Greetings! This document is a draft report intended to provide a basis for public comment and for discussion by the Economic and Technology Advancement Advisory Committee at its November 29, 2007 meeting to be held on the campus of the University of California at Merced.

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 November 27, 2007 to be available to the Committee at the November 29 ETAAC meeting.

Further information on ETAAC can be found at

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

and information on the November 29 ETAAC meeting is available at

http://www.arb.ca.gov/cc/112907pubmeet/112907pubmeet.html

Economic And Technology Advancements for California Climate Solutions

Discussion DRAFT summaries of proposals to
The Economic and Technology
Advancement Advisory Committee to
The California Air Resources Board

November 15, 2007

Note: This discussion draft report includes proposals made to ETAAC by ETAAC members or members of the public. Consideration by ETAAC does not represent an endorsement by ETAAC or the California Air Resources Board.

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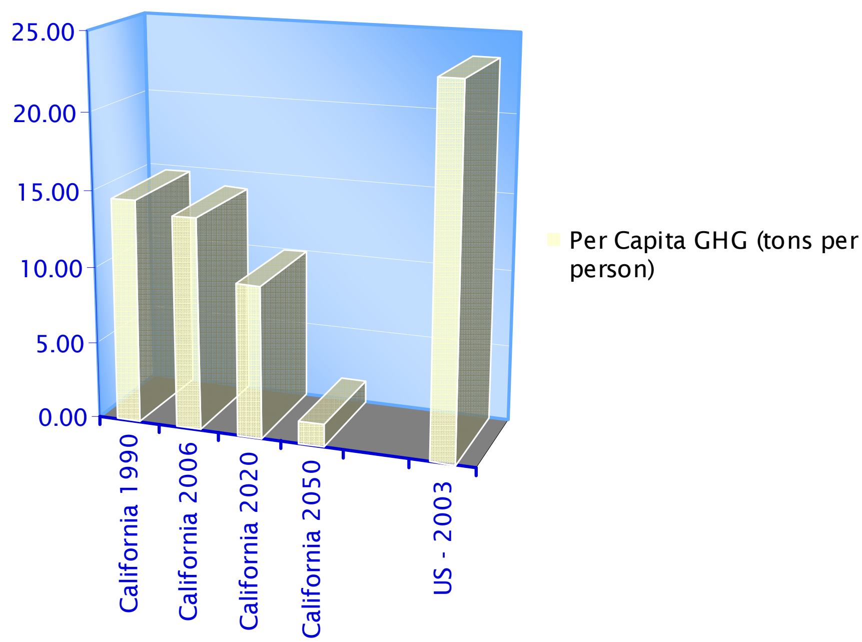
1. INTRODUCTION

I. The Challenge Facing California

The California Legislature passed Assembly Bill 32, The California Global Warming Solutions Act of 2006, and Governor Schwarzenegger signed the legislation into law in September 2006. The focus of this ground-breaking bill is to direct the California Air Resources Board (CARB) to implement policies to reduce the state's greenhouse gas emissions (GHG) by 25 to 29 percent by 2020, a percentage decrease that equates to approximately 174 metric tons of GHG from the projected "business as usual" scenario.

The legislation did not specify how much each sector of the California economy would have to reduce emissions, but unlike the approach being implemented by the European Union – focused largely on point sources -- AB 32 covers all sectors of California's economy. The Governor has also set a state goal of cutting GHG emissions by 80 percent by 2050 – which will represent a 90 percent reduction per capita from 1990 baseline levels if the state's population continues its current growth trend[1].



These goals are quite an impressive challenge, but California's track record on achieving environmental and economic progress in the face of great challenges is equally impressive. California's power plants now emit less than 90 percent of the nitrogen oxides that form ozone and fine particulates than two decades ago. California's greenest new passenger cars are more than 99 percent cleaner for Volatile Organic Compounds (VOC) and Nitrogen Oxides (NOx) than in 1970. California per capita energy consumption has remained essentially flat for decades despite a national trends showing consumption increasing by 50 percent, according to figures compiled by the California Energy Commission (CEC). Sustained technological advancement supported by a range of policies impacting a broad swath of California's economy will be necessary to meet AB 32's 2020 goals. Innovations on new zero or near zero GHG emitting technologies will play an even more crucial role in California attaining year 2050 GHG emission reduction goals.

California has before it a prime opportunity to meet these aggressive AB 32 goals. But 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 reduction targets. Development of new kinds of clean vehicle 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. By acting sooner rather than later, California can lower the costs of transitioning to an economy less dependent upon carbon and other GHG emissions[2] while reaping the rewards of a more sustainable, efficient and competitive economic system.

While California's current GHG emissions from the energy sector represent a challenge in meeting the AB 32's reduction targets, they also represent a map of opportunity. Between 2001 and 2006, the United States has experienced a general decline in manufacturing employment, with California faring worse (-19.9 percent) compared to national average (-17.0 percent). California's investment in advanced and emerging clean technologies in all of the sectors analyzed by ETAAC has the potential to bring billions of investment dollars into the state and promote long term sustainable economic and business growth. The opportunities cut across all sectors examined in this ETAAC report – transportation, industrial, energy, agriculture and forestry. Renewable energy and alternative fuels could create jobs in all stages of economic development, ranging from research and development to manufacturing and the rest of equipment lifecycles.

II. The Role of ETAAC

ETAAC was created to facilitate the development of new policies and technologies as quickly and economically as possible - including efforts that reach outside of direct GHG regulations. One specific provision of AB 32 instructs CARB to create the Economic and Technology Advancement Advisory Committee (ETAAC):

> *"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."*

CARB provided several specific areas of focus for ETAAC. CARB also requested that ETAAC look broadly at issues that relate to CARB, state agencies and the 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 agreement was not possible. Each recommendation may not necessarily reflect the views of every ETAAC member.

The 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). The ETAAC has also agreed to develop an Internet website providing access to details of the technologies ETAAC is reviewing as vehicles to comply with AB 32.

The work of ETAAC is designed to complement ongoing efforts to reduce GHG emissions in California. The recommendations contained in this report do not replace or supersede existing state regulatory programs, or any adopted future policies authorized under AB 32. However, the ETAAC report may facilitate the development of technologies that help meet, or even exceed, the GHG 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.

III. General Principles

General principles guiding policy recommendations put forward by ETAAC include the following overarching themes:

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 in the near-term to demonstrate near-term progress, but policies must also be designed to meet a 25 to 29 percent 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. That's why California must continue to accelerate innovation to make progress in reducing GHG emissions in all sectors of the economy in the future.

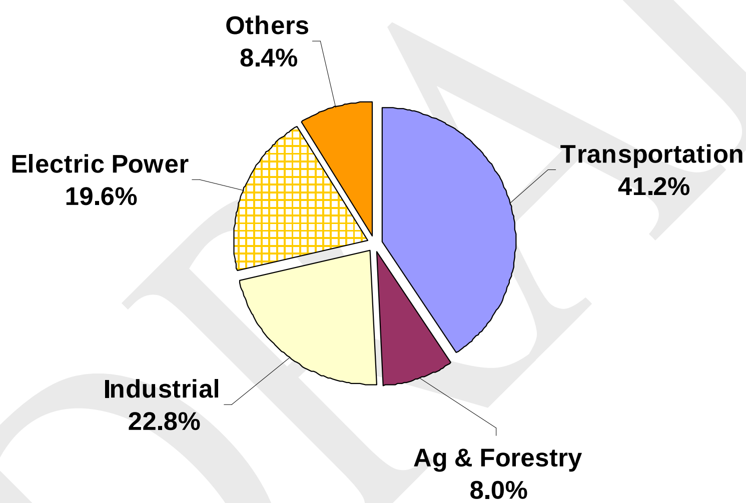


Figure 1 Carbon Emissions by Sector

Participation Across All Sectors: GHG emissions are a function of many activities ranging from manufacturing and agriculture to how residents power their homes and use transport. Policies implemented under AB 32 and the Governor's Executive Order for 2050 should address all sectors, so that all significant sources of 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 reduction goals in a timely manner.

GHG Prices and Complementary Policies: Placing a price on GHG emissions is a critical step to respond to the climate change threat as it allows private markets to incorporate the value of reducing emissions into their everyday business investment decisions. As the Market Advisory Committee notes, however, undervaluing GHG emissions is but one of many market imperfections that can limit solutions to climate change. 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. These complementary strategies form the core of ETAAC's policy recommendations.

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 norm. ETAAC makes a number of recommendations based on the need to help emerging technologies move through demonstration phases to achieve full commercial viability. The best approach may be to support new technologies to a point where they can stand-alone within a market structure characterized by performance standards and carbon prices. To the extent that stubborn market failures or other barriers require on-going incentives or other forms of support for GHG reduction technologies beyond the point of full commercialization, these programs should be based on performance.

Maximize Public Health and Socio-Economic Co-Benefits*:* Some policies can reduce pollutants that affect climate change as well as local public health. For instance, ground level ozone contributes to both climate change[3] and major public health problems in California.[4] Black carbon -- in particular fine particulates –is also an important public health issue. As discussed during U.S. Senate hearings, 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 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 affects may need to occur when specific implementation measures are developed by CARB or other agencies or organizations

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. For instance, ETAAC recommends that CARB distribute lists of potential measures to other state agencies to identify areas where early coordination is needed to identify opportunities 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 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 required GHG emission reductions.

It is also critical that California's state government work with the federal government to achieve AB 32's goals, in order to lay the groundwork for transferring successful programs and strategies to the national stage. California's energy efficiency programs, renewable energy development efforts and passenger vehicle GHG standards can clearly 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 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 international transportation beyond the scope of California's state regulatory authority.

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

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. The type of 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 technology research and implementation funding, with at least some overlap with AB 32's GHG emission reduction goals. For example, equipment change-outs to cut criteria air pollutant benefits 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. To broaden the resources available to develop low-carbon solutions and help spread the co-benefits, ETAAC also recommends that partnerships with industry and other private organizations, other state and local governments, and the federal government be pursued. 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.

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 capital intensive infrastructure that is 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.

IV. 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 recommendations that support climate change solutions that stretch across sectors and then one chapter for each of the five specific sectors analyzed (transportation, industry, energy, 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. 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] Values for California Air Resources Board inventory, not including "excluded" categories related to international aviation and marine emissions.
[2] Stern Review, 2006, Cabinet Office - HM Treasury
[3] IPCC, Fourth Assessment Report (AR4), Working Group 1 Report "The Physical Science Basis," Summary for Policymakers, 2007
[4] The California Almanac of Emissions and Air Quality - 2007 Edition

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 reduction technologies. The general public contributed a variety of written suggestions on financial tools to accelerate GHG reduction technologies, which will be documented at the ETAAC web site (www.etaac.org). This report 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 to maintain a strong nexus between manufacturing and RD&D and still to be close to major markets, and yet barriers to this potential synergy remain. These barriers can result in relocation of Cleantech companies to other regions and states.

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 reduction targets (see recommendation C below.) AB 32 sets the stage for a timely opportunity to rationally link the state's many 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[i] 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 positioned well to attract venture capital investments in Cleantech companies. California led the nation in Cleantech venture investments in 2006 with over $1 billion, representing over 40 percent of total Cleantech investments nationwide. 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.[ii]
- 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, energy; agriculture; and forestry. An ETAAC analysis of the Market Advisory Committee's report is also included to frame how market structures will also impact early actions, innovations and price signals in each of the state's economic sectors.

II. Central Recommendations: Carbon Trust & Cleantech Commercialization

A. Create a California Carbon Trust

A new public or a public-private entity that 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.

- *Timeframe:* in place by 2012.
- *GHG Reduction Potential*: The potential for GHG 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. If the Trust is able to secure reductions at a cost equal to or slightly less than auction prices, then 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 greenhouse gas 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 outside the AB 32 cap, helping California to reach its ambitious GHG 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 for 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 -- 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. For example, a project applicant might want to retrofit the 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.

To ensure the integrity of the carbon reductions, the Trust must limit funding to project 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 all cases, the Trust would need to hold a reserve to protect against unexpected shortfalls (i.e., some percentage of carbon reductions is held in reserve so that environmental integrity can be maintained in case of project failure.)

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 could 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 units 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 ensure that carbon reductions occur within California and 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 air pollution reductions 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 reduction. In these cases, the Trust would pay not only for carbon reductions, but would also pay for 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 reduction targets, but also achieve environmental justice goals such as job creation and pollution reduction.

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 reduction credits could be retired for public benefit or possibly sold into voluntary markets.

3) Actively Manage the Carbon Market and Mitigate Price Volatility

The third role of the Trust could be as an enabler and/or "market maker" of the 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 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.

4) Encourage Research, Development, and Demonstration

A fourth role for the Trust would be to fund low-cost, high impact University research and demonstration projects. These are both 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 this area, with funds to be distributed based on judgments of the relative promise, reliability, and cost-effectiveness of projects in various categories.

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[iii]. 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. We should expect that 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 a nexus must exist 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.

Central Recommendation: Cleantech Commercialization

B. Promote Clean Energy Innovation and Commercialization

Support California research, development, demonstration 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 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 sector to identify opportunities 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 GHG reductions.
    - Would orient disparate clean energy programs toward the unifying goal of GHG reductions without decreasing importance of other 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 make an affirmative commitment to research, development and demonstration 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 in the outer years. 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.

To be considered "Cleantech," products and services must: optimize use of natural resources, offering 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 are:

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

- **Target R&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 (ie 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 GHG reduction goal, 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 run 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.

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 greenhouse gas emissions than those resulting when manufactured elsewhere.
- *Ease of implementation:* Moderate. Could use existing public goods charge funds.
- *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; Legislature; California Business Transportation and Housing Agency.

Problem: California lacks sufficient incentives and faces barriers to developing a strong Cleantech manufacturing sector. California alone lost nearly 340,000 manufacturing jobs in a recent five year period. Cleantech manufacturing could help create new jobs to replace those lost and create a substantial multiplier effect with suppliers and the transportation and financial sectors, while reducing greenhouse gas emissions.

Specifically, companies contemplating the transition from the lab to production 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 in-state. 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 more greenhouse gases 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. While California cannot match the incentives offered by every other state, California should 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, and also take action to ensure that capital investment in California is competitive with other states.

California should examine policies from states like 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 economy to out-of-state locations.

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 economic *and* environmental sense for them to be manufactured domestically. These technologies offer direct GHG 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. A 1 megawatt (MW) fuel cell system shipped from Connecticut to California will generate over 130,000 pounds of CO_2 from the cross-country transport alone. Similarly, for every megawatt of a fuel cell system shipped from China, over 250,000 pounds of CO_2 are emitted.[vi] Early actions to reduce the state'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 is 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.[vii] 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.

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 State Business Transportation and Housing Agency, 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 for incentives 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.

<u>D. Cleantech Workforce Training Program</u>

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 greenhouse gas 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 train 1,000 people per year in projects that that teach skills in advanced energy technologies at a cost of $3,000-$6,000 per trainee per year. The Cleantech Workforce Training Program would leverage by 50 percent 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 a 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.
- *Co-benefits /Mitigation Requirements*: None expected
- *Responsible parties:* Changes would be enacted by the 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 generates less GHG emissions in their lifecycle manufacturing or in their actual use. Two example categories are the state excise tax on transportation fuels and car registration fees assessed with new vehicle purchases.

A standard measurement of lifecycle GHG emissions for transportation fuels is instrumental to the development of the Low Carbon Fuel Standard. 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 in being considered in the 2007/2008 legislative session (see AB 1190 – Horton) and an overview of this specific approach can be found at "California Clean Fuel Incentive."[viii] 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".[ix]

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 issue remains in 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 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, and 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).

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[i] "The Dynamics of Innovation and Cap-and-Trade Programs", Margaret Taylor (to be published)

[ii] "CleantechCleantech Venture Capital: How Public Policy has Stimulated Private Investment," Stack, Balbach, Epstein and Hanggi, May 2007.

[iii] While one specific project has set a precedent for CEQA mitigation fees for GHG impacts, the development of CEQA guidelines for GHG currently underway. The Governor's Office of Planning and Research (OPR) is in the process of developing CEQA guidelines for the mitigation of greenhouse gas emissions or the effects of greenhouse gas 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.

[iv] See Industrial Sector Draft Section II. E.

[v] See Transportation Sector Draft Section III. B.

[vi] Analysis using data from http://www.eia.doe.gov/oiaf/1605/factors.html

[vii] "Cleantech Venture Capital: How Public Policy has Stimulated Private Investment," Stack, Balbach, Epstein and Hanggi, May 2007

[viii] http://www.e2.org/ext/doc/AB 1190 Factsheet.pdf

[ix] http://www.e2.org/ext/doc/AB 493 Ruskin factsheet.pdf

3. TRANSPORTATION SECTOR

I. Introduction

Transportation accounts for over 40 percent of all anthropogenic GHG produced in California, divided among different fuel types as shown in Table 1 below.[1] GHG emissions from transportation are a function of:

- Vehicle technologies;
- 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. ETAAC recommends additional measures of the following types:

- Conserving energy by lowering passenger and freight motor vehicle miles traveled;
- Substantially lower GHG emitted per mile traveled for each vehicle;
- Lower the global warming effect of transportation energy.

Table 1: Transportation GHG emissions (MMTCO2-e)[2]

LPG	0.19	0.10 percent
Gasoline	130.92	70 percent
Jet fuel	22.24	12 percent
Diesel	32.16	17 percent
Residual oil	0.61	0.33 percent
Lubricants	0.75	0.40 percent
TOTAL	186.87	

According to the California Department of Transportation (CDOT), the number of vehicles in California is increasing faster than the population for many reasons. Among them are rising standards of living, which increases vehicle ownership and boosts the global trade that increases freight movement through California. The annual Vehicle Miles Traveled (VMT) is rising, in part, due to longer commute distances, but increases 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 in GHG emissions per trip.

