ETAAC Report Final Draft – to be considered for adoption 2/11/08

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

This draft final report will be considered for adoption as the Committee's recommendations to the California Air Resources Board at the next ETAAC meeting, currently scheduled for February 11, 2008 at the Cal/EPA Headquarters Building in Sacramento.

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

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Written public comments should be received no later than February 10, 2008 to ensure they will be available to the Committee at the February 11, 2008 ETAAC meeting.

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

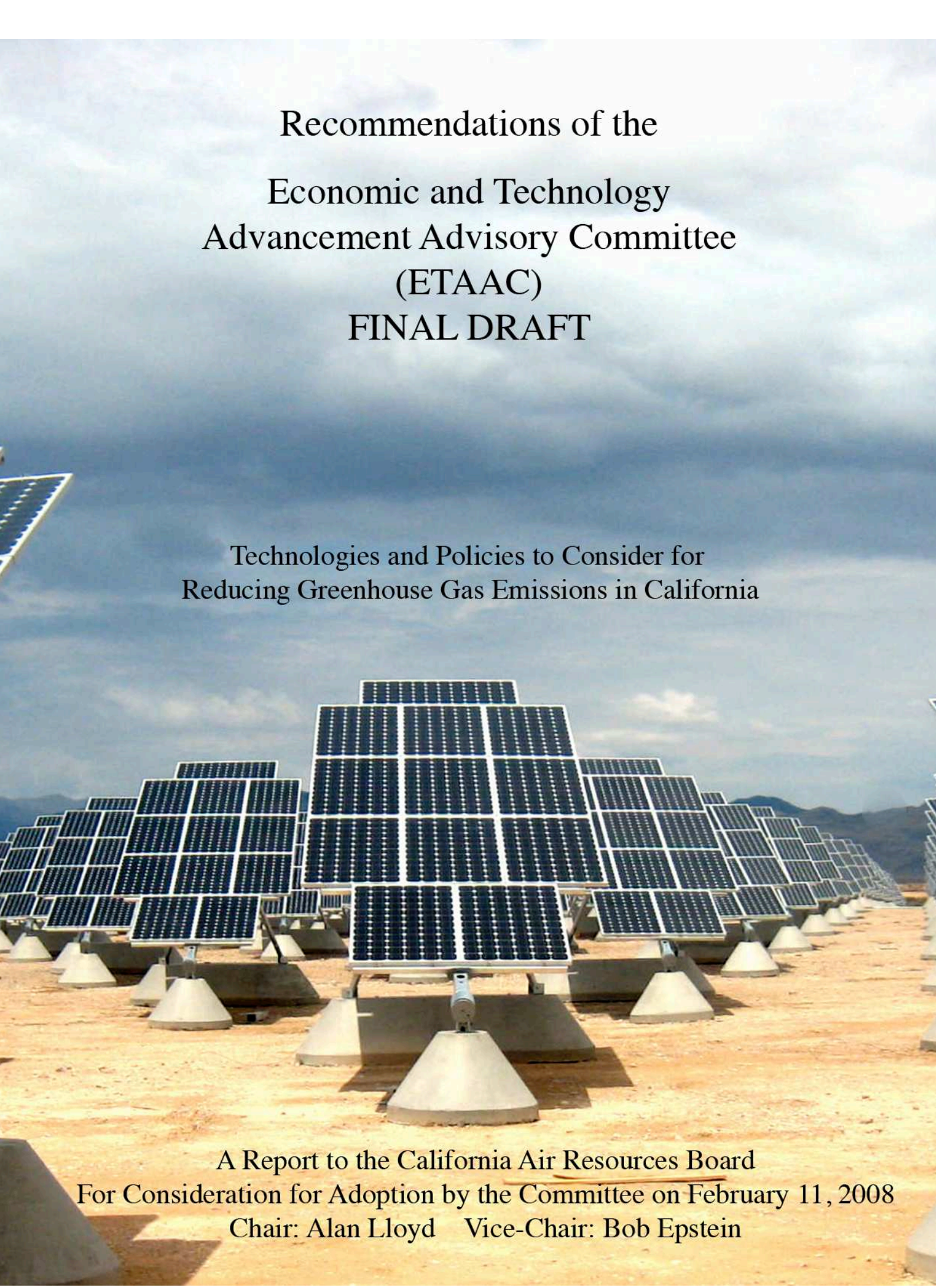
http://www.arb.ca.gov/cc/etaac/etaac.htm

# Recommendations of the

# Economic and Technology Advancement Advisory Committee (ETAAC)

# FINAL DRAFT

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



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

# Recommendations of the Economic and Technology Advancement Advisory Committee (ETAAC)

## Draft Final Report

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



To Be Considered for Adoption by the Committee on February 11, 2008

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# 1. INTRODUCTION AND EXECUTIVE SUMMARY

## I. The Challenge and The Opportunity

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

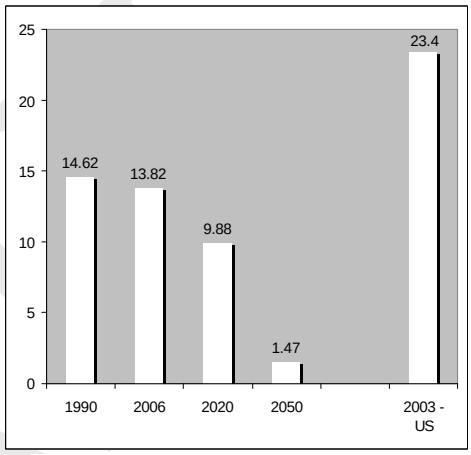



*Figure 1-1: California Per Capita $CO_2$-Equivalent (tons per person)*

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

Despite these seemingly daunting challenges, California's climate change policies can benefit the state's economy, environment, and residents. Developing cleaner energy and transportation systems will give California a chance to improve the security of fuel supplies, address stubborn air pollution concerns, and develop better designed communities and buildings. The development of better methods of moving people and goods throughout the state is another opportunity to improve economic efficiency and reduce pollution and congestion in the implementation of our climate change response program. In many cases, these solutions provide important co-benefits by addressing difficult and long-standing problems. Among them is the inequitable distribution of the environmental costs associated with California's electric power and transportation infrastructure.

