal and state governments, private sector

A.4 Hydrogen

A more long-term possibility is elemental hydrogen as a fuel, either in a combustion engine or fuel cell.[53] Because the use of hydrogen for energy produces only water vapor (a greenhouse gas that is already saturated in the atmosphere), it does not lead to climate forcing. There is some variability between hydrogen production processes in regards to their GHG emissions, but assuming the appropriate production methods are in place a hydrogen-based economy could have an extremely low climate impact. However, such an economy requires integration of technologies for hydrogen production, compression and storage, distribution and delivery, dispensing at fueling stations, utilization by vehicles, and establishment of codes & standards for safety, measurement and environmental regulations.

- *Timeframe:* Long term
- *GHG Reduction Potential:* Potential to eliminate GHG emissions.
- *Ease of Implementation*: Very challenging.
- *Co-Benefits / Mitigation Requirements*: Can reduce the need for petroleum imports. May have negative costs. Eliminates tailpipe emissions.

- *Responsible Parties:* Federal and state governments, private sector

A.5 Other

A number of other vehicle and fuel technologies may lower GHG emissions in California. One is hydraulic hybrid technology, which uses a pair of reservoirs operating at high and low pressure, hydraulic fluid and a pump/motor to store energy. This system transfers the vehicle's kinetic energy to the high pressure reservoir during braking and uses the stored energy to supplement or substitute the engine's power during acceleration. Hydraulic hybrid technology is less expensive that electric hybrid technology, and may be particularly applicable for heavy duty vehicles with frequent stops and starts (such as buses, refuse trucks, etc.). Other fuels may help lower GHG emissions from transportation as well, such as natural gas, which is currently used in both heavy duty and light duty vehicle applications in California.

B. Transportation Planning and Incentives

Demand for transportation services is linked to GHG emissions. Many opportunities exist to reduce this demand by providing more transportation options in a way that reduces demand for automobiles and other energy-intensive modes. Some of these mechanisms use incentives to shape the choices facing travelers today, some involve changes in land use and infrastructure development, and some are wholly technological in nature.[54] These opportunities are divided into three categories: correct incentives, improved transportation planning, and advanced transportation systems. These approaches to lowering GHG emissions will have important co-benefits in terms of less congestion, neighborhood designs designed for high quality of life instead of just convenient parking, and others.

B.1 Incentives: Road Pricing

Road pricing policies can reduce congestion and vehicle GHG emissions by inducing demand shifts from autos to public transportation and by reducing discretionary travel. They include cordon pricing (toll rings in high-activity centers like central business districts that charge drivers for entry into a specific area), "FAIR" lanes (fast and intertwined regular lanes that charge drivers to use express lanes and transfer a portion of the collected money to drivers using the non-express or regular lanes), and "HOT" lanes (or high occupancy toll lanes that enable drivers without the minimum number of passengers to access high occupancy vehicle lanes for a). Roadway pricing makes drivers more aware of the true cost of driving in a way that may encourage them to switch modes or reduce travel, and ultimately ease congestion.

Transport for London reports that the central London congestion-charging program was responsible for a 16 percent reduction in CO2 traffic emissions within the charging zone during 2002 and 2003 (annual averages)[55]. In addition, the city of Stockholm implemented a six-month trial of cordon pricing in January 2006, including provisions for expanded transit services and park-and-ride facilities. Using emission

models, the Stockholm trial is estimated to have reduced CO2 and particle emissions by "approximately 100 tons per weekday 24-hour period or by 14 percent".[56]

- *Time Frame:* Near to mid term
- GHG Reduction Potential: Modest
- *Ease of Implementation*: Technically not too difficult, but may be unpopular
- *Co-Benefits / Mitigation Requirements*: Reduced congestion, Revenue
- *Responsible Parties:* Local, regional, and state governments, private sector

B.2 Incentives: Pay-As-You-Drive Insurance

Pay-Per-Mile or Pay-As-You-Drive insurance assesses individualized premiums based upon miles driven instead of the calendar year, providing motorists a new option to save money by reducing risk exposure through driving less. Pay-As-You-Drive premiums incorporate traditional risk factors such as driving record and vehicle make and model, and they reflect coverages selected by the consumer.[57]

- *Timeframe:* Pay-as-you-drive insurance could be implemented quickly, either through California regulation or insurance companies' own initiatives.
- *GHG Reduction Potential*: Applying the results of studies assessing mileage changes related to fuel prices, researchers have projected that pay-as-you-drive insurance could lead to up to a 12 percent reduction in driving and energy use.[58] Even a more modest benefit of a several percent reduction in driving would achieve significant GHG emission reduction benefits.
- *Ease of Implementation:* There are a range of challenges insurance companies face related to offering such or pay-as-you-drive insurance, including product start-up costs, explaining to customers the benefits of a new pricing scheme, mileage verification costs, consumer acceptance of at least some monitoring (even if only of mileage), and loss of premium dollars from existing low-mileage customers.[59]
- *Co-benefits / Mitigation Requirements*: Government incentives to promote Pay-As-You-Drive insurance have been projected to be very cost competitive in terms of reducing air pollution and saving lives with other government transportation-related expenditures aimed at achieving these objectives.[60] A 1 percent reduction in VMT typically decreases total vehicle crashes by about 1.2 percent, including crash reductions to the vehicle that reduces its mileage and to other road users.[61] Although difficult to predict actual congestion alleviation, even a small reduction in driving demand can provide a large reduction in congestion delays.[62]
- *Responsible Parties:* Insurance Companies, transportation agencies, California Air Resources Board, and the State Insurance Commissioner.

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Problem: At present, automobile insurance premiums do not adequately factor in the number of miles driven. This subsidy encourages VMT, GHG emissions, and traffic accidents.

Possible Solution: Convert insurance to a variable cost, while still factoring risk factors such as driving record. Several key organizations can play a major role in changing current insurance practices so that they account for climate change impacts.

- *Insurance Companies*: Insurance companies are the ultimate arbiter of products that will be offered to consumers and they face challenges in implementing this type of insurance. The insurance companies also have the flexibility of instituting a Pay-As-You-Drive strategy, and various insurance companies have already piloted programs based on this insurance scheme.[63] For example, the General Motors Acceptance Corporation (GMAC) since mid-2004 has offered mileage-based discounts to OnStar subscribers located in certain states.[64]
- *Transportation Agencies*: Cal-Trans is pivotal in alleviating congestion and implementing successful transit systems. Their implementation of traffic operations can assist pay-as-you-go operations to make them successful.
- *State Insurance Commission and CARB*: The State Insurance Commission plays a significant role in how insurance companies determine charges to drivers. The most recent change came in 2006 when insurance companies were ordered to place more weight on a individual driver's record, rather than his/her zip code. The State Insurance Commission could mandate similar rules, ordering insurance companies to reflect how much consumers drive. This is currently given little weight. Smog check mileage records could provide information to verify the mileage provided by consumers.

B.3 Incentives: Congestion Charges

Congestion pricing uses electronic transponders in the vehicle, database-linked cameras and other barrier-free means to charge drivers as they enter congestion zones located around areas of heavy traffic. London, Norway, Rome, Singapore, and Stockholm are places where congestion pricing has been implemented.

- *Timeframe:* Initial project(s) in place by 2012; with additional potential projects feasible in time for 2020 targets.
- *GHG Reduction Potential***:** Exact reductions would depend on the areas covered and specific program design. Potential GHG emissions reductions of one million tons per year or more could be achieved if applied to areas responsible for 10 percent of the state's vehicle GHG gas emissions.[65] The City of San Francisco Climate Action Plan sets a goal of reducing 165,000 tons per year of carbon dioxide emissions by reducing vehicle miles traveled.[66] The San

Francisco County Transportation Authority has identified congestion pricing as a key component of that strategy.[67]

- *Ease of Implementation:* Local planning authorities need legal authority from the State to implement congestion pricing. State support for planning and/or initial set-up of congestion mitigation pricing systems would also be beneficial.
- *Co-benefits / Mitigation Requirements*: Reductions of pollutants such as fine particulates and ozone forming pollutants, and reductions in traffic deaths and injuries, are examples of major co-benefits. Revenues can be used for projects to accommodate increased demand for alternatives such as transit, walking, and bicycling. Public hearings and outreach can help focus these improvements to mitigate disadvantages and maximize improved transit and other transportation co-benefits to meet AB 32's Environmental Justice goals.
- *Responsible Parties:* The State Legislature would provide legal authority and local transportation planning agencies would be responsible for evaluating potential projects with support and coordination from CalTrans and Regional Transportation Agencies as needed.