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 were to continue, gasoline use and related CO_2 emissions in the State will increase approximately 30 percent over the next 20 years. This increase has a substantial environmental price tag, in addition to a $13 billion increase in the cost of fueling the transportation system. 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 in the national or international markets. The corresponding outflow of capital from California reduces the purchasing power and living standard of growing numbers of state citizens.

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]

It is notable that each one-percent reduction in transportation energy consumption (or rate of consumption growth) could amount to $440 million savings annually. Every one percent reduction in GHG from the transportation sector through decreased VMT, improved vehicle technology, and fuels, will avoid 1.81 million metric tons (MMT) of GHG emission, and reduce California's total GHG emissions by 0.5 percent. [6] Reductions in transportation fuel 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 (as well as more savings.) 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, or roughly 18 percent of the state's goal. At the same time, this 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.[7]

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 oil producers. Policies that reduce petroleum consumption and imports also address these related problems as well. These benefits can occur due to both a reduction in transportation energy consumption and a shift away from petroleum-based fuels as virtually the sole source of transportation energy.

The GHG reduction strategies recommended 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 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.

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.[8] Table 4 contains a summary of specific recommended actions to reduce GHG emissions from the transportation sector.

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

Table 3: Measures Contained in CARB's Draft Early Action Plan[9]

Name	**Summary**	**Estimated emission reduction (MMTCO2e)**
Smartway Truck Efficiency	Require existing trucks and trailers to be retrofitted with devices that reduce aerodynamic drag.	
Tire inflation	Require tune-up and oil change technicians to ensure proper tire inflation as part of overall service.	
Green ports	Allow docked ships to shut off their auxiliary engines by plugging into shoreside electrical outlets or other technologies.	

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

	Policy Strategy		
	Standards	Incentives	RD&D
Reducing GHG rates from passenger cars	• AB1493 phase II (beyond 2016) • fleet procurement requirements • Extending ZEV requirements for all pollutants to be fully in place by 2035	• feebates for vehicles and fuels (see Finance Sector) • Roadway Congestion pricing	• substantial increase • continued national and international cooperation on electric drive and renewable energy
Demand Reduction	• Congestion Pricing • Land Use Restrictions	• Land Use Planning • Pay-as-you go insurance • Bicycling economic incentives Transit Funding	• improved modeling/measurement
Goods Movement	• anti-idling enforcement • HDV retrofit requirements • Evaluation of new vehicle standards	• Coordinationing GHG reduction programs with Moyer program	• substantial increase
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
Fuels	• Continue to develop zero and near- zero carbon energy sources and fuels	• feebates • green fuel labeling • infrastructure for advanced, low GHG fuels	• substantial increase • develop infrastructure for future transportation needs

The 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 (www.etaac.org).

II. General Principles

There are a number of important principles that guided the development of transportation recommendations. It is recognized that a combination of technology forcing regulations and market mechanisms wil be necessary to get the substantial reductions required by 2020 and 2050 (i.e. 13.8 tons per year per capita down to 1.5 tons per year per capita):

Price Signals can be Powerful Tools to Achieve GHG Emission Reductions, but They Cannot Always be Applied Correctly: The costs of many aspects of our transportation system are distorted and incentives for efficiency are missing.[10] Examples include the implicit subsidy for driving that comes from free provision of parking at work, or the lack of any price penalty for contributing to congestion by driving at peak times. The high prices for petroleum caused by market power and other imperfections are additional costs of the status quo.[11]

As noted in the Market Advisory Report, price signals are important but do not remove the need for complementary policies, such as technology development programs. As is true in other sectors, private incentives lead to much less innovation than is socially optimal because much of the benefit of RD&D becomes a public good rather than a competitive advantage for the firm that undertakes the effort. This is one of the main reasons for public policies to support increased innovation. In the transportation sector, there is also a need for coordination between different entities for advanced vehicles, and energy supply production and distribution to support these vehicles.

Support Public Health and other Policy Objectives: Achieving GHG emission reductions offer significant opportunities to promote public health and other co-benefits. For instance, mobile sources are the largest share of California's inventory of smog-forming hydrocarbons and nitrogen oxides. They also represent a significant portion of the fine particulate inventory. Mobile sources are also responsible for an estimated 146 tons per day of fine particulates less than 2.5 microns in diameter. These transportation related emissions include several toxics that are listed as known or potential carcinogens and have other negative public health impacts.

Because many poor and minority communities are often located near roadways -- and therefore are disproportionately impacted by motor vehicle pollution -- decreasing vehicle emissions can address Environmental Justice concerns. But it is also important to design mobile source GHG emission reduction policies that avoid re-distributions of emissions that negatively impact poor and minority communities that already bear a disproportionate level of environmental risk.

Policies Should Aim for a Level Playing Field: The ETAAC transportation committee does not recommend selecting any specific technology or technologies as the solution to the challenges of Climate Change, and acknowledges that a very wide array of transportation technologies and other innovations can help address the transportation GHG challenge. While policies and programs should be performance-oriented whenever possible, it is also important to recognize that technologies at different stages of development may need different types of support. For instance, policies to offer incentives for the innovative technologies that are ready for initial commercial deployment should be different than policies for the development and demonstration of new transportation technologies and innovations. Alternatives should be evaluated on factors such as their short and long-term potential for GHG reductions, environmental and socio-economic co-benefits or disadvantages.

Consider, for instance, the different ways in which a transition to electric-powered cars might occur in the future. Currently, hybrid gasoline-electric vehicles are available to help meet near term goals. In addition, plug-in hybrid electric vehicles (PHEVs) are expected to become fully commercialized in time to begin contributing to 2020 objectives. However, the turnover of the automobile fleet is very slow (about 14 years), so introduction would have to occur quite soon to make a significant difference by 2020. By that time, liquid fuels with much lower carbon intensity than gasoline are also likely to be introduced and the prospects for battery electric vehicles (BEVs) and fuel cell electric vehicles (FCEVs)[12] cars are also likely to be better than they are today. It is not clear what combination of all-electric, hydrogen, and advanced liquid fuels will best serve our transportation needs to meet the dramatic reductions in GHG emission by 2050.

Consider Long-Term Technology Goals, as well as Short Term Needs: Both short-term and long-term strategies are need now to create a transportation system that is consistent with California's long-term goals of an 80 percent reduction (from 1990 levels) in greenhouse gases by 2050, and contribute (along with intermediary technologies) to 2020 reduction goals. However, this does not mean picking technology winners. Therefore policies must look towards the longer term to encourage the development of the technologies California will need to achieve deep reductions in GHG emissions by 2050. Similarly, policies to change travel behavior must also address the short, medium, and long term.

Boosting Economic Growth: Climate policies that create direct incentives for industries to invest in new technologies can provide additional stimulus for new employment and growth.[13] In addition to the economic growth generated from new technology incentives, California will experience the macroeconomic benefit of consumers' dollars being spent on items other than imported petroleum. This money will be spent on some in-state goods, and enhance California's economy. As transportation policy is introduced for the purpose of GHG reductions, California should address consumer behavior and industrial incentives for innovation and investment that will boost economic growth.

Apportioning GHG Reduction Credits: Policies to control GHG emissions may have significant economic implications for different sectors of the economy, especially the energy sector. Many factors must be taken into account in designing these policies, including environmental effectiveness, economic efficiency, and fairness. An important example is how electricity used as a transportation fuel should be treated: should any GHG credits created go to the electricity provider or the consumer (or perhaps even the automaker?) And how should any GHG emissions associated with generating electricity for the transportation sector be treated by regulators? [14] If a broad cap-and-trade system is put in place in addition to regulations and covers the full range of vehicle energy choices, that system may equalize GHG emission reduction levels across technologies. Otherwise, further evaluation will be necessary to ensure fair treatment across fuels.

The above discussion signals a desire to use the market as much as possible. However, California's history in achieving air emission reduction goals has demonstrated the effectiveness of technology forcing regulations. This is a less complicated task than meeting the requirements of AB32. It is anticipated that the overall program will need to continue to utilize both technology forcing standards and market mechanisms and that the government will play a key role in implementing both.

III. General Policy Recommendations

Enhance Research Development & Demonstration: The ETAAC proposes a California Clean Transportation RD&D Program that increases State investments in low-carbon technologies substantially. These efforts should focus on research, development, and demonstration 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 improved durability, reliability, and product life. It is important to encourage private research as well as to provide public funds, because private research funds are much larger than public funds, and private research often focuses on areas not covered by public research. [NOTE: This section will be expanded to cover the current contributions of existing funding programs (e.g, SCAQMD's efforts)

In addition, as vehicles are taken off petroleum fuels, new ways of charging for the use of roadway infrastructure and operations which are currently paid for by federal and state gas taxes as well as local funds, will need to be developed. Many methods for supporting such research exist, from direct grants to competitions to State procurement policies, and more. AB118 is a constructive new tool for guiding research and demonstration activities, but additional funds may be needed (perhaps generated through auction revenue or other climate-oriented fees).

Encourage Private and Public Investment: The three key emission reduction strategies identified in the introduction – reduce travel, boost efficiency and alternative 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[15] As described in the Finance sector of this report, California could set up something similar, much in the spirit of the California Institute of Regenerative Medicine.

It is important to encourage private research as well as to provide public funds, because private research funds are much larger than public funds, and private research often focuses on areas not covered by public research.

Coordinate Between Levels of Government and the Private Sector: The transition to a low-carbon economy will require shifts in virtually all industries. This is particularly important in the transportation sector, where vehicle manufacturers and fuel producers and distributors must be coordinated in a way that meets customer needs to enable the development of many new vehicle technologies. The further development of the initial "Hydrogen highway" is a prime example, as it will continue to be very important to continue collaborations between different levels of government, private industry, and the academic world. Given the scope of the task facing California, effective collaborations will likely become increasingly important.

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 challenge are making the fuel infrastructure sustainable by producing hydrogen from renewable sources, and maximizing efficiency through energy stations that produce stationary heat and power in addition to hydrogen as a vehicle fuel.

Source: http://www.fuelcellpartnership.org

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 energy reduction. The State should emphasize the importance of public education and outreach programs for the transportation sector similar to the "flex your power" programs the State promotes for energy conservation of electricity to enhance existing efforts like "Spare the Air" efforts to reduce or defer driving on bad air quality days. A much broader public outreach effort is needed. 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 that result in GHG reductions. This information can complement market-based incentives. However, the evidence about the effectiveness of public education campaigns to achieve public polices is poor.[16] 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 the good they are about to purchase.[17] Consumers are then allowed to make an educated and active decision to reduce their emissions footprint if they so choose. The California Air Resources Board is actively discussion green labeling efforts, and cars sold in California already have a smog index label on them.[18] GHG emissions information will also become part of this label by 2009. The State Legislature may want to consider further labeling efforts in terms of energy use and corresponding emissions of different fuels, or the emissions that were produced in making or shipping consumer goods.

IV. Conserving Energy by Reducing Passenger and Freight Motor Vehicle Miles

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.[19] Traffic volumes are projected to continue growing, too.[20] 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.[21] Thus, there are many measures that will both reduce GHG emissions and internalize some of these costs by pricing strategies, or else improved planning measures that will lead to reductions in these "externalities." Some travel demand strategies that are likely to have larger or more certain effects include:

- Pay-As-You-Drive insurance and road pricing;
- Improved planning such as Smart Growth and Transit Villages;
- Improved transit systems such as Electric Freight Rail and Bus Rapid Transit.

Some 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 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.[22] While idling can increase GHG emissions in conventional vehicles, high vehicle speeds can also boost GHG emissions due to lower fuel efficiency.

Currently, the per-mile price of driving does not reflect many of the true costs that occur due to each mile driven. Policies A, B, C and D below increase economic efficiency, and decrease GHG emissions, by requiring drivers to pay for each mile driven, and realize savings if they choose to decrease the number of miles that they drive. Policies E, and F reflect improvements in transportation planning that are expected to reduce GHG emissions; and Policies G,H, and I reflect improvements in transportation systems.

A. Pricing: 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 reflect coverages selected by the consumer.[23]

- *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 or pay-as-you-drive insurance could lead to up to a 12 percent reduction in driving and energy use.[24] 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.[25]
- *Co-benefits / Mitigation Requirements***:** Government incentives to promote or 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.[26] 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.[27] Although difficult to predict actual congestion alleviation, even a small reduction in driving demand can provide a large reduction in congestion delays.[28]
- *Responsible Parties:* Insurance Companies, transportation agencies, California Air Resources Board, and the State Insurance Commissioner.

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 players can play a major role in forging solutions to current insurance practices that fail to 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.[29] For example, the General Motors Acceptance Corporation (GMAC) Insurance has offered mileage-based discounts to OnStar subscribers located in certain states since mid-2004.[30]

- *Transportation Agencies*: Cal-Trans is pivotal in alleviating congestion and implementing successful transit systems. Their implementation of traffic operations would assist pay as you go operations.
- *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's driver 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. Pricing - Congestion Charges

Drivers are charged, using electronic and other barrier-free means, to enter areas of heavy traffic. London, Norway, Rome, Singapore, and Stockholm are some of the areas that have implemented congestion pricing to reduce pollution and congestion.

- *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.[31] 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,[32] and San Francisco County Transportation Authority staff has identified congestion pricing as a key component of that strategy.[33]
- *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 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/coordination from CalTrans and Regional Transportation Agencies as needed.

Problem: As noted earlier, increasing 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[34], lowered congestion, and improved transit and bicycle use.[35] 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”[36]. Pricing could based on different tiers. For instance, London offers exemptions for electric cars.[37] 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.

C. Pricing: 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.[38]"

- *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[39].
- *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 vehicle miles traveled and increased transit ridership.
- *Responsible Parties:* State and local/regional governments, employers

Problem: Some employers or employees may not be aware of or 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.

D. Pricing: Car Sharing

Through car sharing (or short-term vehicle access) individuals gain the benefits of private vehicle use without the costs and responsibilities of ownership. The cost of using a vehicle is a variable cost rather than an upfront cost, offering consumers the chance to avoid a significant fixed up-front cost, and reducing GHG by increasing the price paid for each mile driven. Carsharing is most commonly deployed in locations where transportation alternatives are easily accessible and is complementary to mass transit.[40]

- *Timeframe:* Immediate to long term (growth potential)
- *GHG Reduction Potential:* Car sharing has been documented to reduce vehicle ownership and vehicle miles/kilometers traveled as trips are shifted to transit, biking, and walking. This results in lower greenhouse gas emissions. In Europe, car sharing is estimated to reduce the average user's CO_2 emissions by 40 to 50 percent.[41] In addition, many car sharing organizations include low-emission vehicles, such as gasoline-electric hybrid cars, in their fleets. More recently, Communauto announced a 13,000-ton reduction in CO_2 emissions this year as a result of their 11,000 car sharing users in the province of Quebec, Canada. Communauto calculates that each car sharing user reduces his or her distance traveled by car by 2,900 kilometers per year on average. Furthermore, they anticipate with a potential market of 139,000 households in Quebec that annual CO_2 emission reductions could be as high as 168,000 tons per year.[42]
- *Ease of Implementation:* Typically a great deal of local and regional governmental, transit, university, employer, and developer support. Identifying dedicated parking for car sharing vehicles in premium locations can be challenging as car sharing grows.
- *Co-benefits / Mitigation Requirements*: Car sharing is associated with reduced vehicle ownership, vehicle miles traveled, fuel, and parking impacts; it is also linked to improved air quality, transit use, cycling, walking, and equity (e.g., low-income populations).
- *Responsible Parties*: Car sharing organizations, local and regional government, transit operators, universities, and employers

Problem: Many individual owners and fleet owners pay a significant up-front vehicle cost, which greatly diminishes the variable cost of car usage.

Possible Solution: Government agencies and other organizations can support car sharing by providing available space for car storage; and utilizing car sharing as an alternative (or a partial alternative) to traditional vehicle fleet vehicles featuring moderate or low utilization by employees.

E. Transportation Planning: Smart Growth and Transit Villages

There are a number of planning measures that can reduce GHG emissions. A direct measure is to integrate GHG emissions into transportation planning, such as including GHG emission reductions in guidelines for 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 [43] (and thus is not an area of focus for this ETAAC report.) There are also a number of measures that improve transportation planning generally, with reduced GHG emissions as one of a number of co-benefits, as described in policies E and F below.

Smart growth, for example, is an urban planning and transportation strategy that emphasizes growth near city centers to prevent urban sprawl. This approach includes promoting mixed-use development, transit and bicycle and pedestrian-friendly infrastructure, and other land-use strategies, such as reduced 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."[44]

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 reduce driving, increased walking, spur transit use, curb obesity, and promote cleaner air.[45] Transit villages, one form of smart growth, are generally mixed-use residential and commercial areas that are designed to maximize encourage access to mass transit systems. They are typically located within one-quarter to one-half mile (0.4 to 0.8 kilometer) of a mass transit station.

- *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. [46] This estimate is based on a CARB study estimating transit village household private vehicle mileage reductions of approximately 20 to 30 percent annually[47].
- *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.[48]

- *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.
    - *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.[49] 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[50] 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.

- *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 developments 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 VMT, subsequently increasing GHG emissions and can lead to an inefficient land use practices. In addition, urban sprawl leads to more land consumption and a subsequent threat to farmland. Urban sprawl can also lead to spending government funds on creating new infrastructure for expanding developments instead of maintaining the existing infrastructure.[51] The growth and expansion problems of urban sprawl are also thought to have a negative affect on peoples' well being.[52]

The current Williamson Act mechanism used to keep farmland in agricultural use and delay housing or commercial development may not be sufficient incentives for farmland owners to reduce VMT. Currently a large share of the Williamson Act land in San Joaquin County is in non-renewal status, for example. Other states are more proactive than California in both supporting farms and in particular in supporting small holdings and encouraging low impact farming methods.