Continuing California's long-standing tradition of innovation on environmental issues, AB 32 has given the California Air Resources Board (CARB) a leadership role in forging new approaches to diminishing the state's carbon footprint. Existing California programs have demonstrated that major air pollution reductions can be achieved through economic and technological advancements. For example, new electric power plants in California now emit 90 percent less ozone and particulate forming Nitrogen Oxides (NOx) than they did two decades ago due to technology-forcing regulations. Strict technology-forcing standards have also resulted in California's greenest new passenger cars emitting 99 percent less Volatile Organic

Compounds (VOC) and NOx than vehicles did in 1970. Policies supporting aggressive energy efficiency upgrades, as well as higher energy prices and a transition toward a service-oriented economy, have all helped California keep its per capita electricity consumption flat for the past few decades. California has achieved this feat, in part, through a balanced portfolio of policies, performance standards and market-based incentives. These State policies addressed important market failures: pollution externalities; market barriers to private sector Research, Development & Demonstration (RD&D); misplaced financial incentives; and imperfect information for energy consumers. As California turns its attention to combating global climate change, new State policies designed to surmount these and other market failures must expand in scope and creativity.

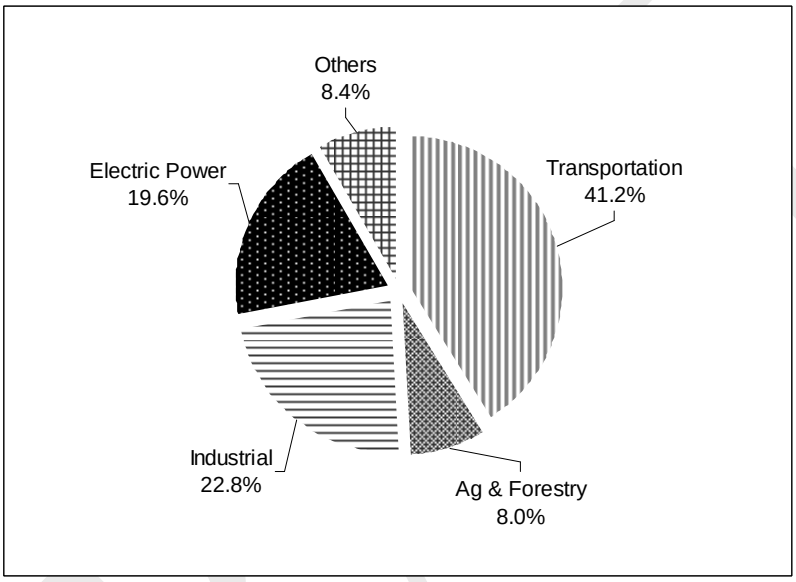



*Figure 1-2: Carbon Emissions by Sector*

As shown above in Figure 1-2, GHG emissions result from many activities ranging from transportation to manufacturing to agriculture. Policies implemented under AB 32 and the Governor's Executive Order for 2050 must address all sectors of California's economy so that all significant sources of GHG emissions participate in both the challenges and opportunities afforded by this critical piece of state legislation. This broad-scaled approach is the most likely to create a level playing field, and address new alternative energy sources that could be used in multiple sectors. For example, policies need to recognize that electricity and biofuels will likely compete with more traditional transportation fuels in the future; therefore, policies that address only the electric sector or only the petroleum refining sector are unlikely to achieve the goals of AB 32.

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

the short term. This report identifies recommendations to achieve both short-term and long-term goals. Balanced and innovative approaches are clearly needed.

## II. Major Strategies and Opportunities

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

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

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

**Strategy #1: Accelerate GHG Emission Reductions**

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

There is an urgent need for investments in GHG emission reductions before the AB 32 cap goes into effect in 2012 because some investments in particular technologies may preclude other choices that would lead to even greater GHG emission reductions. In many cases, delaying these investments will also delay the total benefit of actions that could be taken today to reduce GHG emissions.

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

**Strategy #2: Balance a Portfolio of Economic and Technology Policies**

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

If markets were perfect, such a cap and trade system would bring enough new technologies into the market and stimulate the necessary industrial RD&D to solve the climate change challenge in a cost effective manner. As the Market Advisory Committee notes, however, placing a price on GHG emissions addresses only one of many market failures that impede solutions to climate change. Additional market barriers and co-benefits would not be addressed if a cap and trade system were the only state policy employed to implement AB 32. Complementary policies will be needed to spur innovation, overcome traditional market barriers (e.g., lack of information available to energy consumers, different incentives for landlords and tenants to conserve energy, different costs of investment financing between individuals, corporations and the state government, etc.) and address distributional impacts from possible higher prices for goods and services in a carbon-constrained world. Investing revenues from any allowance auctions in low carbon technology development and deployment will greatly increase the benefit of putting a price on carbon. Performance standards (i.e. emissions per kilowatt-hour, per mile traveled, per units produced, etc.) also have a proven history of success and need to continue to be part of California's strategy. In complying with a performance standard, a regulated entity should have the choice to use a mix of technologies that brings the entity into compliance on an equivalent basis with a particular performance standard. In addition, California can consider revenue-neutral fee shifting to reward the purchase of lower carbon products (see Chapters 2.III.E and 3.IV.G).