Problem: As noted earlier, increases in vehicle miles traveled (VMT) are an important contributor to GHG, air pollution, and other congestion-related problems.

Possible Solutions: Congestion pricing has the potential to reduce congestion, vehicle miles traveled, and GHG emissions. Under congestion pricing, drivers are charged using a variety of electronic and other barrier-free options to enter an area of heavy traffic. London reduced GHG emissions from road traffic by 16 percent within the charging area[68], lowered congestion, and improved transit and bicycle use.[69] The City of Stockholm is estimated to have reduced CO_2 and particulate emissions by "approximately 100 tons per weekday 24-hour period or by 14 percent"[70]. Pricing could vary based on different tiers. For instance, London offers exemptions for electric cars.[71] Other factors could be studied during the local planning process for California agencies. Revenues collected under the program would be used for projects such as transit improvements, thus further reducing private vehicle emissions and congestion. Roadway improvements could also be candidates for this source of funding.

The City of San Francisco is currently seeking to move forward with a project covering access to downtown and certain other areas of San Francisco from the Golden Gate Bridge via Doyle Drive. San Francisco is also conducting a study to be completed by summer 2008 for a possible second project that would cover traffic hotspots like the downtown area.

The California Legislature should adopt legislation providing local governments with the authority to implement congestion pricing projects after a public process that includes a public hearing. CalTrans and Regional Transportation Agencies should examine appropriate opportunities to support and coordinate potential projects within the state.

B.4 Incentives: Indexed Fuel Taxes and Vehicle Registration Fees

The effectiveness of standards in reducing GHG emissions from passenger vehicles can be greatly improved by adopting additional fiscal incentives to promote more fuel efficient vehicles without restricting customer access to a full range of vehicle choices. Increasing these taxes, and devoting part of the revenue in support of public transportation or Moyer-style grants for energy efficient vehicles and equipment, could make a substantial contribution to meeting California's GHG emission reductions goals.

- *Timeframe*: by 2012
- *GHG Reduction Potential*: Potentially significant.
- *Ease of Implementation:* Potentially difficult
- *Co-Benefits / Mitigation Requirements*: Increased registration fees could be phased-in to give consumers time to adapt; and increased gas taxes could also be used in part to increase transit opportunities for low-income and other communities
- *Responsible Parties:*

Many countries create market pull for such vehicles through higher fuel taxes and registration fees levied on GHG emissions directly, or on surrogate factors (vehicle weight, engine displacement). The UK indexes vehicle registration fees according to tailpipe GHG emissions, while Germany and Japan sets those fees based upon other factors that relate to GHG emissions (engine displacement, vehicle weight). These policies affect both existing (a phase-in period for existing vehicles could be considered to facilitate a transition) as well as new vehicle purchases, and create a very clear price signal to consumers.

In California, fuel taxes have steadily decreased (adjusted for inflation) as road usage, greenhouse gases, and infrastructure needs have increased. The Legislative Analysts Office has identified a critical need to increase fuel taxes to fund infrastructure repair. Increased fuel taxes can also provide additional support for public transit, especially in environmental justice areas where consumers may be most affected by increased costs. The LAO has identified a need to increase gas taxes by ten cents per mile, for a total of *X+Y* state and federal taxes. Taxes on gasoline in Japan are approximately triple that of California's combined $0.63 per gallon for federal and state excise taxes, with some countries in Europe charging as high as six times that level. A modest tax increase will provide critical maintenance of road infrastructure and transit while still falling well below taxes in most other developed countries. [72] Indexing fuel taxes to inflation and vehicle miles traveled (as fuel consumption per mile is likely to fall without reducing the need for infrastructure) is crucial to avoid future funding short-falls. The state should also encourage similar policies at the federal level.

B.5 Incentives: Parking Cash Out

Parking cash out offers "commuters the option to 'cash out' their employer-paid parking subsidies. [It gives] commuters the choice between free parking or its equivalent cash value….The cash option also rewards those who carpool, ride public transit, walk, or bike to work.[73]"

- *Timeframe:* Near to long term (growth potential)

  GHG Reduction Potential: Estimates of CO_2 reduction from parking cash out programs range from 123 tons annually in Pleasanton, California (offered to city employees) to 200 tons in Santa Monica, California[74].
- *Ease of Implementation:* Medium to high challenge (policies needed to result in behavioral change, could be linked to road/value pricing)
- *Co-Benefits / Mitigation Requirements*: Reduced vehicle miles traveled, parking demand, and increased transit ridership.
- *Responsible Parties:* State and local/regional governments, employers

Problem: Some employers or employees may not be aware of or may not be fully implementing the employee cash-out program.

Possible Solutions: CARB should proactively inform employers and employees of parking cash-out programs, covering as many employers and employees as possible.

B.6 Planning: Smart Growth and Transit Villages

There are a number of planning measures that can shift investments in housing and transportation infrastructure in a way that would reduce GHG emissions over the long term by providing desirable and low-GHG transportation options, largely by replacing automobile trips. One direct measure would be to integrate GHG emissions into planning assessments. For example this would include the addition of GHG emission reductions into the guidelines of the California Environmental Quality Act. This change to CEQA is extremely important and is already underway with a January 1, 2010 deadline for new guidelines to address global climate change [75] (and thus is not an area of focus for this ETAAC report.) There are also a number of other measures that improve planning generally with the added benefit of long-term reductions in GHG emissions (as described in policies E and F below).

Smart growth is an urban planning and transportation strategy that emphasizes growth near city centers and transit corridors to prevent urban sprawl. This approach promotes mixed-use, infill and transit-oriented development; transit, bicycle and pedestrian-friendly infrastructure; preservation of open space; affordable housing; and other strategies to reduce traffic injuries and improve the livability of urban neighborhoods

including non-residential speed limits, roundabouts, "parking maximums, shared parking, flexible zoning for increased densities and mixed uses, innovative strategies for land acquisition and development, and design emphasis on a sense of place."[76]

Smart-growth policies play a critical role in reducing GHG emissions while improving the economy. Proponents of smart growth – instead of the business-as-usual urban sprawl -- point out that this alternative reduces driving, increases walking, spurs transit use, curbs obesity, and promotes cleaner air.[77] Transit villages, one form of smart growth, are generally mixed-use residential and commercial areas that are designed to maximize access to transit systems. They are typically located within one-quarter to one-half mile (0.4 to 0.8 kilometer) of a mass transit station. The implementation of electric powered guideway personal rapid transit (PRT) systems could substantially broaden the reach of transit oriented development by expanding beyond existing transit corridors and forming networks that reach perpendicularly into the urban environment. Environmentally, PRT offers an attractive alternative due to its quieter, zero emission operation, but it does require new infrastructure, including overhead guideways.

- *Timeframe*: Implemented by 2012. Emission benefits will continue to increase over time as new development incorporates these concepts.
- *GHG Reduction Potential*: CalTrans estimates that the average household living in a transit village could emit 2.5 to 3.7 tons less CO_2 yearly than a traditional household. [78] This estimate is based on a CARB study estimating transit village household private vehicle mileage reductions of approximately 20 to 30 percent annually[79].
- *Ease of Implementation:* Ease of implementing smart growth aspects will vary among regional areas, but ultimately require each regional development agency to make reduction of GHG emissions a priority in its planning and development. State-level legislation requiring regional transportation agencies to address smart growth and provide incentives for implementation of smart growth would enable regions to effectively address and plan for sustainable growth.
- *Co-benefits / Mitigation Requirements***:** Urban in-fill housing can be an effective tool to prevent creating further suburbs from existing farmland. Proponents point out that smart growth can reduce driving, increased walking, spur transit use, curb obesity *and* promote cleaner air.[80]
- *Responsible Parties:* Land use decisions are made at multiple levels (e.g, building and urban design, local zoning and use separation, regional integration with land use patterns). It is therefore imperative that several interventions and policies are required at different institutional levels. Nonetheless, these should be consistent and complementary to spur smart growth.