Possible Solution: The most important vehicle for implementing more smart growth planning is the coordination and consistent incentives throughout the agencies involved in infrastructure planning and development. Tying decisions to funding will encourage smart growth and make it a more attractive option.

Another effective way to reduce VMT is through land use planning. For example, transit oriented development can reduce VMT by 20-30 percent compared to conventional lower density auto oriented development. With higher density urban dwellings, 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 improvement transit, pedestrian, and bicycling infrastructure. More electrified light rail systems are needed for intracity travel and as collectors to intercity transit systems. Congestion pricing for urban car use may need to be implemented.

Incentives to locate jobs closer to residential areas and to provide housing for the workforce close to job rich locations, support transit oriented development, expand telecommuting, and use video-conferencing in lieu of air travel, could reduce VMT, as could mixed-use development where shopping and services are within comfortable walking distance of a large percentage of each neighborhood and district.

F. Improved Transportation Impact Analysis Planning

Traditional transportation planning tools and metrics tend to under-estimate the benefits of transit and other alternatives to increased 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.[53] 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[54] 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 in the form of 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 use to LOS and related measures as a proxy for significant transportation-related air quality impacts. [55]
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.[56]

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 access to goods and services and reducing VMT over increasing motor vehicle traffic and pollution. Recognizing this improvement under CEQA guidelines will facilitate this shift, and complement Smart Growth. To the extent that access to goods and services are considered an environmental issue that should be addressed by CEQA guidelines, per capita congestion delays and travel times is an example of more meaningful measurements. 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.

G. Improved Transportation Systems: Electric Freight Rail

Improving transportation systems is another way to reduce GHG emissions in the transportation sector. Full funding of public transit systems is there a very fundamental need. Other sections of this report identify economic and technological innovations for transit systems linked to roadway pricing and improved transportation planning. Policies G, H and I below discuss electric freight rail and human-powered transportation alternatives. Other options include improved use of today's cars and trucks through improved driving behavior and simple maintenance issues such as proper tire inflation on motor vehicles. [ETAAC is exploring further recommendations like those below, and will coordinate with the California High Speed Rail Authority and with electrification efforts being evaluated in the South Coast Air Basin.]

As cargo transport is responsible for 8 percent of state CO_2 emissions, policies are needed to substitute rails for highways.

- *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). An electric, high-speed rail line between the Bay Area and Southern California would reduce GHG emissions considerably. The largest benefits are likely to occur from reducing mid-length trips by providing frequent and reliable rail service from major urban corridors such as between Sacramento-Bay Area, Bay Area or Sacramento-Fresno, Riverside-San Bernardino-Los Angeles-Orange County-San Diego, etc. These rail systems improvements would primarily displace highway motor vehicle trips.

- *Ease of Implementation:* Most rail systems are privately owned. Even 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.

H. Improved Transportation Systems: 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. Many involve active movement by users and do not produce CO_2 emissions.

- *Timeframe:* Near to long term (growth potential)
- *GHG Reduction Potential*: One way to encourage bicycling as an alternative mode is through a better low-speed mode infrastructure, particularly on-street bike lanes[57]. The city of Stockholm's long-term plan to reduce CO_2 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. It is estimated that such improvements will reduce CO2 emissions by 2,900 tons per year by 2050[58].
- *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[59]"
- *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 Paris, allowing convenient use of bicycles.

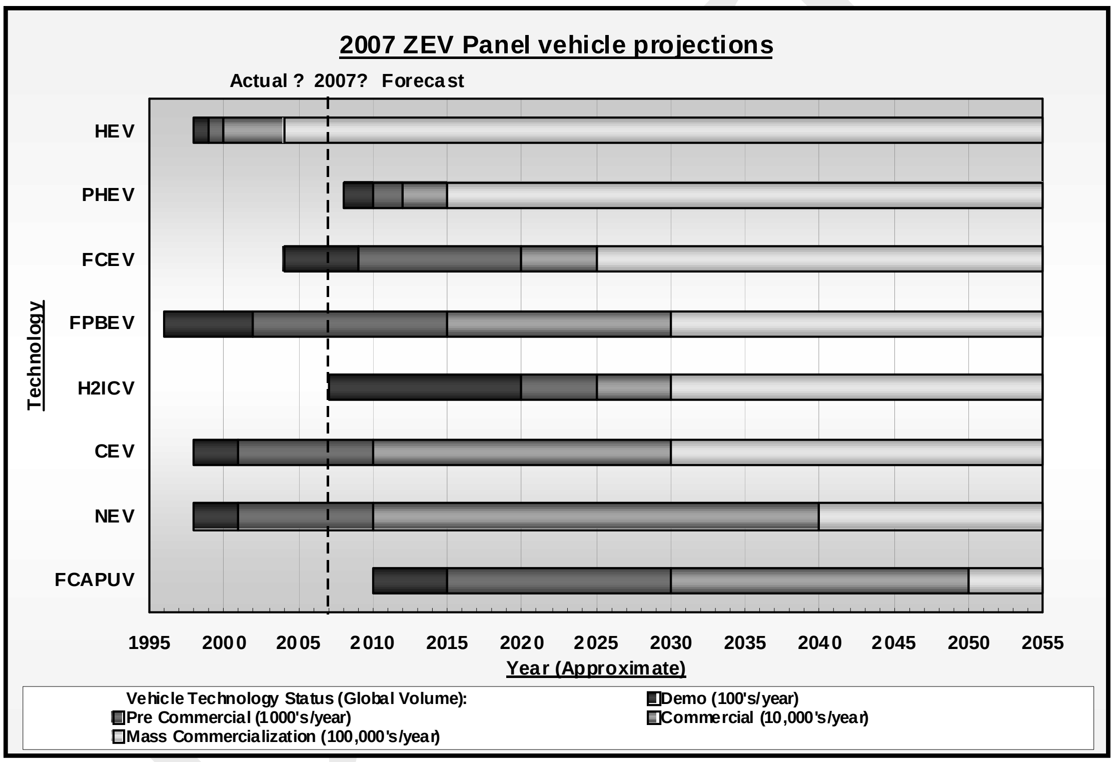
I. Improved Transportation Systems: Telecommuting

Telecommuting is "generally defined as work at a remote location or home office rather than working at a fixed employer-provided site or office."[60]

- *Timeframe:* Near to long term.
- *GHG Reduction Potential*: Estimated fuel savings per telecommuter range from 49 to 177 gallons per year across three studies.[61] This range converts to approximately a 0.5 to 1.7 ton CO_2 reduction using a standard assumption of 19.4 pounds of CO_2 emitted for every gallon of gasoline combusted.[62]
- *Ease of Implementation*: Requires support from employers and public sector (e.g., incentives and pricing of parking/roads).
- *Co-Benefits / Mitigation Requirements*: Kitou and Horvath (2003) used a systems model 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. Both deterministic and probabilistic analyses were conducted and evaluated. The "probabilistic analysis over a set of likely parameters" demonstrated that tele-work may reduce CO_2 emissions. While telecommuting could potentially reduce CO_2 emissions related to commuting, reductions may be offset by increased home office energy use and/or commercial electricity use at the business office.[63]
- *Responsible Parties*: Employers, state, and regional agencies (e.g., large employers, metropolitan planning organizations, Cal-trans, business, transportation and housing agency).

V. Improving Vehicle GHG Performance

There are several key existing programs to build on in order to improve California vehicle performance on GHG emissions. In particular AB1493 is a critical, performance-based system for driving low-carbon vehicle technologies into the market. The standards have been established through 2016, and work should begin soon to develop performance levels beyond 2016 taking into account the full range of vehicle technologies now emerging (e.g., hybrid, clean diesel cars that are expected to meet California's strict emission standards, CO_2 vehicle air conditioning systems, and a number of additional technologies identified in the King Review of low-carbon cars Part I: the potential for CO_2 reduction). In addition, the state's Zero Emission Vehicle (ZEV) program is intended to help drive the development of automotive technology that will reduce GHG emissions. [64] In addition to the recommendations below, the vehicle "feebate" proposal in the Finance sector subgroup report could be an important contributor to both near-term and long-term improvements in vehicle GHG performance, potentially increasing the benefits of existing vehicle GHG standards by 25 percent.[65]



66

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

J. New Vehicle Technology Improvements

While forward thinking when written -- and vitally important for near term GHG emission reductions – AB 1493 does not begin to capture the full potential for GHG emission reductions now technically possible. One noteworthy omission is that only passenger vehicles are covered. A more comprehensive standard for post-2016 vehicles of all types would net even greater GHG emission reductions.

- *Timeframe:* in effect by 2020.
- *GHG Reduction Potential*: 4 MMT by 2020, and 27 MMT by 2030.
- *Ease of Implementation:* Difficult
- *Co-benefits / Mitigation Requirements*: Very high, including reductions in up-stream refinery emissions and reduced reliance on imported petroleum
- *Responsible Parties:* CARB; auto manufacturers

Problem: Continued reductions in vehicle GHG emissions will be necessary after the first round of AB 1493 standards are in-place in 2016. The recent United Kingdom's King review of low carbon cars found that significant market barriers to deployment of encouraging new technology. These include fixed capital investments in older technology, the need for economies-of-scale to make new technologies economical, and lack of high-priority given fuel economy in consumer purchases.[67]

Possible Solution: 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 beginning with the 2009 model year. The standards adopted by CARB phase-in during 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.

New standards would be adopted to phase in beginning in the 2017 model year to follow up on the existing mid-term standards that reach maximum stringency in 2016. Work should begin soon to develop performance levels beyond 2016 to take into account the full range of vehicle technologies now emerging and to provide manufacturers with adequate lead time to introduce new cleaner products. Assuming that the new standards call for about a 50 percent reduction, phased 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 reduction of 27 percent[68] -- 27 MMT[69] -- in 2030.

Additional reductions would be achievable if new-vehicle standards were also applied to the heavy duty trucking sector, which account for nearly one-fifth of transportation sector emissions. In particular, new engine, transmission, tire, and aerodynamic designs could ultimately reduce GHG emissions by one third to one half from new freight trucks.[70] Although the freight industry is sensitive to fuel prices, technologies that slash fuel consumption have been slow to find their way to market. Standards would speed the uptake of existing technologies and drive innovation in cleaner motor vehicles .

K. Air Quality Program Incentives

Air quality programs such as the Carl Moyer incentive program do not include a value for diminishing GHG emissions. Coordinating GHG reduction programs with existing air quality improvement programs would help meet AB 32's climate change response goals.

- *Timeframe:* by 2012.
- *GHG Reduction Potential*: To be determined, based on funding levels.
- *Ease of Implementation:* Low, compared to implementing separate programs.
- *Co-benefits / Mitigation Requirements*: Criteria pollutant reductions.
- *Responsible Parties:* CARB, regional, and local implementing agencies, plus any new organization created to administer GHG reduction funds

Problem: Several State air quality incentive funds are available to decrease pollutants such as fine particulates and ozone that violate State and Federal standards. The Carl Moyer Memorial Air Quality Standards Attainment Program provides incentive funds for the incremental cost of engines and equipment that go beyond State minimum air quality requirements. Eligible projects include cleaner on-road, off-road, marine, locomotive and stationary agricultural pump engines, as well as forklifts, airport ground support equipment, and auxiliary power units. The program achieves near-term reductions in emissions of oxides of nitrogen (NOx), particulate matter (PM), and reactive organic gas (ROG), and is currently funded at $140 million annually[71]. The state, in partnership with local agencies, is also implementing a new 1B Goods Movement Program to upgrade technology and reduce air pollution emissions and health risk from freight movement along California's trade corridors. The State has allocated $250 million for the 2007/2008 state budget, and the program is funded at a total of $1 billion.[72] Other funds are available for VMT reduction strategies such as pedestrian, bicycling, and transit improvements.

Possible Solution: Incentive funds that are available for GHG reductions in the transportation sector are likely to substantially overlap with these existing programs, creating opportunities to coordinate programs and achieve greater over-all benefits of both ambient "criteria" pollutant levels and GHG emissions. For instance, if a GHG allowance auction were held, local agencies implementing these existing programs could apply to a California Carbon Trust or other organizations with funding available for cost-effective GHG emission reductions. A project with an incremental cost of $100,000 that achieves an estimated $60,000 in GHG emission reduction benefits and $60,000 in criteria pollutants could be co-funded by both GHG and criteria pollutant funds -- if it meets all project eligibility rules. Implementing agencies would be responsible for showing that their program's criteria pollutant benefits compared to criteria pollutant expenditures meet cost-effectiveness requirements. Similarly, GHG emission reduction programs they would also be required to meet cost-effectiveness criteria.

L. Low GHG Fleet Standards and Procurement Policies

Performance standards and procurement policies can facilitate implementation of low carbon vehicles available today -- and low and zero emission vehicles in the future.

- *Timeframe*: by 2012, continuing through 2020 and expanding into heavy vehicles by 2050.
- *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 GHG 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 Solution: 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 minimum 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, this cost complying with the standard would fall on the buyers of new vehicles, not the sellers. Such a standard is not subject to the same legal challenges as the AB 1493 rule. This policy should be applied to State fleets immediately, and all other public and private fleets that receive any funding through state tax or fee revenue and/or utility ratepayer revenue. For instance, the State has recently completed a purchasing arrangement allowing 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, 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.

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

Federal, State, regional and local government agencies -- as well as utility and other private fleets – should participate in advance technology vehicle demonstration. This effort should start immediately and targets should be set with the ultimate goal of implementing 100 percent ZEV in support of California's aggregate goal of 80 percent GHG emission reductions by 2050. 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: development of advanced vehicle technology and infrastructure; enhance air quality, and familiarize fleet managers with new low-carbon and no-carbon vehicle technologies.

VI. Renewable and Other Low-Carbon Fuels

After vehicle miles traveled are reduced and the efficiency of motor vehicles is increased, there will still be a need for large quantities of transportation fuels. The lifecycle GHG emissions of fuels is being addressed through the Low-Carbon Fuel Standard (LCFS) mandate being developed by ARB. However, independent incentives might expedite achieving or exceeding that standard and creating a basis for deeper future reductions, while creating opportunities for additional in-state production. We note that other fuel tax incentives to encourage low carbon fuels are covered in the finance sector, and biofuels production is covered in the agricultural section of this report. Comments on the implementation of the Low-Carbon Fuel Standards are located in an Attachment.

M. Create Markets for Green Fuels

The Low-Carbon Fuel Standard (LCFS) mandate being developed by CARB addresses the lifecycle GHG emissions of transportation fuels. However, independent incentives might expedite achieving or 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 ARB 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 LCFS protocol. Therefore, a new tracking system would be required, but would not require significant additional technical analysis.

- *Co-benefits / Mitigation Requirements:* Low-GHG fuels may have better environmental performance on other dimensions as well.
- *Responsible Parties*: Depends on if voluntary or mandatory. A mandatory system would have the greatest benefit.

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. Biofuels grown on degraded land are much more likely to reduce GHG emissions than when land is cleared for growing biofuels that displace food production. California farmers could be encouraged to collect and use agricultural waste as a bio-fuel feedstock to complement the existing CARB regulatory requirements, as noted in the agriculture sector of this report.[73] 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 Solution: A voluntary or mandated 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), and this information could be included on fuel content labels. Other fuel tax incentives to encourage low carbon fuels are covered in the Finance sector, and biofuels production is covered in the Agricultural sector chapter of this report.

Next Generation Transportation Energy

Many opportunities exist for development of advanced zero-emission and low GHG vehicles and fuels. There will be multiple widening areas of overlap between electricity generation and transportation fuels, as noted below, compared to a relatively smaller overlap today (such as refinery use of natural gas and electricity to produce vehicle fuels, and natural gas use as a vehicle fuel). Infrastructure planned today for electricity supply will need to accommodate near-term deployment of Plug-in Hybrids (as noted in the Energy Chapter). In addition, full performance battery electric vehicles and fuel cell vehicle (which could be powered by hydrogen produced via hydrolysis) will be fully commercialized by the 2025 to 2030 timeframe (based on the CARB Zero Emission Vehicle review panel) – well within the expected lifetime of electric generation, transmission and distribution system that will result from the decisions made today. Therefore, careful planning will be necessary to capture the advantages of synergies between energy sources that can be used for traditional electricity use, or as a vehicle energy source, and make sure that infrastructure developed today will serve the needs of the future.

Key policy goals for CARB, the California Energy Commission, and the California Public Utilities in partnership with other government agencies and other public and private organizations should include:

- 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 and other electric vehicles, and hydrogen (produced by electrolysis) fuel cell vehicles as energy storage 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 higher prices for sale of on-peak power
- Develop fuel distribution & dispensing infrastructure of low and zero GHG alternate fuels
- Create an overall system that optimizes energy use across both sectors, and creates flexibility to adapt to future circumstances, as the future vehicle mix will depend largely on technology and economic developments

Next Generation Transportation Energy

Many opportunities exist for development of vehicle fuels for internal combustion engines; and for advanced zero-emission vehicles. However, careful planning will be necessary to capture the advantages of synergies between energy sources that can be used for traditional electricity use, or as a vehicle energy source, and make sure that infrastructure developed today will serve the needs of the future. There will be multiple widening areas of overlap, as noted below, compared to a relatively smaller overlap between electricity generation and transportation fuels today (such as refinery use of natural gas and electricity to produce vehicle fuels, natural gas use as a vehicle fuel).