These complementary economic and technology development strategies form the core of ETAAC's policy recommendations found in this report. Many of the strategies outlined in the following pages of this report would be much more effective with appropriate price signals that

flow from a declining cap on GHG emissions combined with near and long-term development of low and zero carbon alternatives. A well conceived diverse portfolio featuring both market-based policies and regulatory measures will be more efficient and less costly than relying exclusively on options from either category of potential solutions on their own.

Government policy should not attempt to pick technology winners. Rather, performance-based programs—whether market-based, command-and-control, or incentive oriented—should be the normal course of business. ETAAC makes a number of recommendations based on the need to help emerging technologies move through demonstration phases to achieve full commercial viability. For instance, policies shaping development and demonstration of innovative technologies may differ from those focused on introducing technologies into the marketplace on a commercial scale. The best approach may be to support new technologies to the point where they can stand-alone within a market structure characterized by performance standards and carbon prices that become a part of everyday decision-making by consumers and businesses. Full performance battery electric and fuel cell vehicles, for example, are two major zero tailpipe emission technologies currently under development. While both technologies will require significant government involvement to become fully commercialized, ETAAC does not advise selecting one or the other as the preferred future technology. In the shorter term, plug-in hybrids using clean electricity as part of their vehicle fuel may compete with other vehicle technologies using lower carbon advanced vehicle fuels. Thus, standards, policies, and incentives should be aimed towards establishing a level playing field and lowering barriers to technologies that can then compete based on price, efficiency, emissions, convenience, and other factors.

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

**Strategy #3: Create Innovative Public Funding to Complement Private Investment**

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

The policies created to support AB 32 will galvanize significant private sector investment in California, but this expected investment will not be enough to reach all areas necessary to

achieve the overall GHG emission reduction goals. ETAAC reviewed areas where public financing, possibly leveraged with private capital, can stimulate innovation and accelerate adoption of cleaner products. ETAAC has identified the technology demonstration/pre-commercialization phase in a product's life cycle as a critical stage for this type of investment. If California decides to adopt a cap and trade system that includes the auction of emission allowances, ETAAC proposes that a California Carbon Trust – discussed in greater detail in Chapter 2.II.A – can direct investments in RD&D and finance technology pilot projects in disadvantaged communities and throughout the State of California. Often, these projects offer co-benefits such as improved air quality or employment. Investments from the California Carbon Trust can fill RD&D funding gaps by leveraging the capabilities of universities, State agencies, non-profits and other pioneering research leaders throughout the state.

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

California does have a variety of existing incentive fund programs underwriting RD&D and related research activities (outlined in Appendix III). They typically serve specific functions. At present, none of them specifically target GHG emission reductions and they also are not currently coordinated to achieve the maximum amount of co-benefits. ETAAC recommends that the State of California make an affirmative commitment to RD&D programs geared toward GHG emission abatement (see Chapter 2.II.B), and examine how to best integrate these climate change priorities and existing State funded programs with existing environmental and energy policy goals. The State should also consider creating a new organization to house these and other programs. By not just supporting, but actively promoting clean energy innovation, California has the opportunity to seed the marketplace with promising new technologies that may provide critical tools to achieve AB 32's reduction targets. This seeding effort will also bring to market solutions necessary to meet the 2050 goal of a carbon-free economy. This will also drive new investment dollars to California and better enable our state to attract and nurture the most promising clean energy start-up businesses.

**<u>Strategy #4</u>: Foster International and Domestic Partnerships**

California should learn from the European Union and others in the international community that have already moved forward on the implementation of policies designed to respond to global climate change. California can learn from both policies that have worked and those that have not. Success on the climate change front domestically can benefit greatly from partnerships between the public and private sector (see Chapter 4.III.H), between State and local governments, between the State and Federal government, and between the State and other nations. Broad deployment of clean technology will generally drive down costs and lead to

subsequent generations of innovation. California must leverage agreements with western U.S. states, Canadian provinces, the European Union, the United Kingdom and other countries and integrate with Federal programs (such as the recently signed "Energy Independence and Security Act" – H.R. 6) if AB 32 is to accomplish its expressed intent. Achieving genuine success on climate change will also require the transfer of clean technology to developing nations, including China, India, Mexico and Latin America. Exporting both information on public policy solutions and the benefits of a strong Cleantech industry is one example recommended by ETAAC (see Chapter 2.II.B); partnering with other states, the Federal government, and other nations on low and zero tailpipe emission vehicles is another (see Chapter 3.IV.E).

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

**Strategy #5: Leadership Across State Agencies**

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

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

goals into other State programs. AB 32 calls for an annual Report Card summarizing progress from all State agencies (section 12892). ETAAC strongly supports this Report Card as a way of providing regular feedback. If possible, these Report Cards should be strengthened with independent, third party verification.