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- *State Government*: In June 2007, the CEC released *The Role of Land Use in Meeting California's Energy and Climate Change Goals*, a report addressing the need for land use planning to reduce the GHG emissions from the transportation sector.[81] CalTrans has also looked at ways to reduce VMT; one of their programs is the Regional Blueprint Process, which establishes 20-year goals, including reducing VMT on a regional basis. In addition, policies and requirements relating to CEQA, the California Transportation Plan, housing element updates, the California Water Plan, and stormwater plans can all affect local land use planning and development. These state agencies will be critical in providing incentives for linking ongoing State planning processes with GHG emission reduction strategies.
- *Land Use Agencies*: California local land use agencies, such as San Diego's SANDAG, provide regional plans for more efficient land use. They can play key roles in implementing smart growth policies and then monitor the progress of these planning practices over time. They can also generate funding for smart growth incentives. Implementation of Smart Growth policies by local agencies to reduce VMT will be particularly important to meet AB 32's GHG emission reductions. Smart Growth blueprints have been completed by the Sacramento, Bay Area, and Southern California regions and are underway in other areas, such as the San Joaquin Valley.
- *Land Use Advocacy*: Land use agencies such as the Smart Communities Network[82] provide information sharing and best practices for local government and regional planning agencies to learn from.
- *Metropolitan Transportation Commission*: The Metropolitan Transportation Commission (MTC) is the transportation planning, coordinating and financing agency for the nine-county San Francisco Bay Area. MTC functions as both the regional transportation planning agency and as the region's Metropolitan Planning Organization (MPO). It is responsible for regularly updating the Regional Transportation Plan, a comprehensive blueprint for the development of mass transit, highway, airport, seaport, railroad, bicycle and pedestrian facilities. The latest Plan features "smart growth" development patterns. MTC has developed new policies, funding programs and technical studies to foster smart growth, including transit-oriented development, regional growth planning, station area plans, and parking policies.

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- *Developers*: Developers are the integral part of smart growth implementation. Equipped with sustainable practices, developers can build structures that generate fewer GHG emissions from both upfront construction as well as ongoing daily operations. For example, the real estate developer Thomas Properties Group (TPG) developed the headquarters building for the CalEPA in Sacramento as a public-private partnership with the City of Sacramento. The 25-story, 950,000 square foot office building is recognized nationally as a highly efficient and sustainable commercial office development, winning the BOMA TOBY award and becoming certified "Platinum" by the US Green Building Council's Leadership in Energy & Environmental Design program (LEED).

Problem: Urban sprawl can increase and lock-in high rates of VMT, subsequently increasing GHG emissions and leading to inefficient land use practices. In addition, urban sprawl requires high rates of land consumption, which threatens farmland. Urban sprawl can also lead to inefficient spending of government funds on new infrastructure while leaving existing infrastructure unattended.[83] The low rates of physical activity associated with urban sprawl are also thought to have a negative effect on peoples' health and well-being.[84]

The current Williamson Act mechanism used to keep farmland in agricultural use and delay housing or commercial development may not provide sufficient incentives for farmland owners to prevent urban sprawl and halt the growth of VMT. Currently a large share of Williamson Act land in San Joaquin County is in non-renewal status, for example. Other states are more proactive than California in supporting farms, particularly those owned by small farmers.

Possible Solution: The most important vehicle for implementing more smart growth planning is the coordination and provision of consistent incentives in infrastructure planning and development. Tying decisions to funding will encourage smart growth planning.

For example, transit oriented development can reduce VMT by 20-30 percent compared to conventional lower density auto oriented development. With higher densities, more consideration is needed regarding how neighborhoods share open space, bike paths, and pedestrian corridors and how urban dwellers travel within and between cities. These Smart Growth housing and land use practices are critical to reducing VMT, along with improved transit, pedestrian, and bicycling infrastructure. More electrified light rail systems are needed for intracity travel and as collectors to intercity transit systems.

Incentives to locate jobs closer to residential areas, to provide housing close to job rich locations, to support transit oriented development, to expand telecommuting, and to use video-conferencing in lieu of air travel could reduce VMT, as could mixed-use development where shopping and services are within a comfortable walking distance for residents.

B7Planning: Improved Transportation Impact Analysis

Traditional transportation planning tools and metrics tend to under-estimate the benefits of transit and other alternatives in a way that leads to greater road construction for automobile use. These processes should be dramatically improved with new tools and larger public sector budgets.

- *Timeframe:* Planning processes implemented by 2012. On the ground effects will become more visible over time as the cumulative effects of project decisions become greater in 2020 and 2050.
- *GHG Reduction Potential*: Each 1 percent of VMT shifted to non-polluting modes of travel is likely to result in reductions of one million or more tons of GHG emission reductions.[85] Exact results will depend on the outcome of local planning decisions.
- *Ease of Implementation:* Low to moderate.
- *Co-benefits / Mitigation Requirements*: Significant co-benefits including improved air quality, public health[86] and quality of life.
- *Responsible Parties:* State, regional, local transportation and environmental planning agencies

Problem: There are inherent trade-offs between different forms of transportation and accessibility of goods and services. Roadway design and land use patterns that are designed for maximum motor vehicle traffic are generally less suitable for other modes. Traditional transportation planning metrics such as automobile Level-of-Service (LOS) compare existing and expected motor vehicle volumes to estimates of roadway capacity. "LOS" is convenient due to its simplicity, but it fails to recognize the environmental benefit of improving mass transit and non-motorized modes of transportation. Despite the limitations of LOS, CEQA guidelines give great weight under case law to LOS and related measures as a proxy for significant transportation-related air quality impacts.[87]

Projects that increase roadway capacity and speeds are rated favorably even though they increase VMT, discourage non-motorized transportation, and tend to decrease quality-of-life in the communities where they are located. In-fill housing projects or a dedicated lane for bus rapid transit would be rated unfavorably under LOS despite the overall decrease in VMT and GHG emissions that would be the end result. Such projects may beneficial from an *accessibility* perspective, but they would be considered unbeneficial from a motor vehicle *traffic* perspective.[88]

CEQA Guidelines are not established in the CEQA code, but rather by local agency action. However, a state or local planning agency that uses alternatives to LOS could increase the risk of legal challenges based on the existing CEQA guidelines. This approach creates barriers for projects that improve transit and non-motorized transportation.

Potential Solution: Local and regional planning agencies should prioritize reductions in VMT over increases in motor vehicle traffic and pollution, while maintaining access to goods and services. Recognizing this under CEQA guidelines will facilitate a shift to Smart Growth planning practices. To the extent that access to goods and services should be addressed by CEQA guidelines, per capita congestion delays and travel times are examples of meaningful measurements. The ETAAC transportation sector subgroup also offers the following recommendations:

- Local, regional, and other transportation planning agencies should use alternatives to LOS whenever possible.

- The California Resources Agency should recognize, under CEQA guidelines, the benefits of using alternatives to LOS, or abandon traffic congestion as an indicator of environmental quality and instead evaluate motor traffic-related air quality impacts directly.

B.8 Indirect Source Rule

An indirect source rule applies to land development or other projects that will lead to increased vehicle use (whether VMT for individual travel or ton-miles of goods movement) and requires the developer to at least partially offset the transportation-related emissions that their project will cause. Currently at least six California Air Pollution Control Districts have indirect source rules for air pollution (Colusa, Great Basin, Mendocino, Placer, San Joaquin, and Shasta). This idea could be extended to GHGs so that developers of projects that will increase vehicle use would be required to at offset at least some of the associated GHG emissions.

- *Timeframe:* Could be implemented by 2012.
- *GHG Reduction Potential***:** Potentially large.
- *Ease of Implementation:* Low to moderate.
- *Co-benefits / Mitigation Requirements***:** Unclear.
- *Responsible Parties:* State, regional, local transportation and environmental planning agencies

C. Mobility Options

C.1 Bus Rapid Transit

Bus rapid transit (BRT) is the application of a series of ITS technologies, route planning, exclusive rights-of-ways, and management to improve bus service—each of which can reduce travel times. Increases in bus ridership associated with BRT implementation have

been reported in the U.S., Australia, and Europe. If a mode shift occurs from a single occupancy vehicle to BRT, there is an efficiency benefit. If the previous mode was non-motorized, such as walking or cycling, the impact on fuel efficiency/CO_2 emissions is negative. If additional riders are attracted from another bus route, the impact is neutral.