Infrastructure planned today for electricity supply will need to accommodate near-term deployment of PHEV (as noted in the *Electricity* Chapter), as well as full performance battery electric vehicles and potentially also hydrogen production via hydrolysis for fuel cell cars. All of these vehicles will be fully commercialized by the 2025 to 2030 timeframe (based on the CARB Zero Emission Vehicle review panel) – well within the expected lifetime of electric generation, transmission and distribution system

that will result from the decisions made today. Key policy goals for CARB, the California Energy Commission, and the California Public Utilities in partnership with other government agencies and other public and private organizations include:

1) develop low-cost, sustainable production processes for low GHG biofuels and hydrogen fuels
2) increase renewable electricity development in order to maintain renewable goals during expanding use as a vehicle supply
3) assess plug-in hybrids, full performance battery electric cars and other electric vehicles, and hydrogen (produced by electrolysis) fuel cell vehicles as energy storage 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
4) plan and implement electric metering infrastructure and tariffs that allow customers with these vehicles to access the lower cost of off-peak power, and higher prices for sale of on-peak power
5) develop fuel distribution & dispensing infrastructure of low GHG alternate fuels
6) create an overall system that optimizes energy use across both sectors, and creates flexibility

VII. International GHG Sources

International shipping and aviation are two sources that are continuing to grow significantly, and require internal cooperation to address. We note that that the International Marine Organization and International Civil Aviation Organization play important roles in establishing environmental requirements for these sectors. For instance, California does not have the authority to set engine GHG standards. Some policies designed to reduce NO_X emissions, such as speed-reduction zones, are expected to provide co-benefits for GHG. Some jurisdictions have used revenue-neutral incentives, such as airport landing fees that vary with NO_X emissions of different planes. We encourage state and local agencies to consider actions under their authority, such as marine vessel speed reductions or carbon-based landing fees, we also note that the federal government will also need to play a leading role in international cooperation on broader efforts to reduce these emissions.

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[1] Bemis, G. *Inventory of California Greenhouse Gas Emissions and Sinks: 1990 to 2004*. Sacramento, California Energy Commission, (2006), p. 117.

[2] Ibid.

[3] Mizutani, C. *Transportation Fuels, Technologies, and Infrastructure Assessment Report. Integrated Energy Policy Report*. Sacramento, California Energy Commission: (2003), p. 86.

[4] This regulation's implementation has been delayed by a lengthy, expensive, and unsuccessful lawsuit brought by six automakers (DamilerChrysler, Ford, General Motors, Honda, Nissan, and Toyota) and by the failure of the U.S. Environmental Protection Agency to issue the waiver needed under the federal Clean Air Act, despite federal court orders to do so.

[5] Kavalec, C., J. Page, et al. Forecasts of California Transportation Energy Demand 2005-2025. Washington, DC, California Energy Commission (2005).

[6] Introduction largely drawn from *Climate Action Program at CalTrans*, December 2006

[7] Roland-Holst, D. Economic Assessments of California Climate Change Policy: Application of the BEAR Model (2006); M. Hanneman and A. E. Farrell, *Managing Greenhouse Gas Emissions in California*.. Berkeley, University of California (2006). [?]

[8] The ETAAC did not have the resources to evaluate current CARB regulations pertaining to AB 32. In addition, it would be premature for the ETAAC to make recommendations on those rulemakings at this time without the benefit of information that will be developed later during the rulemaking process and public comment period.

[9] Draft Expanded List of Early Action Measures to Reduce Greenhouse Gas Emissions in California Recommended for Board Consideration, September 2007.

[10] Button, K. J. *Transportation Economics*. Brookfield, VT, Edward Elgar (1993).

[11] Farrell, A. E., D. Sperling, et al. *A Low-Carbon Fuel Standard for California Part 1: Technical Analysis*. Transportation Sustainability Research Center. University of California Berkeley (2007). p. 22-24. http://repositories.cdlib.org/its/tsrc/UCB-ITS-TSRC-RR-2007-2/.
Farrell, A. E., D. Sperling, et al. *A Low-Carbon Fuel Standard for California Part 2: Policy Analysis*. Transportation Sustainability Research Center. University of California Berkeley (2007). p. 19-25. http://repositories.cdlib.org/its/tsrc/UCB-ITS-TSRC-RR-2007-3/.

[12] HTAC report to the Secretary of DOE, Sept 2007

[13] Roland-Holst, David. *Economic Growth and Greenhouse Gas Mitigation in California*. UC Berkeley, August 2006.

[14] Farrell, A. E., D. Sperling, et al. *A Low-Carbon Fuel Standard for California Part 2: Policy Analysis*. Transportation Sustainability Research Center. University of California Berkeley (2007). p. 25-26. http://repositories.cdlib.org/its/tsrc/UCB-ITS-TSRC-RR-2007-3/.

[15] http://www.carbontrust.co.uk/default.ct

[16] Morgenstern, R. D. and W. A. Pizer *Reality Check: The Nature and Performance of Voluntary Environmental Programs in the United States, Europe, and Japan*. Washington, DC, RFF Press (2007)..

[17] Turner, B. T., R. J. Plevin, et al. *Creating Markets for Green Bio-fuels.* Transportation Sustainability Research Center. Berkeley, University of California (2007) p. 62.

[18] http://www.arb.ca.gov/msprog/labeling/labeling.htm

[19] 2005 Urban Mobility Report, TTI).

[20] Preceding text from US DOT: http://www.fhwa.dot.gov/congestion/

[21] Button, K. J. *Transportation Economics*. Brookfield, VT, Edward Elgar (1993)..

[22] Noland Choo, S., P. L. Mokhtarian, et al. *Does Telecommuting Reduce Yehicle-Miles Traveled?* An aggregate time series analysis for the US." Transportation 32(1) (2005): p. 37-64; Handy, S. *Smart Growth and the Transportation-Land Use Connection: What Does The Research Tell Us?* International Regional

Science Review 28(2) (2005). P. 146-167; Kitou, E. and A. Horvath "Energy-related emissions from telework." Environmental Science & Technology 37(16): (2003). p. 3467-3475; Noland, R. B. and L. L. Lem *A Review of the Evidence for Induced Travel and Changes in Transportation and Environmental Policy in the US and the UK*. Transportation Research Part D-Transport and Environment 7(1): (2002). P. 1-26.
Noland, R. B. and M. A. Quddus. *Flow Improvements and Vehicle Emissions: Effects of Trip Generation and Emission Control Technology*." Transportation Research Part D-Transport and Environment 11(1) (2006): p. 1-14.
[23] Greenberg, Allen. *Applying Mental Accounting Concepts in Designing Pay-Per-Mile Auto Insurance Products*. US Department of Transportation. 2005
[24] Litman, Todd. *Distance-Based Vehicle Insurance Feasibility Costs and Benefits: Comprehensive Technical Report*. Victoria Transport Policy Institute, Victoria, B.C., 19 February 2007. (available at www.vtpi.org)
[25] Greenberg, Allen. *Applying Mental Accounting Concepts in Designing Pay-Per-Mile Auto Insurance Products*. US Department of Transportation. 2005. p. 3
[26] Greenberg, Allen. *Comparing the Benefits of Mileage and Usage Pricing Incentives with Other Government Transportation Incentives*, Transportation Research Board, available on TRB 82nd Annual Meeting Compendium of Papers CD-ROM, Nov. 15, 2002.
[27] Litman, pg. 75
[28] Ibid, pg. 76.
[29] Greenberg, pg. 3
[30] http://www.vtpi.org/tdm/tdm79.htm
[31] The California Air Resources Board emissions inventory for gasoline powered vehicles alone exceeds 137 tpy CO2(eq) for 2004. Based on data from London and Stockholm showing reductions of ten percent or more from the covered areas, applying this policy to ten percent of the state's inventory could potentially achieve one million tons of reductions, or greater, if similar results are achieved.
[32] San Francisco Climate Action Plan, 2004
[33] SFCTA website:
http://www.sfcta.org/images/stories/Planning/CongestionPricingFeasibilityStudy/PDFs/sfcta_maps_2007-07.pdf
[34] Central London Congestion Charging, Forth Annual Report, June 2006
http://www.sfcta.org/content/view/415/241/
[35] SFTA website
[36] City of Stockholm, 2006
[37] The King Review of low-carbon cars, 2007, p.50
[38] Shoup, D. *The High Cost of Free Parking.* American Planning Association Planners Press, Chicago, Illinois. (2005) p. 262.
[39] References: Grant, M., and Ecola, L. *Parking Cash Out: Implementing Commuter Benefits Under the Commuter Choice Leadership Initiative*. EPA Rep. No. 420-S-01-006. U.S. Environmental Protection Agency (EPA), Washington, D.C.
http://www.commutesolutions.com/letsride/Resources/commuterchoice/parkingcash.pdf. (2001); and Drumheller, B., Quaid, A., Wyman, M., Liljenwall, J., and Young, A. *Sustainable Transportation Options for Protecting the Climate*. International Council for Local Environmental Initiatives (ICLEI), Berkeley, California. http://www.iclei.org/documents/Global/Progams/CCP/Sust_Trans_Options.pdf. (2001); Donald Shoup (1993) has estimated that offering all employees in the U.S. the option to cash out their parking subsidies could lead to a reduction in 40 million tonnes of CO_2 emissions per year. Reference: Shoup, D. C. *Cashing Out Employer-Paid Parking: A Precedent for Congestion Pricing?* UCTC Report No. 205. University of California Transportation Center (UCTC), Berkeley, California.
http://www.uctc.net/papers/205.pdf>http://www.uctc.net/papers/205.pdf. (1993).

[40] Shaheen, S., Cohen, A., and Roberts, J.D. Carsharing in North America: market growth, current developments, and future potential. "Transportation Research Record," No. 1986: pp. 116-124. (2006) Shaheen, S., Sperling, D., and Wagner, C. Carsharing in Europe and North America: past, present, and Future. "Transportation Quarterly," Vol. 52, No. 3: pp. 35-52. (1998).

[41] Rydén, C. and E., Morin. Mobility Services for Urban Sustainability. Environmental Assessment. Report WP 6. Trivector Traffic AB. Stockholm, Sweden. http://213.170.188.3/moses/Downloads/reports/del_6.pdf. (2005).
[42] Communauto. CO2 Emissions Reduced by 168,000 Tons Per Year Thanks to Car-Sharing. Press Release. Montreal, Canada.
[43] http://opr.ca.gov/index.php?a=ceqa/index.html
[44] CNT. *Combating Global Warming Through Sustainable Surface Transportation Policy*. Center for Neighborhood Technology (CNT), Chicago, Illinois. http://www.travelmatters.org/about/final-report.pdf. (2003).
Feigon, S., Hoyt, D., McNally, L., Campbell, S., and Leach, D. *Travel Matters: Mitigating Climate Change with Sustainable Surface Transportation*, Transit Cooperative Research Program Report 93. National Research Council, Transportation Research Board, Washington, D.C. http://ttap.colostate.edu/Library/TRB/tcrp_rpt_93.pdf. (2003).
[45] Levine, Jonathan. *Zoned Out: Regulation, Markets, and Choices in Transportation and Metropolitan Land-Use*. Resources for the Future.
[46] Parker, T., McKeever, M, Arrington, G.B., and Smith-Heimer, J. *Statewide Transit-Oriented Development Study: Factors for Success in California*. Business Transportation and Housing Agency and California Department of Transportation, Sacramento, California: (2002). (p. 43). http://www.dot.ca.gov/hq/MassTrans/doc_pdf/TOD/Statewide_TOD_Study_Final_Report_Sept percent2002.pdf.

[47] JHK and Associates. *Transportation-Related Land Use Strategies to Minimize Motor Vehicle Emissions.* California Air Resources Board, Sacramento, California (1995). http://safety.fhwa.dot.gov/ped_bike/docs/landuse.pdf.

[48] Levine, Jonathan. *Zoned Out: Regulation, Markets, and Choices in Transportation and Metropolitan Land-Use*. Resources for the Future.
[49] http://www.energy.ca.gov/2007publications/CEC-600-2007-008/CEC-600-2007-008-SD.PDF
[50] http://www.smartcommunities.ncat.org/landuse/tools.shtml
[51] Brueckner, Jan K. *Urban Sprawl: Diagnosis and Remedies*. International Regional Science Review. 2000.
[52] Ewing, Reid et.al. *Relationship Between Urban Sprawl and Physical Activity, Obesity, and Morbidity*. American Journal of Health Promotion. September, 2003.
[53] The California Air Resources Board emissions inventory for gasoline powered vehicles alone exceeds 137 tpy CO2(eq) for 2004.
[54] "Automobile Level of Service: A Liability for Health and Environmental Quality", Working Policy Paper, September 23, 2005, Rajiv Bhatia, MD, MPH, Director, Occupational and Environmental Health, San Francisco Department of Public Health

[55]Governor's Office of Planning and Research in Title 14, Chapter 3, of the California Code of Regulations, Appendix G of the Guidelines describes an "Environmental Checklist Form". The criteria in Section XV of the checklist ("Transportation/Traffic") evaluate a project based on its effect on the convenience for automobile drivers, such as motor vehicle capacity, LOS, and parking. http://www.ceres.ca.gov/ceqa/guidelines/

[56] Measuring Transportation Traffic, Mobility and Accessibility, Todd Litman.10 March 2005.
[57] CARB. *Bicycle Fact Sheet.* California Air Resources Board (CARB), Sacramento, California. http://www.arb.ca.gov/plannng/tsaq/bicycle/facsht.htm. (2005); and Jakowitsch, N. "Charting a Course for Transportation in the New World of Climate Change," Harrington-Hughes, K. (Ed.) *Global Climate Change and Transportation: Coming to Terms.* Eno Transportation Foundation, Washington, D.C. (2002), p. 87-97.

[58] City of Stockholm. *Stockholm's Action Programme Against Greenhouse Gas Emissions*. City of Stockholm, Stockholm, Sweden. http://www.miljo.stockholm.se/ext/klimat/pdf/Stockholm_ActionProgramme_against_Greenhouse_Gases_2002.pdf. (2002).

[59] International Energy Agency *Saving Oil and Reducing CO2 Emissions in Transport: Options and Strategies.* Organization for Economic Cooperation and Development, France, p. 120.
[60] GAO. Telecommuting: Overview Of Potential Barriers Facing Employers. Report No. Gao-01-926. U.S General Accounting Office (GAO). Washington, D.C. http://www.gao.gov/new.items/d01926.pdf. (2001).)
[61] Boghani, A.B., Kimble, E.W., and Spencer, E.E. Can Telecommunications Help Solve America's Transportation Problems? Reference No. 65740. Arthur D. Little, Inc., Cambridge, Massachusetts. (1991); U.S. DOT.
Transportation Implications of Telecommuting. U.S. Department of Transportation (DOT). U.S. Government Printing Office, Washington, D.C. (1993); and U.S. DOE.
Energy, Emissions, and Social Consequences of Telecommuting. U.S. Department of Energy (DOE). U.S. Government Printing Office, Washington, D.C. (1994), as cited in: Shafizadeh, K, Niemeier, D., Mokhtarian, P., and Salomon, I.
Costs and Benefits of Home-Based Telecommuting: A Monte Carlo Simulation Model Incorporating Telecommuter, Employer, and Public Sector Perspectives. "Journal of Infrastructure Systems" (13)1: pp. 12-25. (2007).
[62] U.S. EPA. Emission facts: calculating emissions of greenhouse gases: key facts and figures. EPA420-F-05-003. http://www.epa.gov/omswww/climate/420f05003.htm. U.S. Environmental Protection Agency (U.S. EPA), Washington, D.C. (2005).
[63] Kitou, E. and A. Horvath (2003) Energy-related emissions from telework. *Environmental Science & Technology*(37)16: pp. 3467-3475. (2003).
[64] Electricity, based on marginal supply from a combined cycle power plant, and hydrogen from steam methane reforming, both have significantly lower GHG profiles compare to current vehicle fuels (King Review, section 3.32.) As noted later in this report, creating zero and low-carbon energy supplies for zero-tailpipe emission cars will continue to be an important policy objective.
[65] McManus. *Economic Analysis of Feebates to Reduce Greenhouse Gas Emissions from Light Vehicles for California*. University of Michigan Transportation Research Institute. UMTRI-2007-19-1. May 2007.
[66] Report of the ARB Independent Expert Panel 2007 Executive Summary Only, prepared for State of California Air Resources Board, http://www.arb.ca.gov/msprog/zevprog/zevreview/zev_panel_report.pdf
[67] The King Review of low-carbon vehicles (2007) p.47.
[68] CARB Presentation "Public Hearing to Consider Adoption of Regulations to Control Greenhouse Gas Emissions from Motor Vehicles" September 23, 2004.
[69] California Climate Action Team report (2006)
[70] Vyas, Saricks, and Stodolsky. *The Potential Effect of Future Energy-Efficiency and Emissions-Improving Technologies on Fuel Consumption of Heavy Trucks*. Argonne National Laboratory. August 2002; Langer. *Energy Savings Through Increased Fuel Economy for Heavy-Duty Trucks*. National Commission on Energy Policy. February 2004.
[71] http://www.arb.ca.gov/msprog/moyer/facts/about.htm
[72] http://www.arb.ca.gov/bonds/gmbond/gmbond.htm
[73] Turner, B.T., R.J. Plevin, M. O'Hare, and A.E. Farrell. Creating Markets for Green Bio-fuels. Berkeley: University of Califorina. http://repositories.cdlib.org/its/tsrc/UCB-ITS-TSRC-RR-2007-1/

4. INDUSTRIAL SECTOR

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, chemical, pulp and paper, computer technology, biotech, food processing, and more.

Through energy use and process emissions, California manufacturers account for 18 percent of total state GHG emissions, with oil refiners and cement plants representing fully half of the industrial sector emissions. (Transportation for manufacturing suppliers and goods movement to the consumer accounts is another source of GHG emissions related to manufacturing not counted in this total).

Electricity is a significant cost component for most manufacturing, and California has traditionally been a high cost state - now the rate premium is 35 percent – but industry has shared in California's energy efficiency successes that have kept per capita energy usage to about third less than the national average, according to the California Energy Commission, and achieved significant cost savings. (All electricity, labor, tax and real estate costs combine to make the cost of doing business in California 23 percent more expensive on average). Excess costs in California are on top of the 32 percent cost burden suffered by US manufacturers generally compared to their international trading partners.