**Opportunity #1: Accelerate Efficiency Measures**

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

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

**Opportunity #2: Remove Carbon from Energy Sources**

California's future sources of electricity, transportation fuels and heating fuels will need to be zero or near-zero carbon by 2050. Renewable energy technologies such as wind, solar, and others offer the technical potential to generate all of California's electricity, but there are a number of technical and implementation challenges that will not be simple to overcome. ETAAC examined the opportunity of how to quickly scale up these sources of renewable energy, (such as wind, solar, and geothermal steam) both on-site distributed generation and central utility-scale power plants. ETAAC identified the issues in increasing the State's Renewable Portfolio Standard to 33 Percent by 2020 – paying particular attention to the barriers that must be overcome (see Chapter 5.III.C). In addition, biomass sources, if coupled with carbon sequestration, could produce renewable energy supplies and permanently remove carbon from the atmosphere provided that there are no net adverse effects from growing the biomass (see Chapters 4.II.D; 5.III.I and 6.II.A).

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

In the AB 32 timeframe, ETAAC believes fossil fuels, including natural gas, can play an important role for both power generation and heating. Over the long term, fossil fuels such as natural gas are most likely to play a valuable role for traditional uses and as a feedstock for vehicle energy supplies if carbon can be separated and permanently stored. Large scale deployment of low carbon, zero carbon and even negative carbon biomass energy will likely require methods to permanently sequester carbon. California should continue to partner with other states, Federal agencies and international partners to encourage RD&D to find cost-effective and safe methods of sequestering $CO_2$ streams from power generation (see Chapters 4.II.C; 5.V.I).

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

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

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

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

California's freight systems will need a similarly dramatic overhaul. California's coastal ports and Central Valley freeways have become increasingly congested. Alternative modes of goods movement have become both a necessity and an opportunity to reduce GHG emissions and other criteria air pollutants.

**Opportunity #4: Reduce GHG Emissions from Industry, Agriculture, Forestry and Water**

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

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

**Opportunity #5: Capture Cleantech, Economic, Health, and Environmental Justice Co-Benefits**

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

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

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

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

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

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

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

## III. Summary Message

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

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

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

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

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

and products created in response to AB 32 will strengthen both the California economy and the state's international leadership on environmental issues.

## IV. The Role of ETAAC

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

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

To meet these objectives, CARB appointed members to the ETAAC in January 2007. Members were selected based on their knowledge and expertise in fields of business, technology research and development, climate change and economics. (Brief biographies of members are listed in Appendix I.) The Committee is chaired by former CARB chairman and former Cal/EPA Secretary Alan Lloyd, Ph D. The Committee vice-Chair is Bob Epstein, Ph D., noted engineer and entrepreneur, and co-founder of Environmental Entrepreneurs.

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

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

8. Address Environmental Justice concerns
9. Participation across all sectors
10. Flexible approaches

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

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

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

## V. Organization of ETAAC report

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

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

## VII. Mapping of Recommendation to Categories, Timeframe and Responsible Parties

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

| | | | |
|---|---|---|---|
| C. Congestion Charges | Balance a Portfolio of Economic and Technology<br>Rethink Transportation to Lower Demand and Carbon | By 2012 | Legislature<br>Other<br>Cal Trans |
| D. Employer-Based Commute Trip Reductions | Rethink Transportation to Lower Demand and Carbon | By 2012 | CARB<br>Other |
| E. New Vehicle Technology Improvements | Accelerate efficiency<br>Rethink Transportation to Lower Demand and Carbon | By 2020 | CARB<br>Other |
| F. Low GHG Fleet Standards and Procurement Policies | Balance a Portfolio of Economic and Technology<br>Accelerate efficiency<br>Rethink Transportation to Lower Demand and Carbon | By 2012<br>By 2020 | CARB<br>Other |
| G. GHG-based Vehicle Feebates and Registration Fees and Indexed Fuel Taxes | Balance a Portfolio of Economic and Technology<br>Accelerate efficiency<br>Rethink Transportation to Lower Demand and Carbon | By 2012 | Legislature<br>Other |
| H. Air Quality Incentives Programs and Standards | Balance a Portfolio of Economic and Technology<br>Capture Economic, Health, and Environmental | By 2012 | CARB<br>Legislature<br>Other |
| I. Create Markets for Green Fuels | Balance a Portfolio of Economic and Technology<br>Remove Carbon from Energy Sources<br>Rethink Transportation to Lower Demand and Carbon<br>Reduce GHG Industry, ag, forest, water | By 2012 | CARB<br>Other |
| **4 – Industrial, Commercial & Residential Energy Use** | | | |
| A. Cleantech Tax Incentives | Innovative public finance<br>Accelerate efficiency | By 2012 | Legislature<br>Other |
| B - Rebates for Load Reduction | Accelerate efficiency<br>Reduce GHG Industry, ag, forest, water | By 2012 | Other |
| C - Improve Policies for Combined Heat and Power Plants | Accelerate efficiency<br>Reduce GHG Industry, ag, forest, water | By 2012 | CEC<br>CPUC<br>Other |
| D. Distributed Renewable Energy Generation: Solar PV | Remove Carbon from Energy Sources | By 2020 | Legislature<br>CPUC<br>Other |