- *Timeframe:* Near to long-term (growth potential)

- *GHG Reduction Potential*: Bus ridership increases due to BRT implementation in five cities ranged from 18 to 76 percent (Houston, Los Angeles, Adelaide, Brisbane, and Leeds).[89]

  Furthermore, faster journey times and reduced acceleration, deceleration, and idle times—resulting from fewer stops and signal priority—have been shown to reduce fuel consumption. Signal priority modeling results indicate a five percent reduction in fuel consumption.[90]

  Using data from the 2001 National Household Survey and emissions data from the Department of Environmental Protection and the Energy Information Administration, Vincent and Jerram (2006) concluded a BRT system, employing 40-foot compressed natural gas buses, provides the greatest decrease in CO2 emissions when compared to light rail and 40- and 60-foot hybrid diesel BRT buses.[91]

- The 40-foot CNG buses used in BRT exceed light rail CO_2 reductions by approximately 300 percent.

- *Ease of Implementation*: Moderate to challenging

- *Co-Benefits / Mitigation Requirements*: Increased transit ridership, traveler satisfaction, reduced congestion; land use requirements and rights-of-way (challenges)

- *Responsible Parties*: Transit agencies, regional and local governments, Caltrans

Problem:

Possible Solution:

C.2 Personal Rapid Transit

Personal Rapid Transit (PRT) is a system of elevated tracks (or guideways) and small vehicles that offer automated, on-demand transportation. Most examples look like small train or monorail systems, sometimes seen at airports. In general, PRT is designed to be a public transit system that is more personalized and avoids many of the undesirable features of ordinary public transit. A government-funded, first generation PRT has been

operating in Morgantown, WV for over 25 years and at least one is under construction at London's Heathrow airport, but no commercial PRT system exists today. Costs are estimated to be similar or lower than those for light-rail systems at $30-$50 million per mile. However it appears that most potential customers (cities or regional transportation boards) seem unwilling to take the risk on building the first such system.[92]

In a PRT system, individual riders or small groups order a vehicles ahead of time and would have exclusive use of their vehicle during their trip, which would take them directly to their stop. This provides a level of privacy and safety (perceived, at least) that ordinary mass transit does not, and avoids the need to rely on scheduled service. PRT vehicles would be electrically powered, like a subway or light rail system, and could lower GHG emissions relative to cars if the electricity provided to them had a lower GHG emission profile than the fuels that were displaced.

- *Timeframe:* Unclear. Firms and advocates involved with PRTs claim it is possible to proceed with the design and implementation of PRT systems in the near term, but a recent study for New Jersey noted that "PRT systems are approaching but not yet ready for public deployment."[93] However, the development of the PRT system at Heathrow and possibly other locations in the near future may provide those first examples of public deployment. Construction times are thought to be similar or less than those for light rail, although the use of new technologies may cause delays.
- *GHG Reduction Potential*: Depends on the carbon intensity of liquid fuels and electricity.
- *Ease of Implementation:* Unclear, in part because elevated guideways are needed.
- *Co-Benefits / Mitigation Requirements*: Added transportation capacity.
- *Responsible Parties:* Cal-Trans, local and regional transportation planning organizations.

Problem:

Possible Solution:

C.3 Smart Cards

Smart cards contain electronic chips that contain information that can be used for a variety of applications such as transit, tolling, and parking payments. Stockholm is interested in integrating smart cards for use on transit, taxis, and carpools throughout the city. The city estimates that this approach could reduce CO2 emissions by 1,500 tons per year by 2030 – 2050.[94]

- *Timeframe:* Near to long term

- *GHG Emission Potential*: Stockholm is interested in integrating smart cards for use on transit, taxis, and carpools throughout the city. This approach is estimated to reduce CO_2 emissions by 1,500 tons per year by the 2030 to 2050 timeframe.
- *Ease of Implementation:* Moderate to challenging
- *Co-Benefits / Mitigation Requirements:* Less travel time associated with payment for parking and transit (e.g., idling), encourages transit use, and less/no time waiting at toll facilities.
- *Responsible Parties*: State (standardization of smart cards) and local/regional governments, transit agencies, and taxi companies

Problem:

Possible Solution:

C.4 Telecommunting

Telecommuting is generally defined as work at a remote location or home office rather than working at a fixed employer-provided site or office. Estimated fuel savings per telecommuter range from 49 to 177 gallons per year across three studies from the 1990s.[95] This range converts to approximately a 0.5 to 1.7 ton CO2 reduction, per year per telecommuter, using a standard assumption of 19.4 pounds of CO2 emitted for every gallon of gasoline combusted.[96] However, more recent and more comprehensive analysis to evaluate the greenhouse gas emissions from business-sector energy (e.g., commuting, office temperature control, lighting, and electric office equipment) in telecommuting and non-telecommuting scenarios suggests that while telecommuting could potentially reduce GHG emissions related to commuting, reductions may be offset by increased home office energy use and/or commercial electricity use at the business office.[97] In addition, workers that do not commute to the office may take other trips from home and back that they would not have if they had commuted that day.

- *Timeframe:* Near to long term.
- *GHG Reduction Potential*: Unclear and dependent on other factors such as energy consumption in the home office and travel behavior during telework days. The overall effect may be small.
- *Ease of Implementation*: Requires support from employers and public sector (e.g., incentives and pricing of parking/roads).
- *Co-Benefits / Mitigation Requirements*: Congestion will be reduced.
- *Responsible Parties*: Employers, state, and regional agencies (e.g., large employers, metropolitan planning organizations, Cal-trans, business, transportation and housing agency).

Problem:

Possible Solution:

C.5 CarPooling

Ridesharing (or carpooling) is an arrangement where two or more individuals agree to share a vehicle to their destination (typically commute trips). Frequently, the motivation for this is to save money, spend less time in traffic (via congestion-free high occupancy vehicle lanes), or reduce hassle (e.g., searching for a parking space at the office). A carpooling project in Stockholm, Sweden allows carpools of three or more people to use bus lanes for destinations in the city. The city government estimates that this effort will reduce CO2 emissions by 15 tons per year by 2050.[98]

- *Timeframe:* Near to long term (growth potential)
- *GHG Reduction Potential:* Modest.
- *Ease of Implementation*: More challenging without value/road and parking pricing policies. Nevertheless, often see an increase in ridesharing with higher fuel prices.
- *Co-Benefits / Mitigation Requirements*: Reduced vehicle miles traveled and parking demand.
- *Responsible Parties:* Regional government, Cal-Trans, employers

Problem:

Possible Solution:

C.6 Park-and-Ride Facilities

Park-and-ride lots are public parking facilities that enable commuters to leave their personal vehicles in such lots and transfer to transit or a carpool for the rest of their trip. Private vehicles are parked in the facility throughout the day and they are picked up when travelers return at the end of the day. Typically such facilities are found in the suburbs of large metropolitan areas. Development and management of park-and-ride lots is an important way to promote sustainable transportation.[99] Increasing park-and-ride facility capacity in Stockholm is estimated by the city to reduce CO2 emissions by 600 tons per year by the 2030 to 2050 timeframe (City of Stockholm, 2002).

- *Timeframe:* Near to long term (growth potential)
- *GHG Reduction Potential*: Moderate to large.

- *Ease of Implementation:* Low to moderate challenge, depending on facilities/spaces needed (and oversight)
- *Co-Benefits / Mitigation Requirements*: Fewer vehicle miles traveled, less parking demand, and greater transit ridership. This could divert individuals away from transit to ridesharing and increase the need for more park-and-ride facilities to accommodate a greater number of parking spaces (i.e., land use impacts).
- *Responsible Parties*: Caltrans, regional planning organizations, employers, transit agencies

Problem:

Possible Solutions:

C.7 "Low-Speed" Modes

"Low-speed" modes are motorized and non-motorized devices that travel at lower speeds, such as bicycles, electric bicycles, Segway Human Transporters, and neighborhood electric vehicles. Some of these modes use human propulsion and do not produce CO2 emissions. By enhancing the bicycle and pedestrian environment, it is possible to encourage travelers to take entire trips or partial trips with non-motorized modes that link with mass transit. One way to encourage bicycling as an alternative mode is through a better low-speed mode infrastructure, particularly on-street bike lanes.[100]

The city of Stockholm's long-term plan to reduce GHG emissions includes replacing 30 million short car trips with cycling annually. For longer trips, the city's goal is to encourage an additional 2,000 cyclists to give up car travel or public transit use every day during the summer months. Not surprisingly, this will require improving the low-speed mode infrastructure. Stockholm estimates that such improvements will reduce CO2 emissions by 2,900 tons per year by 2050 (City of Stockholm, 2002).