Globalization means companies must adopt cost-effective energy efficiency measures to remain competitive in the state. This end-use efficiency combined with the high percentage of renewable, hydro and nuclear power in our electricity generation mix makes California manufactured goods much less GHG intensive than products made elsewhere. If the policies adopted under AB 32 inadvertently encourage industrial production to shift to unregulated regions, net GHG emissions would actually increase while state employment would be diminished, 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 reductions from the state's industrial sector 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 outlines the technological advances that should be supported by state programs and policies, the policy barriers that should be addressed to improve industrial competitiveness to prevent leakage, and recommendations to improve government decision-making and state agency coordination

II. Governance

Regular Reporting of Progress Mandate on All State Agencies: California agencies regulate many business and consumer activities that may have GHG emission impacts. Agencies should review the scope of their authority and find where their policies may be conflicting or not supportive of business and consumer efforts to reduce their GHG emissions and then take appropriate steps to improve the situation.

- ETAAC recommends that each state agency that interfaces with businesses and/or consumers do everything possible to help AB 32 succeed in reducing emissions. Beginning in 2008, each state agency should issue progress reports to the Governor and the legislature at six month intervals.

Improved Analytical Basis for Planning: The AB 32 scoping plan will have significant impacts across business sectors and state agencies, as well as for the public. There is an important need for comprehensive data and program analysis to guide AB 32 implementation. Without proper analysis, policies could be implemented that may have unintended consequences that worsen GHG emissions or other regulatory targets or are prohibitively expensive. To ensure that the state develops policies that result in real reductions that are economically and technically feasible, we propose the following:

- CARB should coordinate with all other state agencies that could affect, or be affected by, California's GHG goals to inform them of potential upcoming rules and measures - such as lists of planned early action measure, measures considered for the scoping plan, etc. Other agencies will review these potential future actions to identify any 1) information resources that may help ARB improve analysis, and 2) any areas of overlapping jurisdiction or regulation, and areas where coordination between state agencies is beneficial. The benefit of this process will be maximized when it occurs upstream of the rule development process.

- The Climate Action Team should establish a GHG inter-agency *Regulation Task Force*. The responsibility of the task force should be to analyze and map the current and proposed regulatory and approval system and the proposed changes that would result from AB 32 implementation. Through the use of process mapping (for instance, *Process Quality Management and Improvement-PQMI*) the task force can identify unnecessary steps and conflicts as companies attempt to comply with AB 32's climate change mitigation regulations on top of existing air and water quality requirements and other regulations.

- A *Greenhouse Gas Policy Institute* should be established to provide research and recommendations for life cycle analysis of GHG mitigation and guidance on policies and decision making. The institute would focus on a baseline approach to life cycle analysis for determining economic impacts across the full life cycle of energy and water utilization, and for establishing trade-off schemes, where necessary, when GHG mitigation efforts conflict with other state policies.

Adaptation to Climate Change: The Resources Secretary is responsible for the natural environment and habitat in California. Various state agencies under the Secretary's jurisdiction have noted changes in California's climate over the past 100 years, and are beginning to change their strategies and programs to adapt to future climatic conditions. Decision-making could be improved through generally accepted scenarios for the impacts of climate change. To date, *adapting* to climate change has not received the focus and attention that *mitigation* efforts have. However, state resources departments and selected cities and towns are making local decisions regarding adaptation without guidance from a state-wide framework.

- The Resources Secretary should join with Cal-EPA, CARB, CEC and the CPUC in a *Climate Adaptation Roundtable* group. Using analyses and likely warming scenarios, the focus of the roundtable should be on integrated resource, habitat, land use and development master planning. Regular briefings to the Governor would help to facilitate state wide discussions and debate.

One Stop Shop for GHG Information: An important goal of AB 32 is to encourage new clean-tech businesses to site facilities and hire employees in California.

- The State should establish a *one-stop shop* for information on GHG implementation focused on the needs of researchers, inventors, and businesses that will design, manufacture, distribute, install, and maintain equipment that reduces GHG emissions. The one-stop-shop should be a collaborative effort between the Business, Transportation, and Housing Agency, CARB, CEC, and the CPUC.

III. Industrial Incentives and Programs

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

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

- *Timeframe:* In place for 2020 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 which 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. In addition, it may be important to remove any negative tax impact for small businesses receiving the benefit of these energy efficiency investments.

C. “Clean-Tech” 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 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 R&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 clean tech equipment by small businesses.

D. Industry/Government Partnerships To Reduce Industrial Energy Intensity

California should join the "Superior Energy Performance Partnership", an effort to improve energy management being led by the USDOE, the USEPA, the Manufacturing Extension Partnership, and a number of industrial firms (including 3M, Dow, DuPont, Ford, Toyota, and Sunoco).

- *Timeframe:* In place by 2012.
- *GHG Reduction Potential:* Assuming conservative implementation rates, *annual* estimated GHG reduction beyond business as usual from implementation of the key elements of Superior Energy Performance (energy management and system optimization) after 10 years is 10 Metric Tons (MT) CO_2 or approximately 10-15 percent of GHG emissions related to industrial energy use

overall and more than 25 percent of GHG emissions related to electrical and natural gas consumption in industry.

- *Ease of Implementation:* Moderate. Requires staffing and development of such a program within CalEPA (or the CEC, which already has some experienced staff). Cost share may be available from the US Department of Energy.

- *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 substantial energy savings and lack the management systems required to continuously improve their energy intensity.

Possible Solution: This initiative will certify plants for energy efficiency and achieve significant cost effective GHG emissions reductions and energy savings through company commitments for reduction, adoption of energy management plans, adopting best practices and reporting annual reductions toward the AB 32 GHG reduction goals. Resources include tools, training, and assessments. Proposed rewards for meeting goals include public recognition and preference for R&D solicitations.

E. A 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 by creating 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.

- *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 are closely involved with the manufacturing process. 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, the technologies will not pass muster with permitting agencies, will not qualify for utility rebate programs, and may not qualify for financing. Until proven through successful demonstrations, technologies cannot gain a foothold in the market. There are limited funds to overcome these barriers. Currently only 8 percent of the PIER program is allocated to industrial RD&D purposes. In addition, there may be uncertainty over appropriate reimbursement rates for the state portion of cost-share funding when a company wishes to retain equipment from a successful demonstration; and the extent to which prevailing wage laws apply to further private investment following initial public-private partnerships.

Possible Solution: 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 by:

- Creating 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.
- Providing demonstration funds on a cost-sharing basis to industry or developers
- Provide 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 1) the environmental benefit of encouraging continued use of successful demonstration projects, 2) fair reimbursements for public dollars invested in equipment costs, and 3) the amount of value that the state would receive from return of the 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

G. Flexible Working Hours

Change California laws to allow more flexible working hours by requiring overtime pay for work in excess of 40 hours per week instead of 8 hours per day, while providing appropriate protections to workers. This would reduce commute-related emissions by allowing employees to work a 40 hour week in fewer days.

- *Timeframe*: In place by 2012.
- *GHG Reduction Potential*: 0.4 MMT (Flexible working hours reduces employee commutes which in turn reduces congestion. Motor gasoline accounts for 130 MT of GHG emissions. A reduction of 0.4 MT is based on the following

assumptions: 30 percent of gasoline is used for commuting; flexible working hours results in a 10 percent reduction in GHG emissions (commuting and congestion); and implementation by 10 percent of employers. This assumes no increase in emissions due to non-commute related travel.

- *Ease of Implementation*: Moderate to difficult depending on opposition.

- *Co-benefits / Mitigation Requirements*: Reduces traffic congestion and emissions of priority air pollutants.

- *Responsible Parties*: Legislature, employers, organized labor.

Problem: California law requires overtime compensation to be paid 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 usually refuse to permit 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 prohibitively 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.

Possible Solution: Change California labor laws to allow one or both of these reforms, while also providing appropriate protections to workers:

- Allow 4-day, 10 hours per day schedules without overtime pay. This would reduce traffic congestion at peak traffic hours and reduce emissions through less idling and 20 percent less commute time per week per employee.

- Allow 12/12 schedules for 24 hour business operations. Instead of three 8 hour shifts, employees working two 12 hour shifts with 3 days on one week (36 hours) and 4 days the next week (48 hours) would provide 8 hours overtime pay (as provided by current federal law). This is another flexible schedule that would reduce commuting related emissions.

IV. Industrial Technologies and Policies

H. Rebates for Load Reduction

Expand load reduction rebate programs to include non-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 load reduction) fall through the cracks of current rebate programs funded by utility customers.

Possible Solution: Expand load reduction rebate programs to include non-generation technologies. 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).

I. Improve Policies For Combined Heat and Power Plants

For small combined heat and power plants, as provided in AB1613, the Waste Heat and Carbon Reductions Act, define 'qualifying' Combined Heat and Power (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 plants by 2020. Also establish targets and qualifying criteria for larger CHP units not covered by AB 1613.

- *Timeframe*: In place by 2009. AB 1613 passed the legislature in September2007 and was chaptered in October of 2007.
- *GHG Reduction Potential*: 9.6 to 11 MMT (Assumes adding 5400 MW capacity, 6500 MWh per MW capacity, 600 lbs GHG/MWh for CHP, and 1100 lbs GHG/MWh per SB 1362. For power that is used at the source, an additional

reduction of 10 percent can be realized for avoidance of transmission and distribution losses.)

- *Ease of Implementation*: Moderate.

- *Co-benefits / Mitigation Requirements*: Will also reduce priority pollutant emissions in utility districts with coal based generation or with existing natural gas fired 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 the reduction of GHG emissions if it is designed to consume less fuel, and therefore produce less emission than the alternative – i.e. emissions from on-site boiler and utility generation from combined cycle unit. While not a new technology, state and utility policies with regard to "self-generation" have in part discouraged full penetration of cost-effective CHP into the industrial sector and commercial sectors.

Possible Solution: We recommend 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. In the report "Assessment of California Combined Heat and Power Market and Policy Options for Increased Penetration" (November 2005), the CEC estimated that CHP could, under an "Aggressive Market Access" scenario with certain parameters including global warming incentives, reach 5,348 MW (pg 2-18, 2-19).

AB 1613 implementation will be determined by the CEC and CPUC. To accomplish the goal to expand both small and large CHP, the state should:

- 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 in the facility)
- Qualifying CHP installations (like other energy efficiency measures) should not be subject to departing 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 ISO tariffs and a robust wholesale market for this excess power.
- Maintain GHG emission credit ownership with the facility for trading in California's cap and trade program

- Recognize GHG benefits of CHP for improving electrical efficiency and reducing thermal requirements (double-benchmarking) as is done in several EU member states.
- Restore qualifying combustion technologies to the Self Generation Incentive Program
- Provide incentives to utilities to participate in qualifying CHP solutions
- Maintain power purchase program administered by the CPUC to provide outlet to CHP for excess power.

V. Waste reduction, Recycling and Resource Management

<u>L. Waste Conversion Evaluation</u>

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

- *Timeframe*: Implemented 10 percent by 2012, 30 percent by 2020 and 100 percent by 2050.

- *GHG Reduction Potential*: By 2012 - 0.5 MMT, by 2020 - 1.4 MMT and by 2050 - 4.7 MMT. (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 bio-mass electricity and fuel production.

- *Responsible Parties*: State and local governments.

Problem: Conversion of municipal waste to fuels and other products can potentially reduce landfill emissions and displace fossil fuels, but can potentially also involve releases to air, land, and water depending on the type of technology used and type of product.

Possible Solution: We recommend that CARB, California Water Resources Board (CWRB), California Integrated Waste Management Board (CIWMB), and the CEC assess whether existing research is adequate to identify technologies that can reduce GHG to identify technologies and would be overall beneficial; and where existing research and evaluation should be supplemented. For technologies that are considered beneficial when considered from the perspective of GHG reductions and all other environmental criteria, we recommend further evaluation of 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 demonstration programs, and how these technologies are treated under solid waste diversion laws.

M. Landfills Regulation and Technologies

Implement policies to encourage enhanced landfill gas collection at existing landfills.

- *Timeframe*: In place by 2012.
- *GHG Reduction Potential*:
- *Ease of Implementation*: Easy to moderate.
- *Co-benefits / Mitigation Requirements*:
- *Responsible Parties*: State, local air districts, private industry.

Problem: There is a significant potential for GHG emission reductions through more efficient collection of landfill gases, better utilization of currently collected gases to be used as fuel instead of incineration, and improvements to landfill design that foster decomposition of solids to usable gases. But it is difficult to “retrofit” existing landfill designs to improve collection efficiency. Existing landfills are exempt, some technologies are not proven, and the quality of gas is not consistent.

Possible Solution: Air districts should revisit existing regulatory requirements for improvements to processes and standards. The State should also provide incentives to encourage development and implementation of innovative technologies. Finally, the Integrated Waste Management Board and air districts should work together to educate stakeholders on existing potential and processes to reduce emissions.

VI. Buildings and Appliances

N. Building Efficiency Programs and Incentives

Encourage better energy performance in new buildings, and encourage 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 the state. The Governor started a "Green Buildings Initiative" to reduce energy use in state building, and the California Energy Commission 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 combined heat and power 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.

O. 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. Energy efficiency standards are currently set by CEC for some appliances (e.g. water heaters), but uniform efficiency standards have not been established for other types of combustion devices.

Possible Solution: ETAAC industry subgroup offers the following recommendations:

- CEC should establish energy efficiency standards for new combustion devices, including for the commercial/industrial sector.
- Air districts, CARB and CEC should assess links between energy efficiency and air emission limits.
- 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.

5. ENERGY SECTOR[1]

I. Introduction

The production and use of electricity offers significant challenges -- as well as golden opportunities – as California seeks to comply with AB 32. Electricity use accounts for about 20 percent of California's carbon emissions. However, about one half of this total is GHG emissions from dirty out-of state coal-fired electricity generation. Therefore, California must design a strategy that reduces and displaces GHG emissions throughout a multi-state electricity market.

California has more renewable energy connected to its grid than any other state. California also has in place the most aggressive renewable energy development goals, so it is quite likely to maintain this leadership role in developing new non-carbon energy supplies. The state boasts proven world-class wind, geothermal and solar resources that can be expanded to meet future needs. California's agricultural sector also has an abundance of animal and agricultural waste that could be converted into green electricity. Deployment of renewable energy systems will have a significant impact on meeting California's GHG reduction targets by meeting future electricity load growth with less carbon intensive fuels and technologies.

Furthermore, enabling technologies such as energy storage, a smarter grid, and plug-in hybrid electric and battery electric vehicles (PHEV/EV) could also contribute to GHG reductions in the transport sector. This approach reduces vehicle GHG emissions from traditional petroleum based-liquid, but could also result in emissions increases from electricity generation, depending on the type of generation (a net overall decrease in greenhouse gas and criteria air pollutants would be expected in any case).Many of these technologies are well established commercial products. With the proper strategies, policies and incentives, these clean energy technologies will spur monumental reductions in GHG emissions while altering the way energy is traditionally generated, transmitted and distributed.

As the United States and other countries invest in new clean technology infrastructure to curb GHG emissions, California is poised to be a leader in clean technology, as it has led the way in high-tech and biotech industries. In Silicon Valley alone, investment in clean technology — from alternative energy products like solar panels and hybrid cars to the use of nanotechnology to solve environmental problems — went from $34 million in the first quarter of 2006 to $290 million in the third quarter, according to an annual report released by Joint Venture: Silicon Valley Network, a research organization based in San Jose, California.

California already has numerous institutions that will drive innovation and emerging technologies, including research, development ,and demonstration centers, universities and venture capital firms, which will help commercialize, deploy, and export technologies and services. According to a 2004 report by Environmental Entrepreneurs and the Natural Resources Defense Council, venture capital investments in California's clean technology industry could seed 52,000 to 114,000 new jobs statewide between now and 2010. Clean -tech investment holds the promise of new business opportunities, job creation, and widespread technological innovation throughout California.

Last, but certainly not least, bioenergy products and programs could potentially provide new opportunities for California's agriculture sector, both in terms of markets for new crops as well as the non-crop portion of the agricultural sector's current production. Since a large portion of available bioenergy feedstock originates in rural areas, creating a bio-based economy will help revitalize the state's rural communities and agricultural base.

The ETAAC energy sector subgroup approached the challenge of energy technology advancement from two vantage points:

- *Technology Categories:* What is the developmental status of those electricity generation and end-use technologies that promise to deliver low-carbon-equivalent energy services to California consumers at reasonable costs?
- *Regulatory and Market Barriers:* What are the technological, financial, institutional or regulatory barriers to the broad deployment of these technologies within the AB 32's 2020 compliance timeframe?

The majority of the recommendations presented in this report will take years to fully implement. But if the full potential of California's available low-carbon energy resources is to be developed, smart near-term choices must be made to enable optimal long-term innovation.

II. Overarching Themes

Among the overarching themes to emerge from the investigation of the problems and possible solutions to the energy sector's impact on AB 32 implementation is that there are a number of "game changer" issues. These game changers include both technologies and policies that facilitate emission reduction by streamlining efforts or providing commercialization incentives for new technology development. In particular, policies play a crucial role in streamlining permitting and siting of advancing energy technologies. If applied correctly, these policies foster innovation, accelerate commercialization timeframes and facilitate market adoption. Without effective policies, technology game changers often remain incomplete, delayed or unable to be brought to market on a timely basis. The right policies are critical to fostering technical and economic feasibility. The game changers are presented below, followed by a list of legislative "to do's" that would need to be implemented by the State of California in the very near future in order to harness the power of markets on behalf of AB 32's GHG emission reduction goals.