| | | | |
|---|---|---|---|
| E. Customer Choice of Electric Service Provider | Remove Carbon from Energy Sources | By 2012 | Legislature<br>CPUC |
| F - Building Efficiency Programs and Incentives | Accelerate efficiency | By 2020 | CEC<br>Other |
| G - Combustion Devices: Energy Efficiency | Accelerate efficiency<br>International and Domestic Partnerships | By 2012 | CARB<br>CEC<br>Other |
| H - Industry - Government Partnerships to Reduce Industrial Energy Intensity | International and Domestic Partnerships<br>Coordinate Across State Agencies | By 2012 | CEC<br>Other<br>CalEPA |
| I - A Revolving Fund for Technology Demonstration Projects | Innovative public finance<br>Accelerate efficiency<br>Reduce GHG Industry, ag, forest, water | By 2020 | No answer |
| J. Develop Suite of Emission Reduction Protocols for Recycling | Reduce GHG Industry, ag, forest, water | By 2012 | CARB<br>CIWMB |
| K. Increase Commercial-Sector Recycling | Reduce GHG Industry, ag, forest, water | By 2012 | CARB<br>CIWMB |
| L. Remove Barriers to Composting | Reduce GHG Industry, ag, forest, water | By 2012 | CARB<br>CIWMB<br>Cal Trans |
| M. Phase Out Diversion Credit for Greenwaste Alternative Daily Credit | Reduce GHG Industry, ag, forest, water | By 2012 | CARB<br>CIWMB |
| N. Reduce Agricultural Emissions Through Composting | Reduce GHG Industry, ag, forest, water | By 2020 | CARB<br>CDFA<br>CIWMB |
| O. Evaluate and Improve Policies for Qualified Waste Conversion Technologies | Reduce GHG Industry, ag, forest, water<br>Capture Economic, Health, and Environmental | By 2012<br>By 2020<br>By 2050 | Other |
| **5. ELECTRICITY AND NATURAL GAS** | | | |
| A. Energy Efficiency Program Coordination | Accelerate efficiency | By 2012 | CARB<br>CPUC |
| B. Aggressive LED Energy Efficiency Programs | Accelerate efficiency | By 2012 | CARB<br>CEC<br>CPUC |
| C. Support an Increase in RPS to 33 Percent by 2020 | Balance a Portfolio of Economic and Technology<br>Remove Carbon from Energy Sources | By 2020 | CARB<br>CEC<br>CPUC<br>Other |

| | | | |
|---|---|---|---|
| D. Competitive Renewable Energy Zones | Accelerate GHG Emission Reductions<br>Remove Carbon from Energy Sources | By 2012 | CEC<br>CPUC<br>Other |
| E. Renewable Energy Technology Assessments | Remove Carbon from Energy Sources | By 2012 | CEC<br>CPUC<br>Other |
| F. Electricity Storage as an Enabling Technology for Renewable Energy | Remove Carbon from Energy Sources<br>Coordinate Across State Agencies | By 2012 | CEC<br>CPUC<br>Other |
| G. Plug-in Electric Drive Vehicles as Storage Devices | Remove Carbon from Energy Sources<br>Rethink Transportation to Lower Demand and Carbon | By 2020 | CARB |
| H. Smart Grid as Enabling Technology for Renewables and Clean Vehicles | Accelerate efficiency<br>Remove Carbon from Energy Sources | By 2012 | Legislature<br>CPUC |
| I. Carbon Capture and Sequestration in Geological Formations | Remove Carbon from Energy Sources | By 2020 | Other |
| J. Low Carbon Electricity Generation Plan | Balance a Portfolio of Economic and Technology<br>Remove Carbon from Energy Sources | By 2012 | CARB<br>CEC<br>CPUC<br>Other |
| K. Unifying Standards for Climate-Related Programs | Balance a Portfolio of Economic and Technology<br>Coordinate Across State Agencies | By 2020 | CARB<br>CEC<br>CPUC |
| **6. AGRICULTURE** | | | |
| A - Manure to Energy Facilities | Remove Carbon from Energy Sources<br>Reduce GHG Industry, ag, forest, water | By 2012<br>By 2020 | CARB<br>CEC<br>CPUC<br>Other<br>CDFA<br>CalEPA |
| B - Enteric Fermentation | Reduce GHG Industry, ag, forest, water | By 2020<br>By 2050 | Other<br>CDFA |
| C - Agricultural Biomass Utilization | Remove Carbon from Energy Sources<br>Reduce GHG Industry, ag, forest, water | By 2020<br>By 2050 | CARB<br>CEC<br>CPUC<br>CDFA<br>CalEPA<br>SWRCB |

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

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

# 2. FINANCIAL SECTOR

## I. Introduction

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

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

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

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

- California is well positioned to attract venture capital investments in Cleantech companies. California led the nation in Cleantech venture investments in 2006 with $1.13 billion, representing 44 percent of total Cleantech investments in the U.S. However, the amount of invested capital is not the same thing as *productive investment*. The State should encourage private investment that is informed by policy trends and technology advancements in order to generate both robust economic and environmental returns.[2]
- International Partnerships can help create export opportunities for California Cleantech companies. As California continues to transform into a greener economy, the State will need to provide a pathway for clean technology manufactured in the state to be showcased in other nations. If California is going to be a leader in developing the technologies of tomorrow, it will be important that these technologies gain traction throughout the world. There is ample opportunity for California to create this market since economies large and small are looking for cleaner practices to cut their carbon emissions. A key aspect to developing these international linkages and partnerships is to ensure that California has an active presence in these nations. It is the State's duty to foster linkages between Cleantech businesses in California and businesses throughout the world. These linkages will not only encourage other nations to use California's home grown technologies, but provide a venue to learn about how best practices give businesses incentive to keep innovating. Existing California trade offices in other countries should showcase the State's accomplishments and offer information on California's clean technologies and corresponding business opportunities.
- 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 sector 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 ETAAC finance sector subgroup issued two central recommendations and a set of additional policies designed to support activities in all of the subsequent ETAAC subgroup reports: transportation; industry/commercial/residential; electricity/natural gas; agriculture; forestry; and water. An ETAAC analysis of the Market Advisory Committee's report in chapter 9 examines how market structures will also impact early actions, innovations and price signals in each of these economic sectors of California.