- *Timeframe:* Near to long term (growth potential)
- *GHG Reduction Potential*: Moderate.
- *Ease of Implementation:* Low to high (depending upon available land and political support)
- *Co-Benefits / Mitigation Requirements*: By enhancing the bicycle and pedestrian environment, it is possible to encourage travelers "to take entire trips or partial trips with non-motorized modes that link with mass transit[101]"
- *Responsible Parties*: Regional and local government, transit providers

Problem: Urban transportation systems are often inconvenient for pedestrians and cyclists.

Possible Solution: Development of pedestrian and bicycle friendly infrastructure at the local and regional level should be a priority. Federal law should also be revised to define bicycling as a "qualified" form of transportation eligible for the transportation fringe benefit, subject to specific incentive caps. The Bicycle Commuters Benefits Act of 2007 would amend the Internal Revenue Code to include a bicycle commuting allowance as a qualified transportation fringe benefit, excludable from gross income. The public sector can play a key role. For example, all state and other government buildings should provide bicycle parking whenever feasible to do so. Municipal governments should try "bike sharing" programs like the one in Paris, Francis, which provides conveniently located public bicycles for a small fee.

D. Traffic Flow Improvements

D.1 Traffic Signal Control

Traffic signal controls can integrate freeway and surface street systems to improve traffic flow and vehicular and non-motorized traveler safety and provide priority services for transit or high occupancy vehicles. They can manage traffic speeds, vehicle merging and corridor crossings, as well as interactions among vehicles and low-speed or non-motorized modes—such as bicycles, pedestrians, and wheelchairs—at intersections.

- *Timeframe:* Near to mid-term

  GHG Reduction Potential: Studies suggest that improved traffic signal control can produce fuel savings.[102] Results from a signalized intersection, using a real-time control strategy, resulted in a "four percent reduction for CO_2 emissions in peak traffic, corresponding to a 14 percent reduction in the part of costs due to stops and delays." These effects are reduced by approximately one half when traffic is fluid.[103]

- *Ease of Implementation*: Within a jurisdiction less challenging, providing transitions from one jurisdiction to next more challenging

- *Co-Benefits / Mitigation Requirements*: Smooth traffic flow, reduces stops and fuel use

- *Responsible Parties*: Local and regional governments

D.2 Incident Management

ITS traffic surveillance technologies—such as radar, lasers, and video image processing used to collect information—can help to reduce detection and incident clearance costs.

Incident management consists of three key areas: traffic surveillance (incident detection and verification), clearance, and traveler information. Also covered by this area are emergency management services, which coordinate local and regional incident response to traffic accidents, security threats, and hazardous material spills. ITS technologies employed can include traffic surveillance, digital and dispatch communications (including route guidance to the site of an incident), and signal priority (optimization of traffic signal timings along routes traveled by emergency vehicles). ITS contributions to incident management include improved surveillance, verification, and dispatch to manage an incident. The use of changeable message signs (CMSs) and personal communication devices, such as cell phones and personal digital assistants (PDAs), can assist with early notification for upstream drivers resulting in reduced incident-related congestion, as drivers have more time to select an alternate route.

- *Timeframe*: Near to mid-term
- *GHG Reduction Potential*: Improved incident management has the potential to decrease fuel consumption by reducing the delay and congestion associated with blocked traffic. While data on incident delay reductions are limited, model calculations for a Maryland initiative (called CHART) have shown fuel savings of 5.06 million gallons per year. [104]
- *Ease of Implementation*: Low to moderate
- *Co-Benefits / Mitigation Requirements*: Reduces traffic congestion, accidents
- *Responsible Parties*: Caltrans, regional and local governments, CHP

D.3 Electronic Toll Collection

Electronic toll collection (ETC) allows for electronic payment of highway and bridge tolls as vehicles pass through a toll station. Vehicle-to-roadside communication technologies include electronic roadside antennas (or readers) and pocket-sized tags containing radio transponders (typically placed inside a vehicle's windshield).

- *Timeframe*: Near to mid-term
- *GHG Reduction Potential*: Studies show that ETC saves time and reduces energy consumption and emissions by reducing the stop-and-go traffic associated with vehicle queues approaching toll plazas, stopping to pay a toll, and accelerating to rejoin regular traffic flow. [105]

  One recent study along the New Jersey Turnpike found savings of 1.2 million gallons of fuel per year due to reduced delays at toll plazas employing ETC.

Approximately three-fourths of the reported savings accrued to passenger cars and one-fourth to commercial vehicles.[106]

- *Ease of Implementation:* Low to moderate

- *Co-Benefits / Mitigation Requirements*: Reduced congestion, accidents; potential equity effects (due credit card billing to ETC account, some may not have access to credit card)

- *Responsible Parties*: Metropolitan planning organizations, Caltrans (as appropriate)

D.4 Traveler Information

ITS-based traveler information technologies—such as traffic surveillance and transit management systems—support the collection, processing, and dissemination of real-time information about travel modes and conditions. The objective of traveler information is to provide the traveling public with information regarding available modes, optimal routes, and costs in real time either pre-trip or en-route via in-vehicle information and CMSs along roadsides or at transit stations. Effective traveler information requires the accurate collection and dissemination of real-time travel information to transportation managers and the public to aid them in making informed decisions about travel time, mode, and route. A wide array of ITS technologies assist with traveler information including in-vehicle guidance, web sites, cell phones, PDAs, and CMSs to distribute user information.

- *Timeframe*: Near to mid-term

- *GHG Reduction Potential*: The actual impact of traveler information on fuel consumption and CO_2 emissions depends on a number of factors. For example, if ITS technologies assist drivers with route selection and guidance, benefits will likely be greater the less familiar a driver is with an area. Fuel economy benefits of route guidance systems could reduce non-optimal route driving and save up to 10 percent of miles driven and proportional fuel consumption.[107]

  The timeliness and delivery of information will also influence the degree to which travelers use it and subsequent energy/CO_2 emission impacts. Benefits might result from mode shifts (e.g., from a single occupancy vehicle to transit or bicycle) and savings proportional to travel time reductions achieved by taking alternate routes.

- *Ease of Implementation*: Moderate to challenging (need infrastructure to collect real-time information)

- *Co-Benefits / Mitigation Requirements*: Traveler satisfaction, reduced delays, increased transit ridership/alternative transportation modes; potential for privacy concerns (monitoring of travel times from toll tags)

- *Responsible Parties*: Metropolitan planning organizations, local governments, and Cal-Trans

E. Goods Movement

E.1 Alternative Fuels

GHG emissions due to diesel fuel consumption are identified for three specific transportation uses in California's GHG inventory: onroad (28.6 $MMTCO_2e$), railroad (3.1 $MMTCO_2e$) and other (0.5 $MMTCO_2e$) (Bemis and Allen 2005).[108] Approximately 3.9 billion gallons of diesel fuel is consumed in California for these uses.

Both biodiesel (fatty acid methyl ester, or FAME) and biomass-derived Fischer-Tropsch diesel (BFTD, and referred to simply as low-GHG FT diesel earlier in this section) can be used by current diesel vehicles. The American Society of Testing and Materials has approved a standard for FAME at blends levels up to 20 percent by volume but some engine manufacturers caution about blends over 10 percent.[109] A third type of biomass-derived diesel fuel can be produced by the hydrogenation of animal or plant oils, possibly including both waste oils and crop-derived oils.[110] BFTD and hydrogenated oils are extremely similar to ordinary petroleum-derived diesel, being sulfur-free hydrocarbons. These fuels have energy densities and other properties very similar to those of ordinary diesel fuel so their introduction is likely to be relatively simple and require little in the way of infrastructure. However, these fuels are relatively new and there is little information about their global warming impact in the open literature, and none in the peer-reviewed literature.[111]

Natural gas is also a heavy duty vehicle fuel, and can be is available in California as both a compressed and liquefied gas. There are over 125,000 natural gas vehicles in the United States today, and about 200 natural gas refueling stations in California. The carbon intensity of natural gas is about 25 percent less than that of diesel fuel, although this advantage is diminished somewhat because natural gas engines tend to be less efficient than compression ignition engines using diesel fuel. Advances in natural gas engine technologies and increasingly stringent diesel engine emission requirements tend to reduce this gap. Thus, heavy duty vehicle use of natural gas may also help lower GHG emissions in the transportation sector.