III. Policy Game Changers

A. Carbon Credit and Valuation for Early Action

Current uncertainty regarding the value of early action in advance of full AB 32 implementation may be delaying early GHG emission reduction investments by private actors.

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

Problem: The current uncertainty over CARB's acceptance of early actions to reduce GHG emissions in the energy sector could be delaying development of cutting edge initiatives. This is a perverse result, given California's emphasis on cost-effective early actions to mitigate climate change, but one that may be amenable to timely and targeted policy intervention.

Possible Solution: CARB should consider creating a banking mechanism, with clear underlying property rights attributable to the entity initiating early action, to allow value to be realized from corresponding early action GHG emission reductions. This effort will encourage investor confidence in the emerging California climate program and will stimulate liquidity in any future carbon market.

As a first priority, the CARB should develop protocols for quantifying carbon value, how emission reductions will be credited, certified, and tracked, as well as a process to bank the credits. This action would supplement, and could potentially precede, resolution of complex issues around the definition of obligated entities (i.e. load-based vs. first-seller approaches), the scope of compliance obligations (baselines and targets), and the ultimate approach to credit distribution (allocation vs. auction). By clearly defining a process by which a risk-taking entity can receive future rewards under a carbon control regime, CARB can liberate early action in new infrastructure investment as well as provide a basis for liquidity in any future credit markets that may emerge.

Regardless of what cost containment strategies, if any, are ultimately implemented, CARB should act now to put forward a stable set of early incentives for carbon-saving investment. A banking system with clear underlying property rights will enable private entities to act on the basis of their own assessment of the future value of carbon credits.

B. Unifying Standards for Climate-Related Programs

California's multiple programs for clean and alternative energy development 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 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 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 savings become the "coin of the realm," there may be value in coordinating these programs better 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.

At the same time, ETAAC recognizes that GHG savings 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 framework and may help to counter the innovation-suppressing effects of a broad carbon offset program.

Possible Solution: 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 energy sector that result in such savings would contribute to GHG reduction targets under AB 32, thus providing an incentive for all energy market participants to undertake what are now generally unrecognized beneficial carbon-reducing acts, and providing certainty to the actor undertaking the investment that GHG 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 regime by clear performance metrics that apply across all technology categories.

C. 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, then this number will be higher.)
- *Ease of Implementation:* The resource zone designation process has commenced, and the CEC and BLM have created a coordinated siting process. The transition to this policy will take time, effort and a lot of coordination and communication. It is a paradigm shift in the planning, resource development and permitting processes.
- *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, especially nitrogen dioxide (NOx).
- *Responsible Parties:* State agencies: CPUC, CEC and CA ISO. Other agencies that will likely be involved in a coordinated process include: California Department of Fish and Game, Regional Water Quality Control Board and the following federal agencies: Bureau of Land Management, Fish & Wildlife Service, National Park Service, Army Corps of Engineers, and Department of Defense land managers.

Problem: Renewable resources are usually located significant distances from load centers and lack adequate transmission infrastructure. Some renewable resource-rich areas, such as the Mohave Desert, have been 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 occur in earnest. Federal and state agency processes to site and permit renewable energy projects can be arduous, lengthy and complex.

The 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. Developing and delivering renewable electricity winds up being a "chicken and egg" issue because renewable and transmission development are inextricably linked. One does not happen without the other, yet financing and constructing one without the other is not quite possible without certain government sponsored guarantees.

In order to begin developing any renewable energy generation project, land leasing and permitting are required. All renewable technologies face permitting hurdles. 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 of these technologies.

Possible Solution: California could adopt a policy to identify and assess Competitive Renewable Energy Zones (CREZs) in the state, and develop a strategy, coordinated among agencies and other stakeholders, to facilitate new generation build-out in these zones as well as supportive transmission infrastructure. This policy should be coupled with a streamlined siting, environmental review and permitting process that is coordinated between the state, local and federal agencies in a master plan format. CARB should also investigate the pro-active financing of transmission expansion into high-resource areas, as a means of accelerating new renewable generation and overcoming the "chicken-or-egg" problem.

In 2007, both Colorado and Texas adopted similar policies. California's energy agencies have just commenced such a process, called 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 AB 32 targets.

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

- Statewide identification and assessment of competitive renewable energy zones;

- 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, federal and state agency coordination where multiple layers of jurisdiction exist. ETAAC suggests a coordinated process that retains the same level of environmental review rigor. The barriers previously mentioned could be alleviated if state and federal agencies cooperated in a coordinated, streamlined and expedited NEPA and CEQA environmental review and single, “master” environmental impact statement for each renewable resource zone as a whole.

A model for this recommendation could be the current work of the CEC and Bureau of Land Management (BLM) to create a joint NEPA/CEQA process for concentrating solar power plants. The joint process will create joint environmental documents and consolidated state and federal permits within one year. The process has a sunset date of January 1, 2012. Joint environmental documents should be created and consolidated state and federal permits within one year, the timeframe currently used by the CEC. A well-coordinated 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 targets.

IV. Technology Game Changers

G. Electricity Storage as an Enabling Technology

Electricity storage has the potential of enabling higher penetrations of intermittent renewable energy in California's power supply portfolio, allowing the state to take better advantage of its superabundance of renewable resource endowments. As such, the ETAAC energy subgroup's top technology development recommendation for CARB and other state agencies is to support an aggressive program to develop electricity storage technologies and associated infrastructure.

Energy storage addresses the services needed to integrate intermittency and works to shift excess off-peak power production to peak periods of demand. Also, when Energy storage is used to provide the necessary services to integrate intermittent renewables, 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 of fossil-fired generation. Thus, large scale successful storage technologies can transform intermittent renewable generation into a reliable resource for energy planning, enabling California to take full advantage of the enormous potential of these technologies throughout the West.

- *Time Frame:* 2007-2012
- *GHG Reduction Potential:* Potentially significant co-benefits, as storage technologies may make renewable electricity more available at times of peak demand, when some of the least efficient fossil resources are typically deployed. GHG emissions may vary based on the type of peaking power that is displaced and the generating source of off-peak power. Reductions could potentially be significant, if powered with off-peak renewable 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 renewable electricity 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 as electricity storage facilitates the market for electric-drive transportation technologies.

Problem: 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 policy recognition that energy storage is a necessary component to successfully managing 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 generate power during times of low electricity demand. The ability of electricity grids to absorb intermittent generation is limited and could be reached before the full potential of these sources is exhausted, unless other resources are added to firm, balance, and integrate them.

Possible Solution: The potential for a transformative effect from electricity storage is truly "game-changing" and that is why ETAAC recommends an aggressive high priority pursuit of these technologies. Storage alleviates the prime shortcoming of intermittent renewable energy resources. Energy storage technologies such as pumped hydro storage, compressed air, or batteries can provide the enabling technology to shift wind and solar power from off-peak generation to peak power consumption, essentially turning these technologies into 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, as well as provide emergency and remote-area power supply.

The state of California should recognize the value of energy storage in enabling intermittent renewable sources and encourage the advancement of energy storage technologies through the following technology push programs:

- *Utility Resource Planning*: California should direct its utilities to integrate aggressive goals for the 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.

Background: Examples of Storage Technologies

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

Pumped Hydro: The most widespread energy storage system in use on power networks; large scale capacity, quick deployment, and 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: Reduces "parasitic" loads at a conventional power plant – a form of energy storage -- but not used to generate electricity directly.

Batteries: Older technologies are commercially viable; 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 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 costs 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.

E. Aggressive LED Energy Efficiency Programs

The State of California has become a model of energy efficiency, as state-wide per capita consumption has remained practically flat while national usage has increased by roughly 50 percent over the past three decades. This trend has occurred despite the increasing use of electricity for a variety of products such as information technology. And this trend is likely to accelerate with the CPUC's new goals of net-zero energy for residential buildings in 2020, commercial buildings in 2030, and major advances in Heating, Ventilation, and Cooling units. In addition to energy-efficiency strategies (including Combined Heat and Power) for particular sectors identified in other sections of this report -- and general support for continuing to advance state energy efficiency programs -- this section of the ETAAC report identifies one technology recommendation that cuts across multiple end users: advanced lighting technologies such as Light Emitting Diodes (LED).

Energy efficiency is the first resource in California Energy Action Plan's "loading order" and provides some of the most cost effective GHG reduction measures. California must aggressively pursue the next generation of energy efficiency technologies to capture unrealized technical and economic potential.

- *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, though further developments in fluorescent lighting continue. Light Emitting Diode (LED) technology provides the next-generation of lighting opportunities and can save up to 30 percent more energy than CFL technology. Currently LED is 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. Research and development are underway regarding fixture design, thermal management, light diffusion, reflector design, and others. However, most of the technological advancements are taking place in the lab and are not transferring well to the outside world. 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. In addition, the State should invest in rapid 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 research and development in this area. The State of California must act now to maintain the momentum and continue to "fill the pipe" 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.

F. Renewable Energy and Energy Efficiency: Technology-Specific Considerations

California has made some significant progress on its way to meeting a state-wide 20 percent Renewables Portfolio Standard (RPS) target by 2010, yet some stubborn delays prove that renewable deployment still faces some significant barriers to entry. 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**.** These renewable energy targets will help California comply with AB 32 by introducing carbon-free electricity into the state's grid.

A few examples are the need for siting and permitting, energy storage and "Smart Grid" as an enabling technology for renewables that deliver electricity "off-peak". Some barriers are specific to types of renewable technologies, and some are universal or nearly universal across technologies. Some of these hurdles are described in detail in below and in the legislative priority list. Further details are also available in Appendix VI of this report. They are also included in the legislative priority list at the end of this chapter. ETAAC believes it is critical to establish as priority state policy to identify, assess and alleviate barriers to rapid renewable energy development. Some changes require regulatory fixes; others may require new legislation.

California has proven world-class wind, geothermal and solar resources that can be expanded to meet future needs. California's agricultural sector also has an abundance of animal and agricultural waste with the potential to be converted to clean renewable fuels and green electricity. There exists substantial potential for distributed renewable technologies, like solar water heating, photovoltaics and solar heating and cooling, and fuel cells that use waste gas. Deployment of renewable energy installations will have a significant impact on meeting California's greenhouse gas targets by displacing more carbon intensive technologies and meeting electricity load growth. Many of the technologies that will be used are already well established and beyond the definition of "game changers", but the deployment of those technologies in large volumes will spur significant reduction in carbon emissions, and alter the way energy is traditionally supplied and distributed.

- *Time Frame:* 2007-2012
- *GHG Reduction Potential:* 8.2 MMT CO2e for investor-owned utilities, and 3.2 additional MMT CO2e from municipal utilities, by 2020. These 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, then this number will be higher.
- *Co-benefits / Mitigation Requirements:* Renewable energy is zero or near-zero emissions. Displacing fossil fuel generation with renewable energy resources will reduce all criteria air pollutants over business-as-usual, especially nitrogen dioxide (NOx).
- *Ease of Implementation:* Barriers to deployment of renewable energy technologies are policies or components of policies that are in the purview of several different public sector actors. These barriers are listed in more detail in Appendix IV of this report.

- *Responsible Parties:* CPUC, CEC, CA ISO, State Legislature, local governments and others.

Problem: In the course of examining a wide range of renewable and low-GHG electricity technologies, the ETAAC energy 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.

*Possible Solutions***:** A broad suite of state policies and incentives to maximize contributions from the following technologies that California has helped nurture in the past and which offer promising solutions to further reduce GHG emissions in the energy sector in the near future.

- Energy Efficiency**:** The energy efficiency "nega-watt" generates no GHG emissions, is located at the point of consumption and therefore does not incur transmission, distribution or transformation losses, and does not require the permitting or construction of a 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. Energy efficiency is expected to capture approximately 6 of the 11GWs in demand growth in California over next decade. The state must ensure that GHG policies developed at CARB do not inadvertently disadvantage, or even worse, jeopardize the state's successful energy efficiency programs.

  In particular, the state should ensure that voluntary and mandatory efforts to reduce GHG through energy efficiency be properly accounted for and credited. Such voluntary efforts should not be considered "free-riders" subject to a higher energy savings baseline. The CPUC has set a precedent in the case of the governor's Green Building Initiative (GBI), where state Department of General Service (DGS) projects undertaken under the GBI are not considered "free-riders." This allows DGS to receive energy efficiency savings credits and incentives under the current CPUC rules governing utility energy efficiency programs. Unless this precedent is extended to other GHG policies promulgated by CARB, utilities will not be inclined to comply with AB 32 through their energy efficiency programs. Energy efficiency is a critical component in California's GHG reduction strategy. As such, the state should ensure that any GHG policy or regulation to be implemented complement its energy efficiency objectives and not create any unintended consequences.

- 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 to not capture estimates of the potential of off-shore wind resources.) 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.

- 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[5] 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.[6] 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 EA 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 federal DOE has 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. 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 the state's diverse biomass inventory. California regulators could play an important role in coordinating, and potentially underwriting, this critical stakeholder cooperation.

H. Plug-in Electric Vehicles as Storage Devices

Plug-in hybrid and dedicated electric vehicles (PHEV/EV) could serve as energy storage devices. The primary advantage of this approach is that they can be charged at night, when cheap (and often clean) excess electrical generating capacity is available. They also have future potential to supply distributed generation to the grid during peak hours or provide other important ancillary services. PHEV/EV enables greater utilization of off-peak renewable resources – such as wind power -- and has the potential to provide cleaner and less expensive peak and ancillary services in the future.

- *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 faces 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 feature higher upfront costs than conventional vehicles largely due to high cost of today's batteries. 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 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 electric sector. Still, this shift complies with AB 32's GHG emission reduction targets. Absent mitigating measures accounting for increases in electrified transportation, a carbon cap for the electric sector could thwart advanced vehicle fuels that cut GHG emissions.

Possible Solution: In order to reduce disincentives for substituting electricity for petroleum transportation fuels, a level playing field must be created for all fuel sources once alternatives reached commercial status. A carbon cap that stretches across both transportation and electric utility sectors would 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 enables greater reliance upon off-peak renewable resources and may provide cleaner and less expensive peak and ancillary service resources.

I. Smart Grid as Enabling Technology

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 are necessary to enable to the two-way flow of energy and data need for widespread deployment of distributed renewable generation resources, PHEV/EV and end-use efficiency devices.

- *Time Frame:* 2007-2012
- *GHG Reduction Potential:* GHG is reduced by not having to operate the least efficient generation to meet peaks. The ability to use more GHG-free energy -- such as solar PV -- is also improved by a smart grid.
- *Ease of Implementation:* Moderate
- *Co-benefits / Mitigation Requirements:* Two-way flow of energy and data would allow customers to respond to price signals to reduce usage at peak times, when the lowest efficiency fossil units are operating. Peak days coincide with "spare the air days" in California. Reducing fossil generation at peak improves air quality.
- *Responsible Parties:* CPUC, 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 Solution: 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 PHEV/EV. In particular, the CPUC should work with utilities to ensure investments in smart grid are implemented on the most accelerated timeframe possible. Furthermore, the California 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.

J. Carbon Capture and Sequestering Strategy

Broad commercial deployment of carbon capture and sequestration (CCS) technology is a critical component of achieving long-term reductions in GHG emissions, yet markets for these technologies are immature.

- *Time Frame:* 2012-2020
- *GHG Reduction Potential*: The Intergovernmental Panel on Climate Change (IPCC) estimates that CCS has the potential to abate CO_2 emissions by between 15 to 55 percent of the cumulative mitigation effort needed by 2100.
- *Ease of Implementation:* Difficult
- *Co-benefits / Mitigation Requirements:* Some technologies to capture CO_2 also reduce criteria pollutants like NOx and SO_2.
- *Responsible Parties:* State Legislature

Problem: 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 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. 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.

Regulatory uncertainties and legal issues regarding property rights and liability are significant barriers for CCS that must be resolved before it could play any major role in meeting AB 32's GHG emission reduction goals. It is not clear whether underground injection of CO_2 is under federal or state agency jurisdiction, for example. 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: The State (or preferably Federal) government should, first and foremost, address the legal and regulatory barriers and issues associated with CCS, including the development of legal framework to address long-term liability associated with carbon sequestration. A regulatory framework for monitoring storage and ensuring compliance is also needed. Ideally, long-term liability for maintaining the integrity of CCS projects should rest with the government, assuming appropriate cost-sharing arrangements are made. California State government could create financial incentives to spur CCS technology commercialization, including increasing the number of CCS demonstration projects and explicitly ensuring full cost recovery associated with these demonstration projects.

V. Suggested Legislative and Regulatory "To Do" List

Table 2 Immediate Horizon Legislative "To Do" List

Item	Relates To	Who
1. Create a process for the early valuation of carbon. (See Chapter 5 A)	Carbon valuation	CARB
2. Create financial incentives to spur CCS technology and implementation. (See Chapter 5 J)	CCS	Legislature
3. Consider the role of low-carbon power in the next version of the Energy Action Plan	Other Technologies	CPUC, CEC
4. 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 J)	CCS	Legislature
5. Create incentives for unsupported distributed generation that reduces gas, like economic solar hot water and advanced solar thermal (solar heating and cooling). (See Appendix IV G)	Solar water and space heating and cooling	CPUC CEC, Legislature
6. Authorize and implement development policy and plans for of Competitive Renewable Energy Zones. (See Chapter 3 C)	Renewable Energy Development Zones	Legislature CPUC CEC, Ca./federal land use agencies
7. 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. (See Appendix IV K)	Renewable Energy	Legislature
8. Ensure that voluntary and mandatory efforts to reduce GHG are counted in the crediting of energy efficiency program achievements. (See Appendix IV A)	Energy Efficiency	CPUC
9. Regulatory reform to encourage capture of methane from anaerobic digesters. (See Appendix IV L)	Biomass	Water Quality Control Board
10. Allow for the use of unbundled Renewable Energy Credits	Renewable	CPUC and

(RECs) for Renewable Portfolio Standard (RPS) compliance. (See Appendix IV K)		CEC
11. Revisit pricing structure of renewable portfolio standard and either modify or eliminate to simplify the structure. (See Appendix IV K)	Renewable	Legislature, CPUC and CEC
12. 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 E)	LED	CARB, CPUC, CEC
13. 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. (See Appendix IV I)	LED	CPUC
14. The State of California should recognize the value of energy storage in enabling intermittent renewable sources and develop programs to encourage the advancement of energy storage technologies, e.g. a "golden carrot" program or other technology push programs. (See Chapter 5 G)	Storage	CPUC
15. The State should actively consider pursuing new, large-scale pumped hydroelectric storage facilities, with the dual purpose of supporting increased penetration of intermittent renewable generation and active preparation for altered precipitation patterns anticipated under future climate change scenarios. (See Chapter 5 G)	Storage	

[1] This chapter focuses on electricity generation and may be retitled

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

[6] 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.