# II. Central Recommendations: Carbon Trust & Cleantech Commercialization

## A. Create a California Carbon Trust

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

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

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

***1) Achieve Additional GHG Reductions and Address Carbon Market Failures***

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

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

The Trust's standard project selection process would be based on the relative cost-effectiveness of emissions reductions, similar to the State's successful Carl Moyer program. The Trust could issue requests for proposals periodically (quarterly or annually, for example), and applicants could include municipalities, hospitals, schools, community organizations, nonprofits, or any

other project sponsor outside of the cap. An application to the Trust for funding would detail the project's plans, including the quantity of emissions to be reduced and a proposed price at which the project will sell the emission reductions to the Trust. A "Dutch auction" or descending price auction could be used to find the lowest cost projects and determine the price at which the Trust decides to purchase carbon reductions. Because the Trust does not fund entire projects, all projects would have to be financially viable through a combination of their own balance sheet and the additional value of selling the carbon reduction credits to the Trust.

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

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

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

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

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

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

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

targets, but also achieve Environmental Justice goals such as job creation and pollution abatement.

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

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

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

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

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

By stabilizing the price of carbon (when necessary) and providing a sense of certainty over time, the Trust would be managing carbon the way that the Federal Reserve Bank manages interest rates. This active management should decrease the likelihood of the regulatory process

overreacting or reacting too slowly to volatile carbon prices. As a dynamic manager of the price of carbon with a long-range view, the Trust would perform the role of a market oriented safety valve and obviate the need for static regulations such as price floors or ceilings.

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

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

***4) Encourage Research, Development, and Demonstration***

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

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

**Funding Sources for the Carbon Trust**

Revenues for the Trust could come from the auction of allowances, from penalties or fees for non-compliance post-2012, or from another source such as the general fund or borrowing guaranteed through repayment from auction revenues. Based on historical experience, revenue

from penalty fees is expected to be minimal. California Environmental Quality Act mitigation fees are another possible revenue source to consider.[3] If the Trust is set up as a public-private partnership, private sector businesses would be another potential source of funding. If the Trust is designed to be a market maker and has the authority to purchase and sell carbon credits, an additional source of funding would be the sale of certified, tradable carbon credits. Finally, another source of funding could be the sale of carbon reduction credits into the voluntary market.

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

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

**Models for the California Carbon Trust**

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

The **Climate Trust** is a non-profit formed in 1997 in response to an Oregon law that requires new fossil fueled power plants to offset a portion of their $CO_2$ emissions. The Climate Trust provides high-quality offset projects for power plants, regulators, businesses, and individuals.

The Climate Trust is one of the largest buyers of offsets in the United States, with a portfolio of sixteen projects that are anticipated to offset 2.6 million metric tons of $CO_2$ over project lifetimes.

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

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

**B. Promote Clean Energy Innovation and Commercialization**

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

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

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

- *Responsible Parties*: California Energy Commission (CEC); California Public Utilities Commission (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, the State's individual subsidy programs are in most cases not optimally coordinated in pursuit of the principal current objective of AB 32 -- GHG emissions reduction -- causing inefficiencies and missed opportunities for improved performance. On top of that, other states are implementing programs and incentives to attract Cleantech companies as part of their economic development strategies.

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

**What is "Cleantech"?**

The Cleantech industry encompasses a broad range of products and services, including everything from from alternative energy generation to wastewater treatment to more resource-efficient industrial processes. Although some of these industries are unique, all share a common thread: they rely upon new and innovative technology to create products and services that compete favorably on price and performance while reducing our collective environmental footprint.

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

The eleven Cleantech categories measured are:

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

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

- *Establish Public Sector Tenants*. Where possible, use the State of California, county and city and/or other large scale public sector customers as "anchor tenants" for demonstration projects.
- *Support Specific Projects with the Highest Likelihood of Return*. A process should be

established whereby projects having the highest likelihood of making a major contribution to climate change mitigation, but are too speculative for the private markets, are given first priority.

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

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

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

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

**Leverage California's Centers of Innovation:** Leverage and provide coordination among the existing RD&D efforts of State and Federal labs, private research institutes and universities. Currently there is no single source of information about what the referenced centers of innovation are working on or how their research priorities are established. A coordinated effort would ensure that market and policy signals reach and influence innovation centers. Such an effort may enable policy initiatives that reflect real technological progress and may help individual innovations achieve scale more quickly. This could be accomplished by a new entity charged with coordinating low carbon research efforts, or it could be accomplished by an existing private or public entity. The CPUC recently acknowledged a similar need and opened a proceeding to consider creating a "Climate Solutions Institute" to be housed within California universities.

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

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

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

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

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

# III. Additional Organizational and Policy Recommendations

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

A five-year "Buy California" incentive program could boost in-state Cleantech manufacturing and take advantage of the lower embedded carbon content of California-manufactured products. Amending current disincentives in the California'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 manufacturing locations to where goods are sold and used. The manufacture and transportation of products manufactured in California for use within state borders is likely to generate fewer GHG emissions than those products manufactured elsewhere.
- *Ease of implementation:* Moderate.
- *Co-benefits / Mitigation Requirements*: Many benefits, no mitigation requirements:
    - Reduced GHG emissions due to California's lower carbon energy supply (relative to other states and countries with Cleantech manufacturing);
    - "Multiplier effect:" additional jobs and economic activity generated through the close proximity of suppliers, installers and other ancillary businesses;
    - To the extent that this encourages the adoption of clean energy technologies, California residents can expect improvements in air quality.
- *Responsible parties:* CPUC; State Legislature; California Business Transportation and Housing Agency.