Off-road electric vehicles in California could contribute to state GHG reductions by 2020. These technologies can be applied in logistics (also known as freight handling

and goods movement) as well as other applications such as small lawn and garden engines, which are numerous in California. Jackson (2005) evaluated two applications at ports: the use of shore power instead of ships' engines for electricity and heat (a practice called "cold ironing") and the use of electric-drive cranes instead of diesel-powered cranes.[112] Two truck-related electric applications were also evaluated: electric truck refrigeration units (e-TRUs) instead of diesel-powered devices, and the supply of electricity at truck stops as a substitute for engine idling.

E.2 Electric Freight Rail

Cargo transport is responsible for 8 percent of state CO_2 emissions and is forecasted to increase rapidly in the future. Meeting California's climate goals will require policies that lower these emissions. One possibility is to substitute electric rail for highways for goods movement. Another possibility is to develop electric powered guideways (similar to PRT systems) for freight shipments.

- *Timeframe:* by 2020.
- *GHG Reduction Potential*: In addition to the shipment of cargo, significant GHG emissions reductions could take place by replacing intrastate air travel with high-speed, electric rail travel. Air travel in California represents 5 percent of the state's CO_2 emissions (roughly equal to half of the GHG emissions generated by in-state electric generation). High-speed electric rail could reduce GHG emissions considerably.
- *Ease of Implementation:* Most rail systems are privately owned. Amtrak operates for the most part on private rail Rights-of-Way, with freight transport taking precedence. Creating new tracks that allow the separation of passenger and freight operations would be a first step toward improving both transport delivery systems.
- *Co-benefits / Mitigation Requirements*: A strategy for rail improvements ideally would be launched near ports and the routes into and out of the ports, where serious Environmental Justice problems result from the concentration of air emissions from diesel ships, trains and trucks. Public health would obviously benefit from a shift in transportation priorities toward electrified rail.
- *Responsible Parties:* Private operators, regional and state transport agencies, Amtrak, Federal Rail Administration.

Problem: A large portion of the cargo coming in and out of California currently relies on the trucking industry and congested highways.

Possible Solution: Standard rail transport systems emit far fewer CO_2 emissions per ton-mile than long-haul trucking (the exact benefit varies with distance). Electrified rail travel, including shipments from truck to rail as well as from diesel rail to electric rail,

would reduce emissions *and* lower oil imports. Coordination with the high speed rail authority would be needed.

F. Other

F.1 Alternative Fuels for Aircraft

There is significant research and development activity into the possible use of alternative and/or renewable fuels for aircraft. This research is inadequately supported given the expected difficulties to gaining significant GHG emission reductions from the aviation sector.

- *Timeframe:* Long-term
- *GHG Reduction Potential*: High
- *Ease of Implementation: Low*
- *Co-Benefits / Mitigation Requirements*: There is potential for air quality benefits near airports as well as reduced radiative forcing impacts from co-pollutants such as nitrogen oxides and particulate matter.
- *Responsible Parties:* ARB, CEC, and California universities.

Problem: Improvements in engine and airframe efficiencies are likely to be outpaced by projected increases in demand for passenger air travel. While aircraft engine and airframe efficiencies have historically improved over time, they are not sufficient to overcome projected increases in passenger miles. That role may ultimately need to be filled by low-carbon fuels.

Possible Solution:

California should publicly support research and development into bio- and alternative fuels for use in aviation applications. According to Boeing, in the near term the use of "bio-jet" fuel from the same feedstocks as vehicle fuels like biodiesel and ethanol is possible as a blend to stretch supplies of Jet-A refined from crude oil. Feedstocks with potentially lower land-use impacts, such as switchgrass and algae, have also been identified as possible options.

Integrated Gasification technology is another potential option for producing fuels from renewable sources. Kerosene suitable for aviation can be co-produced with other liquid fuels, diesel and naptha. Wood is considered a potential feedstock, and the value of electricity co-produced can bring down the cost significantly while the CO_2 emissions

equal to the content of the fuel would be removed from the atmosphere as crops are grown. According to scenario studies, CO_2 emissions could be just a few percent of conventional kerosene.[113] Under a high electricity value and other favorable assumptions, one UK study found that gasification could bring prices closest to petroleum Jet - A. The California Energy Commission has also recently funded a gassifier demonstration project in Northern California using woodwaste as a feedstock.

In the long-term, hydrogen is another potential fuel sources that can be produced from renewable resources. Hydrogen as a fuel is considered very long term, due to the need to re-design aircraft to accommodate this fuel. To the extent that a hydrogen fueling infrastructure is developed for ground transportation, this would also support any future shift in the aviation industry to hydrogen as a fuel source.

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Appendix VI: Summary Table of Public Responses to Request for Climate Change Emission Control Technologies

ID	Suggestion	Pollutant saving	Cost	Contact Last Name	Contact First Name	Organization
1	direct photoelectrochemical H2 generation from Water	CO2	$2.08/kg H2	Oakes	Thomas W	Solar Hydrogen Co.
2	increase recycling and materials-specific waste limits	5mmtCO2-eq		Smithline	Scott	Californians Against Waste
3	petroleum coke to H2-fueled turbine for electricity generation	CO2, sequestered	$2B capital, 2 percent /yr operating	Rau	Tiffany	Carson Hydrogen Power
4	improved fuel/air mixing increases combustion efficiency	CO2, others	$199/gas engine	Mogford	John	Tadger Group International
5	pulse corona discharge to control soot from combustion	soot	na	Harris	Godfrey	Pulsatron Technology
6	more HOV lane stickers to incentivize high mpg vehicles	CO2	na	Kutaka-Kennedy	Joy	citizen
7	fuel and oil additives for improving vehicle mpg	CO2, others	na	Phelps	Kyle	Advanced Lubrication Technology
8	H2 ICE and fuel cell transit buses	CO2	na	na	na	na
9	on-board water to H2 generation for ICE intake air fumigation	CO, PM, HCs, others	$12,900 for large diesels	Gilchrist	Steve	Canadian Hydrogen Energy Company
10	fuel taxes to encourage high mpg vehicle development	CO2	na	Fromm	Larry	Achates Power
11	high-albedo materials to reduce a/c cooling demands	110-210kg CO2/year/100sq m treated roof	$0.0 - $0.20 /sq foot	Taha	Haider	Altostratus Inc.
12	SCR for ferry boats	NOx, THC, PM	17 percent of vessel constructio n costs	Weaver	Chris	EF&EE
13	solar, wind, fuel cell ferry boats	CO2	na	Culnane	Mary	San Francisco Bay Area Water Transit Authority
14	split cycle retrofit kit for existing engines	NOx, PM, 50k tpd CO2-eq for CA diesel fleet	$500/liter displaceme nt	Rutherfor d	Rob	Roted Design Ltd.
15	advanced mpg display in cars to inform/incentivize drivers	CO2	na	Rhett	Norm	citizen
16	improve electricity generation efficiency by enhanced turbine H2 cooling system control	.64mmtpy CO2/yr from 32 plants	$140k-$260k per plant	Speranza	John	Distributed Energy Systems
17	relocate power plants to oil fields for CO2 sequestration and oil recovery	na	na	Zozula	Kerby	Ventura County APCD