6. AGRICULTURAL SECTOR

I. Introduction

Agriculture in California generates $31.7 billion in farm receipts utilizing nearly 10 million acres of irrigated cropland and 15 million acres of rangeland while supporting 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. One component of these emissions includes energy sources such as diesel fuel, natural gas and electricity for field equipment and processing, and these forms of energy release GHG emissions. It is estimated that in 2004, all California agricultural sources accounted for about 30 $MMTCO_2E$[3].

There is the potential to generate significant GHG emission reductions from the capture and use of renewable carbon from agriculture and specific emissions sources. Technology that can deliver these benefits already exist in many cases, but a concerted RD&D effort and new regulatory incentives and programs will be needed to meet the GHG reduction goals included in AB 32.

Seven areas have been identified that present the most promise for significant reductions in agricultural settings. A summary of these technologies is given in Table 1, which includes estimates of the gross and technical reduction potentials for these technologies today. 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 research and a demonstration program are needed to launch critical elements of the program by 2012. The keys to developing the full program will be 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 with a robust multi-agency and industry cooperative effort.

The program described below will demonstrate and develop real and significant 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.

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 CalEPA 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 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 report. Because of their GHG 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 standard 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 standard development process, especially in co-digestion proposals. CVWRB should also develop a simplified design standard process to help assess and evaluate the potential need for pond reconstruction. 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.

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. A CPUC program should be developed to require electric utilities to purchase excess electricity from biogas production at a standard rate and should implement power purchase agreements that have flexible terms (to promote competition) such as 3, 5, 10 year agreements vs. the sole offerings currently being offered from private 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) tariff operations for intermittent and 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 renewable energy credits (RECs), including cases other than those directly related to Renewable Portfolio Standard (RPS) compliance and specific contractual arrangement pertaining to REC's. All GHG credits and RECs must accrue to the farmer generating the electricity. The producer 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 development by providing price targets for producers 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 determine under what conditions it would be feasible to introduce biomethane into natural gas distribution pipelines. If purification and injection is a preferred use of biogas, consideration should be given to incentives and interconnection costs among natural gas utilities. Whereas the potential generation of electricity 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 improves the productivity of animal feeding operations. In addition, improved 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 and other emissions 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. While both biochemical and thermo-chemical technologies are projected to produce cost effective transportation fuels when research and demonstration targets are reached, thermo-chemical technology is likely to be more appropriate for California. (See Industrial Sector for use with other feed stocks.) Both technology and regulatory hurdles exist and are discussed below.
- *Co-benefits / Mitigation Requirements*: These facilities would result in energy and oil 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, CalEPA 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. In addition, the ability of these facilities to sell power is not certain, 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 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 Solution: 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 along with ongoing support for RD&D efforts. 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 GHG 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 has caused the industry to manage rice straw though intensive non-burning alternatives that cost the California rice industry approximately $16-$18 million each year[15]. Other commodities in the San Joaquin Valley are facing the same regulatory pressure to reduce or eliminate open 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 clean transportation fuel standard.

- *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. In addition there is 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:* CalEPA 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 United States 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 meets the agricultural industry's oil crushing needs while obtaining state regulatory approval.

Possible Solution: 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 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.

- *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[18]. If sequestration technologies were applied to all cropland in California, GHG reductions could add up to about 6.1 MMT CO_2E per year. But 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 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
- *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.
- *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.

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 R&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 GHG total 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.

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 cut 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 CT 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, in response to agricultural policies that favor soil conservation and potentially enhance carbon sequestration and nutrient retention. 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 C sequestration by grasslands across different soil types and management regimes, and to assess the tradeoffs involved in land use change from grasslands to other different types of ecosystems.
- *Co-benefits / Mitigation Requirements*: These efforts can have benefits for 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[19], 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.[20]

Possible Solution: Conduct research to quantify the carbon storage from these practices and develop protocols that give landowners the ability to generate GHG reduction credits. 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 managing implementation and monitoring. As with all forms of carbon sequestration, commodity or industry programs to aggregate credits may be a suitable approach for marketing these credits and providing support for funding and monitoring.

It may also 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 like 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[21]. 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[22]. 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 budget under current and possible future conventional and alternative cropping systems in California could be calculated.

- *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[23]. 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[24]) there is great uncertainty about the N_2O emissions inventory. Therefore, there is a need to 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 N use against yield decline that occurs as a result. Additionally, some types of CT practices, like strip tillage, may not have the same increases in bulk density that are found in no-till suggesting growers should look to the full suite of CT technologies and other management practices that have the greatest combined economic and environmental benefits.

This 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 in 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.

[1] California Department of Food and Agriculture. 2006 California Agriculture Resource Directory. At 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. Total estimated uptake = 120 $MMTCO_2E$ = 75 (cropland) + 45 (rangeland).
[3] California Air Resources Board. 2007. DRAFT California Greenhouse Gas Inventory. Updated 8/22/07. At www.arb.ca.gov.
[4] California Biomass Collaborative, 2005. Biomass Resources in California: Preliminary 2005 Assessment. California Energy Commission[4]. Contract 500-01-016. April, 2005.
[5] California Climate Action Registry, 2007. Livestock Project Reporting Protocol. June, 2007.
[6] Anders, Scott J. 2007. 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.
[7] Smith, P. et al. 2007. DRAFT - Greenhouse gas mitigation in agriculture. IPCC Panel on Agriculture. Provided by Charles Rice, Kansas State University.
[8] California Biomass Collaborative, 2006. An Assessment of Biomass Resources in California, 2006. California Energy Commission. Contract 500-01-016. December 2006. p1
[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. p123.
[12] A. Aden, M. Ruth, K. Ibsen, J. Jechura, K. Neeves, J. Sheehan, B. Wallace, L. Montague, A. Slayton, and J. Lukas, 2002. Lignocellulosic Biomass to Ethanol Process Design and Economics Utilizing Co-Current Dilute Acid Prehydrolysis and Enzymatic Hydrolysis for Corn Stover. Report No. TP-510-32438. National Renewable Energy Laboratory. Golden, CO. June, 2002.
[13] Phillips, S., A. Aden, J. Jechura, D. Dayton, and T. Eggeman, 2007. Thermochemical Ethanol via Indirect Gasification and Mixed Alcohol Synthesis of Lignocellulosic Biomass. Report No. TP-510-41168. National Renewable Energy Laboratory. Golden, CO. April, 2007.
[14] California Health and Safety Code Section 41865.
[15] California Rice Commission, 2007.
[16] Shaffer, Steve. Personal communication. California Department of Food and Agriculture. July, 2007.
[17] Kaffka, Steve. Personal communication. University of California, Davis. September, 2007.
[18] DeGryze, S., R. Howitt, J. Six. 2007. "Regional Estimates of Greenhouse Gas Mitigation Potentials by Adopting Alternative Farming Management Practices in California" Presentation at Fourth Annual Climate Change Research

Conference. California Energy Commission. September, 10, 2007. and Personal communication. Johan Six. University of California, Davis. September, 2007.

[19] Tourte, L., M. Buchanan. 2003. Estimated Costs and Potential Benefits for a Perennial Hedgerow Planting. University of California Cooperative Extension. 2003. At coststudies.ucdavis.edu.

[20] S. Smukler, L.E. Jackson, S. Sanchez Moreno, S.J. Fonte, H. Ferris, K. Klonsky, A.T. O'Green, K.M. Scow, A.L. Cordova-Kreylos. 2007. "Carbon and Nitrogen Cycling Associated with Changes in Biodiversity in a California Central Valley Farmscape". Poster at Fourth Annual Climate Change Research Conference. California Energy Commission. September, 10, 2007.

[21] Six, Johan. 2007. University of California, Davis. Personal Communication. September, 2007.

[22] Mosier, A.R., W. J. Parton, D.W. Valentine, D.S. Ojima, D. S. Schimel, and J. A. Delgado. 1996. CH4 and N20 fluxes in the Colorado shortgrass steppe: I. Impact of landscape and nitrogen addition. Global Biogeochem. Cycles 10:387-399.

[23] Six. J., S.M. Ogle, F. J. Breidt, R. T. Conant, A.R. Mosier, and K. Paustian. 2004. The potential to mitigate global warming with no-tillage is only realized when practiced in the long term. Global Change Biology 10:155-160.

[24] California Air Resources Board. 2007. DRAFT California Greenhouse Gas Inventory. Updated 8/22/07. At www.arb.ca.gov.

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 worldwide produces one quarter of all CO_2 emissions linked to human activity, adding almost two billion tonnes of carbon per year[1]. In the United States, 1 million acres of private forestlands were lost to development per year by the 1990s[2]. In California, nearly 3 million acres of private forest and rangelands are conservatively projected to be lost over the next four decades[3].

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. Unnatural stocking in some forests -- too many stems per acre -- and development of fuel ladders from decades of fire suppression now make those forests more vulnerable to wildfire, pests and water stress. 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
- Utilizing waste forest biomass to generate electricity
- 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 response purposes. Additionally, many legitimate forest management projects have been stymied by broad disagreements over forest land management and low public trust that environmental values will be protected. Most project types that would produce climate benefits have already been debated, at least in part, in the context of other forest issues. Thus the 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 identifies a few 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[4].

The durability and health of California's forests are threatened by numerous factors that include the push to convert forests to other land uses, increased incidence of wild-fires, lack of appropriate management in some areas, and increased stress on forests from global climate change itself. Conflicting policy arenas also confound progress on some otherwise logical projects, such as the "chicken-and-egg" dilemma surrounding the inability to link biomass power plant development with fuel reduction programs to reduce wildfires.

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. That said, CARB has limited regulatory authority over forest management, and attempts to extend its regulatory reach could generate political resistance. The most productive path for CARB to offer the forest sector in achieving its AB 32 goals is to develop the frameworks, metrics, structure and incentive-based policies for the sector to participate in climate solutions.

III. Key Policy Principles

The overarching theme to guide forest sector policies can be summed up as: "Enhance gain, avoid loss."[5] 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[6].)

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;
- Substitute excess wood biomass for fossil fuels when generating electricity or in production of transportation fuels;
- Link wildfire reduction programs to the biomass cycle for electricity and fuels.

Ways to avoid loss include:

- Keep the existing forest land base as forest, rather than shift to development and conversion to GHG-emitting activities;
- 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.

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 advocacy 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[7]. 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:

1. Continue to affirm the metrics and structure for forest carbon accounting and reporting. 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.

2. Establish the role forests will have in carbon markets: 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 or national cap-and-trade market is established decisions will be needed: *whether* offsets will be allowed for flexibility, *how much* and *what kinds* (i.e. will forests be eligible). The forest sector argues "yes" for eligibility as a legitimate offset in a California market (should one develop), and in the meantime will continue to participate in the voluntary and Kyoto-based markets.

3. Develop protocols for additional forest activities: Current CCAR Protocols address 'Forest Management', 'Reforestation' and 'Avoided Deforestation'. CARB and CCAR should evaluate whether additional protocols or guidance addressing public lands, urban forestry, biomass, wildfire avoidance and other activities are ready for development.

4. Possible additions to the existing CCAR Forest Protocol may be appropriate to reflect experience gained since they were adopted and the updated policy environment. CARB and CCAR should establish the stakeholder and decision-making framework for developing new Protocols.

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

- 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
- Be open to good ideas

<u>A. Link Forest Fuels Management and Biomass Utilization: Green Bio-fuels Index; Economic Incentives and Technology Development</u>

Public support of forest fuel management projects will provide a three-way climate gain by restoring forest ecosystems to more resilient conditions, directing excess fuels to biomass energy production 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.[8]

- *Ease of Implementation:* Several key barriers to biomass utilization prompt development of a Green Bio-fuels Index, economic incentives and new technology:

  - A “chicken-and-egg” dilemma confounds widespread success in linking fuel reduction projects with appropriately sized and sited biomass plants. Uncertainty in fuel supply is a result of litigation (or threat of litigation) is particularly a barrier on federal forest lands. State support of “green labeled’ federal projects would firm up the supply of fuels available for biomass facilities, thereby improving the cost effectiveness of fuel treatments on adjacent private lands as well.
  - Costs of fuel treatments are high and labor-intensive. Haul-costs of moving wood waste from the woods to a biomass facility are a key determinant of a dependable fuel supply.
  - RD&D is needed on alternate fuels from wood wastes. Wood products laboratories are currently exploring conversion of wood to alternate liquid and gas fuels, for example in-woods pyrolysis to bio-oils or gas. This would reduce haul costs and expand potential uses of wood waste.

- *Co-Benefits / Mitigation Requirements:* Multiple benefits accrue to forest ecosystems, reduced wildfire emissions and biopower generation. Forest ecosystem health and resiliency can be improved in face of climate change. Other 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. CEQA and NEPA processes are well developed for assessing forest management mitigation projects.

- *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 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). When coupled with development of mid-successional fuel ladders, severe fire hazards are created. 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 understanding of benefits of fuel management to address the gridlock of project design and approval.

- 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.

A "Green Biofuels Index[9]" has been suggested as an approach to rank projects and improve public confidence in biofuel sustainability. CARB, CPUC, CEC and USFS can examine whether this might be a useful tool for biomass. 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.

Fuel treatment projects can reduce fuel loading, wildfire intensity and spread, and provide safety zones for firefighter operations. Extensive literature is available on fuel treatment methods, location, economics, environmental impacts and benefits. Projects designed to comply with a "Green Biofuels Index" may face less litigation and greater project success, delivering more reliable supply to appropriately sized biomass facilities.

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[10]).

- *Ease of Implementation:* Reforestation is highly feasible and is not limited by current technology. 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 also deliver reforestation programs on state park lands. The building of carbon stores in established working forests, on the other hand, is a landowner management decision. Among the incentives emerging for development of carbon stores is the high value carbon credit established through the rigorous accounting standards of the CCAR California Forest Protocols. A rapidly expanding voluntary carbon market is also helping. Development of national and international markets for forest carbon credits will further stimulate forest carbon storage projects.

- *Co-Benefits / Mitigation Requirements:* Multiple ecosystem and economic benefits from reforestation and enhanced carbon storage in established forests. Many under-stocked forest areas are the result of wildfire with no follow-up reforestation. Active planting with native tree species would 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.

- *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.

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. Offset credits in a carbon market will attract private landowners into carbon storage projects.
- 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.

<u>C. Urban Forests for Climate Benefits</u>

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.

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.

<u>D. Endorse "California-Grown" Climate Solutions</u>

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 Grown 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 Grown 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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[1] Food and Agriculture Organization of the United Nations. 2006. Global Forest Resources Assessment 2005.FAO Forestry Paper 147. http://www.fao.org/forestry/site/32431/en/. Also: http://www.fao.org/newsroom/en/news/2005/1000176/

[2] Stein, S.M., McRoberts, R.E., Alig, R.J., Nelson, M.D., Theobald, D.M., Eley, M., Dechter, M. & Carr, M. 2005. *Forests On The Edge: Housing Development on America's Private Forests*. Gen. Tech. Rep. PNW-GTR-636. Portland, Oregon, USA, United States Department of Agriculture, Forest Service, Pacific Northwest Research Station. http://www.fs.fed.us/projects/fote/reports/fote-6-9-05.pdf

[3] California Dept. Forestry and Fire Department, 2003. *The Changing California; Forest and Range 2003 Assessment*. FRAP Fire and Resource Assessment Program. http://frap.cdf.ca.gov/assessment2003/

[4] American Forest and Paper Association statistics provided by the California Forest Products Commission. www.calforests.org.

[5] Thanks to the Pacific Forest Trust for capsulizing the concept.

[6] Thanks to Connie Millar, USFS Pacific Southwest Research Station, for reviving a word we can use for this concept.

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[7] A Low-Carbon Fuel Standard for California, Part 2: Policy Analysis - FINAL REPORT, University of California Project Managers: Alexander E. Farrell, UC Berkeley; Daniel Sperling, UC Davis. Posted: 8/2/07. http://www.energy.ca.gov/low_carbon_fuel_standard/#uc.
See also: SF Chronicle, "Emission plan from UC team: State must reduce greenhouse gases, carbon in its fuels." 8/4/07
C-1. David R. Baker. http://www.sfgate.com/cgi-bin/article.cgi?f=/c/a/2007/08/04/BUN5RCLHF1.DTL&hw=low+carbon+fuel&sn=001&sc=1000

[8] See CDF CAT Report, 8/07 for assumptions and calculations for projects on private forest lands

[9] Turner B., R. Plevin, M.O'Hare and A. Farrell. *Creating Markets for Green Biofuels: Measuring and Improving Environmental Performance*. Institute of Transportation Studies, UC Berkeley Transportation, Sustainability Research Center. Year 2007 Paper UCB-ITS-TSRC-RR-2007-1

[10] See assumptions per CAT 9/19/06, CDF – vers. 1.2:

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 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 emissions.