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

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

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

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

Here are a few examples of what these other states are doing. Oregon -- which does not have a state sales tax -- approved House Bill 3201 recently to provide a 50 percent income tax credit up to $20 million (up to ten percent of the annual cost of the facility over five years if renewable energy systems and components are manufactured in state). California provides no comparable investment credit and subjects new manufacturing equipment to a sales tax that generally exceeds eight percent. As a result, a company contemplating a $40 million capital investment could face a final net projected cost of approximately $23 million in Oregon for that facility, but 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 components are manufactured in Massachusetts. 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/kWh from existing program funds for the installation of qualifying technologies that are manufactured in California by companies that maintain their principal place of business in California."

Because fuel cell systems and solar panels are large durable goods, it makes sense from an environmental standpoint for them to be manufactured domestically. These technologies offer direct carbon reductions by generating clean electricity. Locally produced clean energy

technologies offset GHG emissions associated with importing large heavy equipment from across the country or the world. Early actions to reduce the California's $CO_2$ levels should not only consider end-use applications, but lifecycle product transportation impacts on the climate and the environment.

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

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

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

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

- Coordinate with relevant public and private sector parties including the California Labor Federation, the California Manufacturers and Technology Association and TechNet.
- Identify additional barriers to in-state manufacturing and in-state business attraction and retention with strategies for removing them.
- Develop additional recommendations that may include tax incentives for up-front capital costs and State tax credits for businesses that use clean energy equipment produced in state.
- 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: the ability to share resources; strategies for obtaining land use permits; access publicly-funded training; economic trend information; energy efficiency strategies; financial services information; greater supplier access.

- Identify existing manufacturing in California that has the potential to take companies to the next level of success and offer the necessary support mechanisms.

**D. Cleantech Workforce Training Program**

At present, California lacks a program to address workforce needs across industries that are developing and deploying advanced clean technologies in California. Creating a new program in this area could address demands for the skilled workforce necessary to serve the Cleantech industry's needs.

- *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 California; lower turnover rates with skilled workforce.
    - Apprenticeship opportunities and new curriculum for academic institutions that cater to clean energy sectors.
    - Increased coordination between community-based workforce training programs, apprenticeship programs and community college programs.
    - Labor-management training partnerships in Cleantech sectors.
    - Expansion of high-quality, career oriented employment opportunities.
    - Increased tax base for California.
- *Responsible Parties:* The California 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 address global climate change are boosting 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 Solutions:* Establish a "Cleantech Workforce Training Program" that could effectively equip workers with skills in advanced energy technologies at a cost of $3,000-$6,000 per trainee annually. The Cleantech Workforce Training Program would leverage this funding through additional public and private funds. The goal would be to double its funding base. To the greatest degree possible, this program would utilize existing program infrastructure, including the California State Advanced Transportation Technology and Energy program within the community college system and building trades apprenticeship training programs.
This program would support, create and coordinate sector-by-sector training efforts tailored to the needs of new and existing Cleantech businesses. 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. It would also keep California's economy more competitive. Curriculum development in related fields could prepare students and the state's labor force to serve the growing markets in emerging energy sectors, steering them to meaningful, career oriented jobs. This highly skilled labor pool could then also attract new businesses.

The Cleantech Workforce Training Program would coordinate appropriate State agencies and departments, the private sector and non-profit entities to do the following:

- 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 the specific needs of 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 to encourage 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 principal benefit is to encourage innovation and to encourage consumers to purchase products with greater GHG emission reductions by reflecting the cost of carbon in prices that consumers pay.
- *Ease of implementation:* Relatively straightforward; requires legislative action.

- *Co-benefits / Mitigation Requirements*: None expected.
- *Responsible parties:* Changes would be enacted by the State Legislature and then implemented by current State agencies.

*Problem:* Existing incentives and labeling schemes are not doing enough to influence consumer choices and move California 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 carbon content.

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

A standard measurement of lifecycle GHG emissions for transportation fuels is instrumental to the development of the Low Carbon Fuel Standard (LCFS). The LCFS can be used to compare alternative and cleaner fuels against a gallon of petroleum-based gasoline or diesel. Fuels with significantly lower lifecycle emissions can be taxed at a lower rate. The accumulated tax revenues can be made up by a small surcharge on the high emission fuels. A proposal to do this can be found at "California Clean Fuel Incentive."[8] The surcharge is estimated to be 1/10 cent per gallon over the current tax of $0.18 per gallon. The primary advantage of this approach is to help lower the initial costs of low emission fuels and not to create a disincentive for high emission fuels. As alternative fuels are introduced over time, 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 cleaner vehicles by ranking vehicles in class according to GHG emissions per mile driven. The cleanest motor vehicles in each class would be eligible for time of purchase State incentives. The highest emitting motor vehicle in each class would pay a higher initial license fee to cover the costs of the clean car incentives. A proposal to implement this mechanism is being considered by the legislature – AB 493 (Ruskin) - "Clean Car Discount for Families".[9]

This general "feebate" approach can be applied to any product category for where there is already well defined measurement of carbon content 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 photovoltaic (PV) and solar thermal systems) is now much more cost effective for many residential and commercial property owners. Nonetheless, many disincentives to installation remain. A major remaining challenge is the lack of information on the part of many homeowners, residential and commercial developers, and construction companies. Perhaps the most critical of obstacles, however, is the high upfront cost of these technologies and the other financial hurdles that end-users must overcome.