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18	replace high GWP solvents with flammable low-GWP solvents	HFCs, PFCs		na	na	MicroCare, 3M, others
19	oxygen fired combustion for electricity generation & easy CCS	CO2, others	$0.085/kw-hr	DeVanna	Leonard	Clean Energy Systems
20	battery bicycles recharged from nuclear power	CO2, others	$1,000-$1,500 per unit	Jamerson	Frank	Electric Bikes Worldwide Reports
21	ethanol-based fuel borne catalyst to improve combustion efficiency	CO2, others		Randoll	Bill	Accelerated Solutions
22	pressurized oxygen fired combustion with sequestration	50k-100k tonnes CO2 /day in CA	na	Fassbender	Alex	ThermoEnergy Corporation
23	external combustion and detonation rotary engine	20 percent -60 percent CO2 reduction	na	Saint-Hillaire	Gilles	Quasiturbine
24	college campuses to use multiple "hybrid" technologies	CO2, others	7-11 year payback	Clark	Woodrow	LA Community College District
25	natural gas replacement for wood burning stoves/fireplaces	CO2, others	$3400/unit + $50-$70/year	na	na	Sempra Energy, others
26	ultra capacitors for electric vehicles	CO2	na	Chambers	Phillip	USMC
27	vehicles that have limited run on battery power or run on a solar powered monorail	CO2	$150k/mile for rail, $10k/car	Roane	Jerry	Roane Inventions
28	H2 fuel cells to replace marine APUs	CO2	$3400/kw	Bruns-Wustefeld	Stefan	Hannover Export Management Conusult
29	install smart meters to increase consumer awareness of electric power consumption	CO2	$100-$400 per unit	na	na	na
30	Smart Signs connected to hiway remote sensing to make motorists aware of vehicle condition	CO2	na	na	na	na
31	biofuel technology for passenger cars	CO2	less than $1000/vehicle	Ellis	Chris	Hykinesis Inc.
32	plug-in hybrid vehicles with larger batteries	CO2	na	Nortman	Pete	EnergyCS
33	require dockside ships to use cold ironing	CO2	$3.5M/berth, $1M/ship	Waugh	Mike	ARB
34	microsolar panels to supplement residential electricity	CO2	$300/75W	na	na	na
35	synthetic engine oil to increase engine efficiency	CO2, others	$7-$8/qt	Suel	Patrick	na
36	charge fee for low mpg cars to subsidize high mpg cars	CO2, others	na	Hodge	Cal	For a 2nd Opinion Inc.
37	Neste Oil's techology to convert vegetable/animal fat	CO2, others		Hodge	Cal	For a 2nd Opinion Inc.

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	to diesel fuel					
38	liquefied landfill gas for vehicular use	CO2	$.72-$1 /gallon LNG	Watkins	Larry	SCAQMD
39	plasma magneto-hydrodynamic power generation using decaying isotopes	CO2	na	Vahab	Christian	Peeker Atomic Energy Systems Inc
40	react CO2 with H2 to make a fuel for electricity generation	CO2	na	Ralston	Jack	ECO2
41	rebates as incentives for LSVs	CO2	na	Drushell	Theo	Davis Electric Cars
42	hydraulic, pneumatic systems for vehicle regen braking	CO2	na	na	na	CalStart, etc.
43	electrification of airport GSE	CO2	$20k/unit	Pasek	Randall	SCAQMD
44	use waste heat from residential a/c to heat water for house or spa	CO2	$550-$700/unite	na	na	G&S Mechanical Services
45	CEQU-based fee structure for GHG emissions	na	na	Craft	David	MBUAPCD
46	remove barriers to better forest management	na	na	na	na	USDA Forest Service
47	flywheel batteries for port cranes	CO2 15 percent -20 percent	$250/crane	na	na	VYCON
48	100 mpg cars at reasonable cost	CO2	$3k-$11k/car	Starr	Gary	ZAP
49	fuel cell vehicles using H2 from renewable sources	CO2	na			California Fuel Cell Partnership
50	cellulosic ethanol biorefineries	CO2 by 80 percent	$7/gallon/year	Simmons	Blake	Sandia National Laboratories
51	biodiesel from algae	CO2	$.52/L	Simmons	Blake	Sandia National Laboratories
52	on-board ammonia for reducing NOx	CO2	na	Jacobson	Wiliam	SY-Will Engineering
53	capture landfill gas for power generation	CO2, CH4	na	Bennet	Russ	Redding Power
54	increase average vehicle ridership through ridesharing incentives	CO2	na	Bishop	Josepth	Traffic Bulldog
55	Demand Side Management, reduced population growth	CO2, others	na	Bennett	Russ	Redding Power
56	proprietary substitute for blowing agent for polyurethane and polystyrene foams	F-gases, HFCs, 500k tonnes CO2-eq	na	Kalinowski	Tim	Foam Supplies Inc
57	tax rebates for residential solar water heaters	CO2	$1500 rebate/unit	Del Chiaro	Bernadette	Environment California
58	decentralize worksites for large organizations to reduce commute emissions	CO2	na	na	na	na
59	convert diesel engines to natural gas	CO2 down 20 percent -25 percent	na	Funk	Werner	Omnitek Engineering

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60	ice storage air conditioning to shift a/c loads to off peak hours	CO2 4-6 tpy CO2-eq/commercial building	up to $30k/installation	Kuhlman	Paul	Ice Energy Inc.
61	solar conversion of ambient CO2 to fuel	450 tpd CO2 per 100k gallons MeOH produced	$5-$6/gallon gasoline equivalent produced	Stechel	Ellen	Sandia National Laboratories
62	truck APU	CO2, others	$1350 installed, $120/yr	Dennehy	John	Emerson Suphal
63	convert all CI & SI engines to run on plant-based fuels	CO2, others	equal or less than current fuels	Hotaling	Dick	Fleet Multi-Fuel Corp
64	use nuclear power, iron-seed oceans to increase algae	CO2	$.10/kw-hr, trillion dollars	na	na	nrc.gov, planktos.com
65	fuel additive to improve fuel economy	CO2	$03-$.12/fuel gallon treated	Taplin	Harry	BTU Consultants
66	continue incentives for CHP projects	CO2 50 percent reductions over central power plants	$1800-$3000/kw plus .5-2 cents/kw	Wong	Eric	California Clean DG Coalition
67	scrubber for removing VOCs without combustion	CO2, others	10 percent -100 percent cost of conventional thermal oxidizer systems	McGinness	Mike	EcoShield
68	hybrid HVAC using evap cooling, heat exchangers and thermal storage	CO2, others	$15/sq ft	Lentz	Mark	Lentz Engineering Associates
69	install solar collectors as Salton Sea evaporates to reduce dust and generate power	CO2, dust	na	na	na	na
70	install flue gas condensers on boilers/heaters to recover latent heat	CO2, CH4, reduced by 10 percent -15 percent	na	Abma	Sid	Sidel Systems USA Inc
71	reactors to reduce ag waste for burial/sequestration and oil recovery	CO2	$500/unit	Semerau	John	na
72	ban high consumption light bulbs, incentivize residential solar panels, etc.	CO2	na	na	na	na
73	restore ecosystem productivity	CO2 200 tons/hectare	na	Coleman	William	Planktos
74	proprietary battery for EVs, 200 Wh/kg, $150/kw-hr	CO2	$150/kw-hr	England	Christopher	Electrochimica Development

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75	new EV	CO2	$1B-$2B	Woodbury	Rick	Commuter Cars Corp
76	system to recycle exhaust to the intake of vehicle engines	CO2 reduced 23 percent , others	$9000/retrofit	Covit	Raymond Paul	na
77	subsidize retrofits of existing technologies	CO2	na	na	na	na
78	capture potential energy of trains descending long grades as electricity	CO2	$5M/mile	Bartley	Tom	ISE Corporation
79	public outreach and education to remind people where resources come from, what happens to wastes	CO2	na	na	na	na
80	recuperated gas turbines to replace locomotive engines	CO2	$1.126M/locomotive/20yrs	Pier	Jerome	JR Pier & Associates
81	improved drying process for clothes dryers and flue gas cleaning	CO2 8.5M tonnes/yr in Germany	na	Curtis	Fritz	na
82	tree sequestration	35 trees = 6 cars	low	McPherson	Greg	UCDavis Urban Forestry
83	outreach - reduction is the solution, technology is not	na	na	na	na	na
84	hybrid, alt fuel, other "green" vehicles	CO2	na	na	na	na
85	lithium batteries - H2 is a storage medium not a fuel	CO2	na	na	na	na
86	expand electric rail service throughout the State, and nuclear power	CO2	na	na	na	na
87	diesel-electric hybrid class 6&7 trucks	CO2 down 30 percent -60 percent	$47k/truck	Trueblood	Tom	International Truck and Engine Corp
88	fuel cell CHP systems	CO2 down 20 percent -50 percent	$7/kw installed, 6 cents/kw-hr	Slangerup	Tom	ClearEdge Power Corp
89	incentives to reduce cost of HD hybrid vehicles	CO2 down 30 percent -60 percent	incremental cost of 50 percent - 100 percent	Van Amburg	Bill	WestStart-CALSTART
90	increase us of polyurethane foam panels and spray-on insulation to reduce buiding energy losses	CO2 down by 15 percent -20 percent	20 percent -200 percent of conventional insulation cost, but 15 percent -50 percent energy savings	Womack	Frank	Air Products and Chemicals Inc.
91	unique CO2 separation technology to reduce CCS costs	CO2, 10ktpd for 500MW plant	na	Graham	Wendy	Air Products and Chemicals Inc.
92	high speed maglev, as used in Shanghai	CO2, 743ktpy	$19B capital,	Perdon	Alberto	Orangeline Development Authority