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 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 reduction opportunities available under the cap. By increasing the breadth of GHG reduction 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 section IIA) 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 allowances based on historical emissions (known as grandfathering), free allocations based on carbon 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 in that firms that undertake early emissions reductions receive smaller allowance allocations as a result.
>
> *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 output-based free allocation methods are preferable to grandfathering. Any free allocation method

should be designed such 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 price signal. Auctions expose the true market-clearing price for all emissions under a cap, whereas free allocation systems conceal mitigation prices for emissions reductions that are not traded.

D. Use of Auction Revenues

In legal terms, auction revenues are a "fee" and thus must meet the legal standard established by the Sinclair Paint court decision. According to "Sinclair Test" requirements, a nexus must exist between the purpose of the fee and the use of its corresponding revenues. In this case, the fee is intended to further reduce GHG emissions in California and to further the overall aims of AB 32. 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 AB 32's implementation.

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; or 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 and research facilities for RD&D dedicated to technologies with potentially high GHG reduction value. Leverage and provide coordination among existing college and university RD&D efforts to help individual technologies with particularly high GHG reduction value achieve commercialization quickly (see section IIB).
- 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 Financial Sector Draft Report 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.

E. Offsets

Offsets allow a capped entity to claim credit for emissions reductions achieved outside the cap. Offsets can help contain costs and target sectors outside the state's 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 January 7, 2008).

For a variety of reasons, policymakers may choose to place a quantity or a geographic limit on offsets to be used to comply 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 innovation within a particular sector of the economy. Limits on offsets can be expected to increase compliance costs, 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 innovate within a given sector and weaken price signals for would-be innovators. Limits on offsets are therefore useful for encouraging innovation 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 While quantity limits on offsets can be valuable for encouraging action and innovation 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 emissions 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 limited 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. 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 section IIA) is one example of such a market maker. Borrowing could also be used as a cost-containment mechanism, conditioned on the price of carbon. See above for a discussion of borrowing.

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. The same could arguably be true for a dynamic market maker. Nevertheless, such an entity could be 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. This same market maker could be designed in a way that stimulates other forms of innovation.

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.

9. APPENDICES

Appendix I: ETAAC Member Biographies

Appendix II: ETAAC Committee Schedule

Appendix III: Inventory of Current State Funding Programs related to Climate Change

Appendix IV: Background Status Report on Energy Technologies

Appendix V: Background Status Report on Transportation (forthcoming)

Appendix VI: Summary of Public Responses

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.

Dominic DiMare
Mr. DiMare is the California Chamber of Commerce's Vice President of Government Relations and Chief Legislative Advocate. Before joining the Chamber in 2000, Mr. DiMare lobbied for agricultural cooperatives, focusing on deregulation of the electric utility industry, transportation and workers' compensation issues. DiMare earned a B.A. in history and public communications from American University and a J.D. from the McGeorge School of Law, University of the Pacific.

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.

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.

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	Central Valley	Reviewed the draft final report.

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.

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.

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

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.

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.

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.

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

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

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.

Table 1. Program Evaluation Statistics

	Annual Grants (MM$/yr)	Sample Size	Commer-cialization Rate	Time to Sale #	Benefit: Cost ^	Annual Revenue / $ Granted	C lev
SBIR		100's	25% *	~4 yrs			
ATP	145	100's			8:1		
PIER	62	34			1.3 to 3.4:1		
CalTIP	~5	75	31%	2 yrs		3 /yr	
ICAT	*~0.9*	*15*	*53%*	*1.7 yrs*		*1 /yr ^^*	

* >$300,000 revenue
\# Defn of "Time 0" varies.
^ Defn of "benefit" varies.

** derived by staff from data in CalTIP r
^^ $1.2 million revenue in 2004 among
received $1.1 million in grants

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.

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.

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.

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.

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

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.

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.

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.

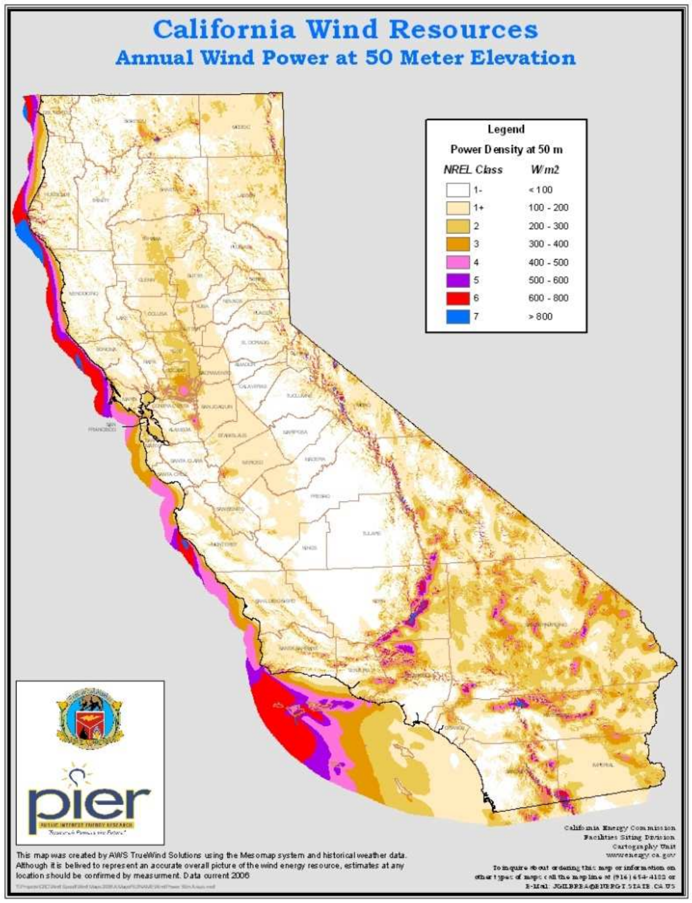
Institutional: While LED lights can last 10 to 15 years in normal use -- and make financial sense on a lifecycle basis -- consumers who make purchase decisions based on payback period are reluctant to invest in LED lighting due to higher upfront cost. In addition, the decision makers (e.g. builders and 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.



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^{o}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^{o}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.

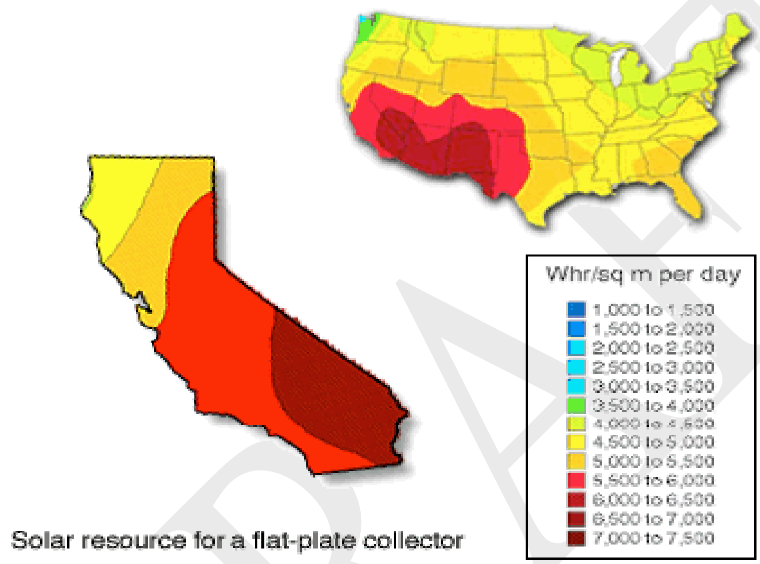
Institutional: There are a wide variety of geothermal resource types in California, but there are a restricted number of capable exploration entities. The Bureau of Land Management (BLM) rarely issues these leases because it is unsure of the geothermal development potential. Since its pre-lease processing 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.

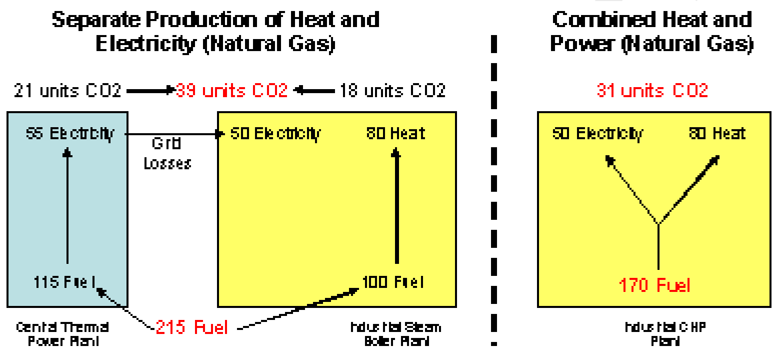
Recent procurement decisions made by PG&E reflect the types of gas-fired assets that are necessary: three highly-flexible combined cycle plants (up to 300 starts per year), three additional simple cycle gas turbines and two reciprocating engine farms. These operations have unprecedented operating flexibility, 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.

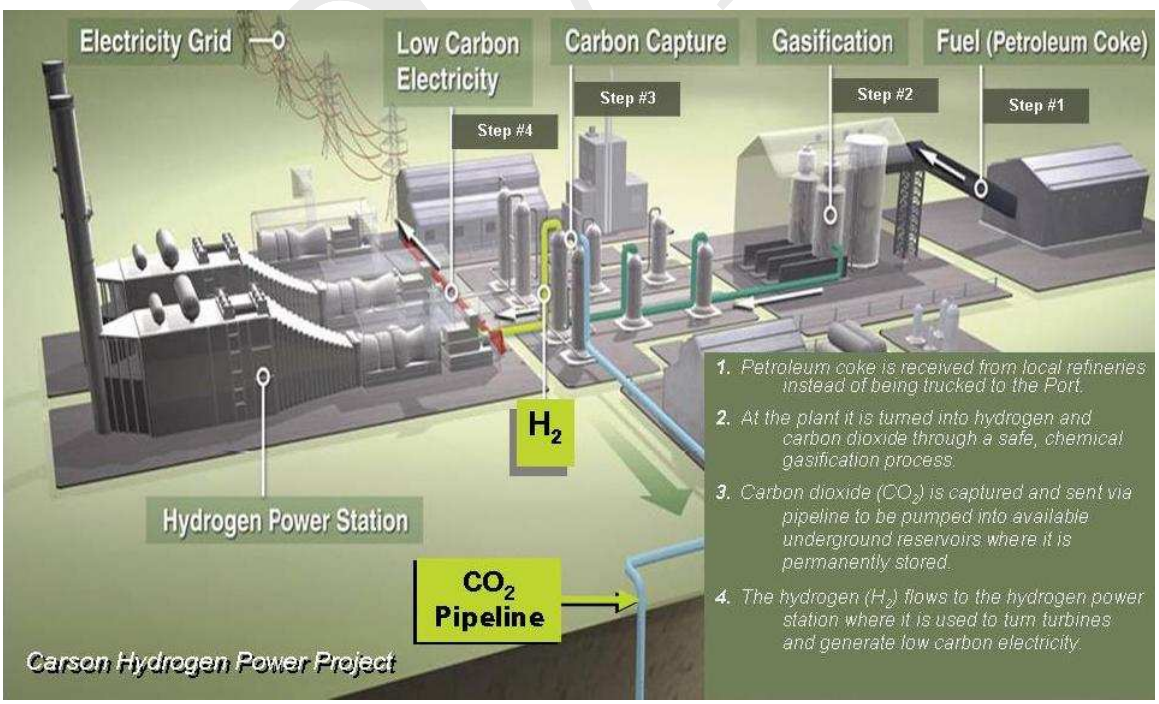
R. IGCC with CCS

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

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

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

Background Status Report on Transportation Sector Solutions and Sources

Appendix IV: Summary Table of Public Response 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 construction 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 displacement	Rutherford	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	na	na	Zozula	Kerby	Ventura County APCD

	and oil recovery					
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 to diesel fuel	CO2, others		Hodge	Cal	For a 2nd Opinion Inc.
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/y ear	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	Kalinows ki	Tim	Foam Supplies Inc
57	tax rebates for residential solar water heaters	CO2	$1500 rebate/unit	Del Chiaro	Bernadett e	Environment California
58	decentralize worksites for large organizations to reduce commute emissions	CO2	na	na	na	na
59	convert diesel engines to	CO2 down 20	na	Funk	Werner	Omnitek Engineering

	natural gas	percent -25 percent				
60	ice storage air conditioning to shift a/c loads to off peak hours	CO_2 4-6 tpy CO_2-eq/commercial building	up to $30k/installation	Kuhlman	Paul	Ice Energy Inc.
61	solar conversion of ambient CO_2 to fuel	450 tpd CO_2 per 100k gallons MeOH produced	$5-$6/gallon gasoline equivalent produced	Stechel	Ellen	Sandia National Laboratories
62	truck APU	CO_2, others	$1350 installed, $120/yr	Dennehy	John	Emerson Suphal
63	convert all CI & SI engines to run on plant-based fuels	CO_2, others	equal or less than current fuels	Hotaling	Dick	Fleet Multi-Fuel Corp
64	use nuclear power, iron-seed oceans to increase algae	CO_2	$.10/kw-hr, trillion dollars	na	na	nrc.gov, planktos.com
65	fuel additive to improve fuel economy	CO_2	$03-$.12/fuel gallon treated	Taplin	Harry	BTU Consultants
66	continue incentives for CHP projects	CO_2 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	CO_2, 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	CO_2, others	$15/sq ft	Lentz	Mark	Lentz Engineering Associates
69	install solar collectors as Salton Sea evaporates to reduce dust and generate power	CO_2, dust	na	na	na	na
70	install flue gas condensers on boilers/heaters to recover latent heat	CO_2, CH_4, 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	CO_2	$500/unit	Semerau	John	na
72	ban high consumption light bulbs, incentivize residential solar panels, etc.	CO_2	na	na	na	na
73	restore ecosystem productivity	CO_2 200 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
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, $394M/year operating	Perdon	Alberto	Orangeline Development Authority
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	CO2	na	na	na	na

program

January 10, 2008	Cal-EPA Headquarters, Sacramento	Approval vote on the final report.

112	enhance phytoplankton fertility as offshoot of Ocean Thermal Energy Conversion facilities	CO_2	na	Barry	Chris	Ocean Renewable Energy
113	digestion and co-digestion of organic feedstocks to methane for CHP	CO_2, CH_4	na	na	na	na
114	suction to remove CO_2 from atmosphere	CO_2, CH_4	na	Goodrich	John	na
115	alt fuels for Container Terminal Equipment	CO_2	na	na	na	na
116	replace older equipment with lean burn equipment	CO_2	na	Ayala	William	Jon's Marketplace
117	partial oxidation catalyst for vehicles	CH_4, NO_x 41 percent	$18-$30/vehicle	Bartley	Gordon	SwRI
118	permitting fast track for businesses using green technologies	CO_2, CH_4	na	Ryan	Hank	Small Business California
119	focus on efficiency, incentives for performance	CO_2	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 H_2 storage in cars	CO_2	na	Deniz	Gladys	na
122	better refrigerator insulation, lower appliance stand-by power demand, prioritize hiway lane access	CO_2	na	na	na	NA
123	CO_2 capture via hydrogenation to methane	CO_2	na	na	na	ECO2 (Norway)
124	innovative HVAC system for improved indoor air quality at reduced energy consumption	CO_2	na	Mumma	Stanley	Penn State
125	wind power to generate H_2 for vehicle use	CO_2	na	na	na	na

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[1] Shipp, Stephanie et al., *Evaluation Best Practices and Results, the Advanced Technology Program*, NISTR 05-714, May 2005; www.atp.nist.gov/eao/ir05-7174/contents.htm

[2] NIST, ATP; *2004 Report on Economic Progress;* www.atp.nist.gov/eao/2004annual/2004annual .pdf

[3] California Energy Efficiency Potential Study, Itron, May 24, 2006

[4] American Wind Energy Association. http://www.awea.org/projects/california.html. March 31, 2007.

[5] California Energy Commission. http://www.energy.ca.gov/electricity/gross_system_power.html. April 16, 2007.

[6] California Energy Commission. *California Gross System Power for 2006 In Gigawatt-Hours (GWh).* http://www.energy.ca.gov/electricity/gross_system_power.html. April 16, 2007.

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

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

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

[10] USDOE 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] http://www.energy.ca.gov/electricity/gross_system_power.html

[12] Information regarding lower and higher temperature resource technologies primarily from "The Future of Geothermal Energy", 2006, Massachusetts Institute of Technology

[13] California Energy Commission. *Comparative Costs of Central Station Electricity Generation Technologies.* Staff Draft Report. June 2007.

[14] http://www.gosolarcalifornia.ca.gov/solar101/orientation.html. Accessed August 12, 2007.

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

[16] L. Stoddard, J. Abiecunas, and R. O'Connell. "Economic, Energy, and Environmental Benefits of Concentrating Solar Power in California." USDOE NREL. April 2006. P. A-6.

[17] Abiecunas, J., L. Stoddard and R. O'Connell. *Economic, Energy, and Environmental Benefits of Concentrating Solar Power in California.* National Renewable Energy Laboratory. April 2006.

[18] L. Stoddard, J. Abiecunas, and R. O'Connell. "Economic, Energy, and Environmental Benefits of Concentrating Solar Power in California." USDOE NREL. April 2006. P. A-7.

[19] Ibid.

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

[21] 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.

[22] SunPower: June, 2007

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

[24] Decision (D.) 07-01-018 in CPUC R.06-03-004, issued January 11, 2007, Conclusions of Law.

[25] 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.

[26] Ibid.

[27] Formerly the San Diego Regional Energy Office (SDREO). This pilot program was set up in CPUC Decision (D.) 06-12-033, following the passage of SB 1, which established the California Solar Initiative. This pilot program is 18 months in duration and sunsets in July 2008.

[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.