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			$394M/year operating			
93	battery-powered school bus	CO2, 100 percent reduction	$225k-$250k/bus, saves $8250/yr in fuel	na	na	na
94	State funded solar and wind power installed on industrial roofs	na	na	na	na	na
95	Advanced Energy Storage to flatten electric grid load curves	CO2	$00-$800/kwhr	Wong	Eric	California Clean DG Coalition
96	electric efficiency improvement through automation and DG	CO2, others	na	Cleveland	Frances	Xanthus Consulting International
97	automated equipment and ground power to reduce locomotive engine run time;	CO2 down by 43 percent	$8000/locomotive	Smith	Wade	Amtrak
98	High Speed Train in California Corridor	CO2 down 12.4B pounds	>$33B	Smith	Wade	Amtrak
99	H2 generator based on ethanol reforming	CO2 down 1ktpy	$2.5-$5/kg H2	Shuster	Terry	HyRadix Inc
100	Advanced Truck Stop Electrification	CO2 down 98k tonnes/year	$16,700/parking space	Doty	Carol	IdleAir Technologies Corp.
101	cellulosic ethanol via acid hydrolysis, also from landfill gas and waste	CO2 down 176ktpy/plant	$1.02/gallon	Sumait	Necy	Blue Fire Ethanol
102	replace current IC engines with Tour engines	CO2, others	na	Tour	Oded	Tour Engine Inc.
103	solid oxide fuel cells	CO2 down by 400lbs/MWhr	$10k/kW	na	na	Bloom Energy
104	CHP DG systems with fuel independent renewables	CO2 65ktpd	4-5 cents/(kWe+kWt)	Castaldini	Carlos	CMC-Engineering
105	bio-oils from microalgae	2M tpd for 30 percent market share	$1/gallon	Asmussen	Keith	General Atomics
106	tidal electricity generation	CO2, others	na	Von Jouanne	Annette	Oregon State University
107	forestry and biomass for power generation	CO2, 7M tonnes/yr	$2M/MW	Reese	Phil	Colmac Energy
108	promote solar pv installations	na	na	na	na	na
109	closed-cycle combustion	CO2, 100 percent reduction	1/3-2/3 cost of conventional boilers	Stockton	Edward	SOG
110	compression and turbo-expansion of process exhaust stream to separate CO2	CO2	na	Chang	Dan	UC Davis
111	incentives for hybrids to replace older cars, ala Moyer program	CO2	na	na	na	na
112	enhance phytoplankton	CO2	na	Barry	Chris	Ocean Renewable Energy

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	fertility as offshoot of Ocean Thermal Energy Conversion facilities					
	January 10, 2008	Cal-EPA Headquarters, Sacramento		Approval vote on the final report.		
113	digestion and co-digestion of organic feedstocks to methane for CHP	CO2, CH4	na	na	na	na
114	suction to remove CO2 from atmosphere	CO2, CH4	na	Goodrich	John	na
115	alt fuels for Container Terminal Equipment	CO2	na	na	na	na
116	replace older equipment with lean burn equipment	CO2	na	Ayala	William	Jon's Marketplace
117	partial oxidation catalyst for vehicles	CH4, NOx 41 percent	$18-$30/vehicle	Bartley	Gordon	SwRI
118	permitting fast track for businesses using green technologies	CO2, CH4	na	Ryan	Hank	Small Business California
119	focus on efficiency, incentives for performance	CO2	na	na	na	na
120	instead of cap & trade, use tax refunds/feebates to incentive technology development and commercialization	na	na	Johnson	Ken	na
121	find substitute for Si in PVs, advance Ni-metal-hydride for H2 storage in cars	CO2	na	Deniz	Gladys	na
122	better refrigerator insulation, lower appliance stand-by power demand, prioritize hiway lane access	CO2	na	na	na	NA
123	CO2 capture via hydrogenation to methane	CO2	na	na	na	ECO2 (Norway)
124	innovative HVAC system for improved indoor air quality at reduced energy consumption	CO2	na	Mumma	Stanley	Penn State
125	wind power to generate H2 for vehicle use	CO2	na	na	na	na

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[28] The CSI program was modified by SB 1 (Murray), Chapter 132, Statutes of 2006, and restricted the funding mechanism to only electric distribution rates. The CPUC, in Decision (D.) 06-12-033, interpreted SB 1 to read that it would be inappropriate to subsidize solar thermal technology that displaces gas with electric ratepayer dollars. Though currently there is $100.8 million for solar thermal in the CSI, the funds can only be used to displace electric usage.

[29] Based on an average yield of 77.5 gallons of ethanol per dry ton and 72 gallons of FT liquids per dry ton. From Recommendations for a Bioenergy Plan for California prepared for the Bioenergy Working Group, by Navigant Consulting, Inc. April 2006
[30]Information derived from: Recommendations for a Bioenergy Plan for California; http://www.energy.ca.gov/2006publications/CEC-600-2006-004/CEC-600-2006-004-F.PDF
[31] It has been estimated that there is the potential of storing over 1 billion tones of CO2 in existing California oilfields. There are several large scale geologic sequestration projects in place: Staoil at Sleipner, Norway; BP at In Salah Algeria; and, Encana at Weyburn in Saskatchewan, Canada.
[32] The volume of carbon dioxide that must be extracted from all power plant emissions streams is orders of magnitude greater than those used and sequestered in enhanced oil recovery processes. A single 800-megawatt coal-fired power plant will produce approximately 6.1 million tons of carbon dioxide annually,

compared to the approximately 5 million tons of carbon dioxide used annually by the largest enhanced oil recovery projects.

[33] CO2 Sequestration Options for California, ETAAC, Larry Myer, CEC, May 10, 2007

[34] Topical Report: Development of Hydrogasification Process for Co-Production of Substitute Natural Gas (SNG) and Electric Power from Western Coals, Ray Hobbs P.E. , NETL, May 31,2007

[35] Presentation: Carbon Capture Corporation, ETAAC, September 2007

[36] Presentation: Greg Rau, U.C. Santa Cruz, ETAAC, May 2007

[37] A number of deep, leak-proof geologic formations have been identified as candidates for long-term CO2 storage. These include depleted oil and gas reservoirs, deep saline formations, and unmineable coal seams. In most cases, CO2 would be injected into such formations as a supercritical fluid to maximize the storage density. To ensure that injected CO2 would remain in this state, the geologic storage formations would have to be at depths greater than 800 meters (about half a mile) below the earth's surface. The effectiveness of such formations for long-term CO, storage is the subject of much international research and many testing programs.

[38] IPCC Special Report, Carbon Dioxide Capture and Storage, Summary for Policymakers

[39] There are ICGG plants operating in Florida, Indiana, California, Delaware, Kansas, Italy, Spain, Japan and Singapore.

[40] There are currently two operating coal-based IGCC plants in the United States and two in Europe. The two U.S. projects were supported initially under the Department of Energy's Clean Coal Technology demonstration program but are now operating commercially without DOE support.

[41] At high elevation, the air pressure - and hence the density of air - is lower. The output of all combustion turbine-based resources, not just IGCC plants, is thus reduced at higher elevations.

[42] The Essential Role of CO2 Sequestration in Stabilizing Atmospheric CO2, Greg Rau, U.C. Santa Cruz & Lawrence Livermore National Laboratory, ETAAC, May,10,2007

[43] Letter to Alan Llyod, Ph D. Chair, ETAAC, from Catherine H. Reheis-Boyd, COO, Western States Petroleum Association, June 13, 2007.

[44] International Carbon Capture and Storage Projects Overcoming Legal Barriers, Robertson, Findsen, Messner, National Energy Technology Laboratory, U.S. DOE, June 23, 2006

[45] Nuclear Power in California: 2007 Status Report Prepared for the California Energy Commission, MRW & Associates, June 2007.

[46] Nuclear Energy Institute, New Nuclear Plant Status as of 8/07

[47] Since LLNL is managed by the UC, it provides several important linkages to the ten UC campuses. The Campus-Laboratory Collaborations (CLC) Program and the Campus-Laboratory Exchange (CLE) Program are efforts to foster and support collaborative research efforts between the campuses and LLNL. Research collaborations between LLNL and the UC campuses have produced many beneficial results in the carbon sequestration area. Three of the eight CCS projects conducted at UC campuses mentioned above were collaborations with LLNL.

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