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

The Energy Assessment District proposed for Berkeley is modeled after existing Underground Utility Districts whereby a group of homeowners in a neighborhood work in coordination with the municipality on a plan to place utility distribution poles and wires underground. All property owners in the designated area vote on the proposal. If a sufficient majority votes in favor, the City works with the local utility to contract to have the infrastructure placed underground. The entire cost of the project is paid for with a non-tax exempt municipal bond. Homeowners repay the bond as an assessment on their property tax bills over a fixed period, typically 20 years or so. The assessment is officially in "second position" as a lien on the property – behind property tax and in front of the mortgage – giving excellent security and a corresponding low interest rate. A 20-year period fits well with the expected minimum lifetime of solar PV 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 PV systems and make energy efficiency improvements to their buildings and then pay for the cost as a 20-year assessment on their property tax bills. No property owner would pay an assessment unless they chose to include their property in the program. Those who do have work done on their property would pay only for the cost of their project and fees necessary to administer the program.

This program solves many of the financial hurdles facing property owners. First, it significantly reduces the upfront cost to the property owner. Second, the total cost of the system may be less when compared to a traditional equity line or mortgage refinancing. This is because the well-secured bond should provide lower interest rates than is commercially available. (Another factor is that the City would require multiple projects to be aggregated in order to reduce construction

costs.) Third, the tax assessment is transferable between owners. If the property is sold prior to the repayment of the assessment, the next owner would take over the assessment as part of their property tax bill.

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

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

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

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

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

*Possible Solutions:* On Bill Financing (OBF) is a method whereby demand savings are purchased the same way supply is purchased: by the month in installments paid via a line item on the utility bill. OBF simplifies the financing and payback for these energy efficiency 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 program. In developing the OBF program, 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 efficiency programs. Where OBF design proposals differ from established norms and would impose unacceptable risk, appropriate means of cost recovery must also be included. San Diego Gas and Electric Company has recently implemented an OBF program and all IOUs will have an OBF program by 2009.

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

# 3. TRANSPORTATION SECTOR

## I. Introduction

Transportation accounts for over 40 percent of all anthropogenic greenhouse gas (GHG) emissions produced in California, making it the largest source of these climate change gases in the state. These substantial sources of carbon dioxide ($CO_2$) and other GHG emissions are divided among different segments of the state's transportation infrastructure (see Figure 3-1 below). California's transportation sector impacts on global climate change are clearly dominated by gasoline to fuel the state's large fleet of motor vehicles (See Figure 3-2 below.) These GHG emissions flowing from various modes of travel and goods movement are a function of: (1) motor vehicle technologies;[1] (2) carbon intensity of transportation fuels; (3) overall transportation activity levels.

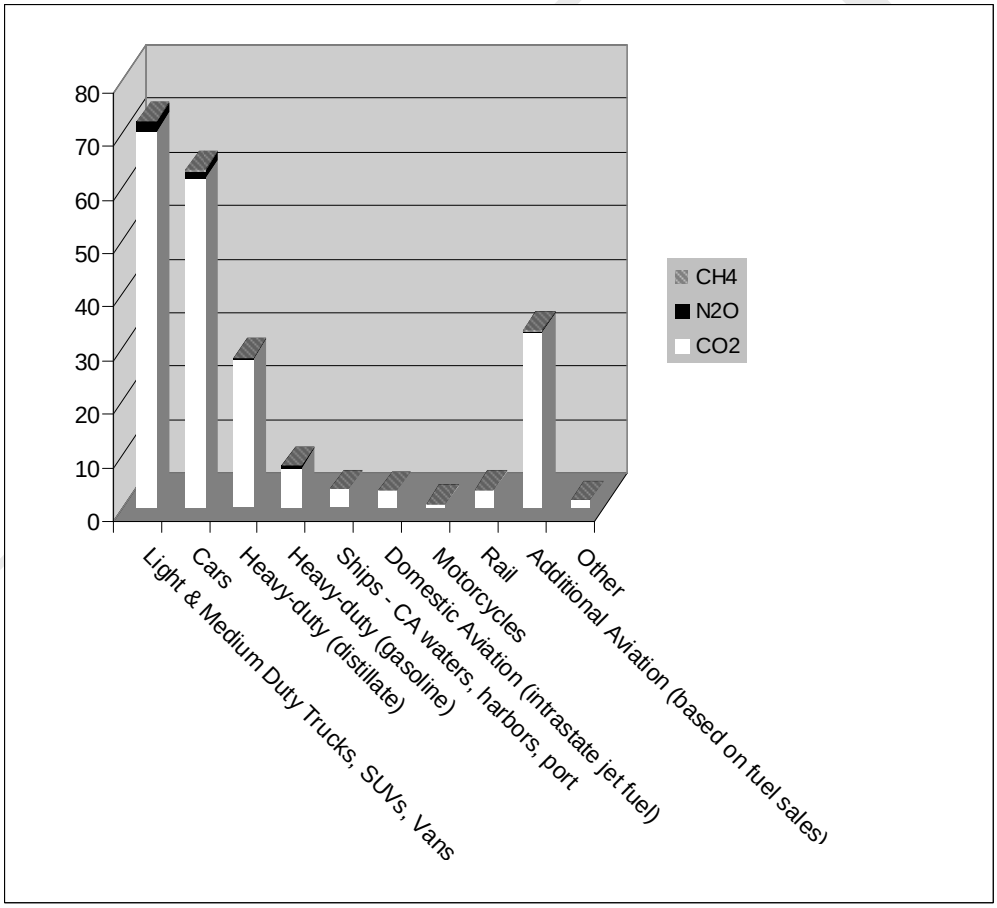



*Figure 3-1: Greenhouse Gases by Transportation Mode (CARB Inventory for 2004)*[2]

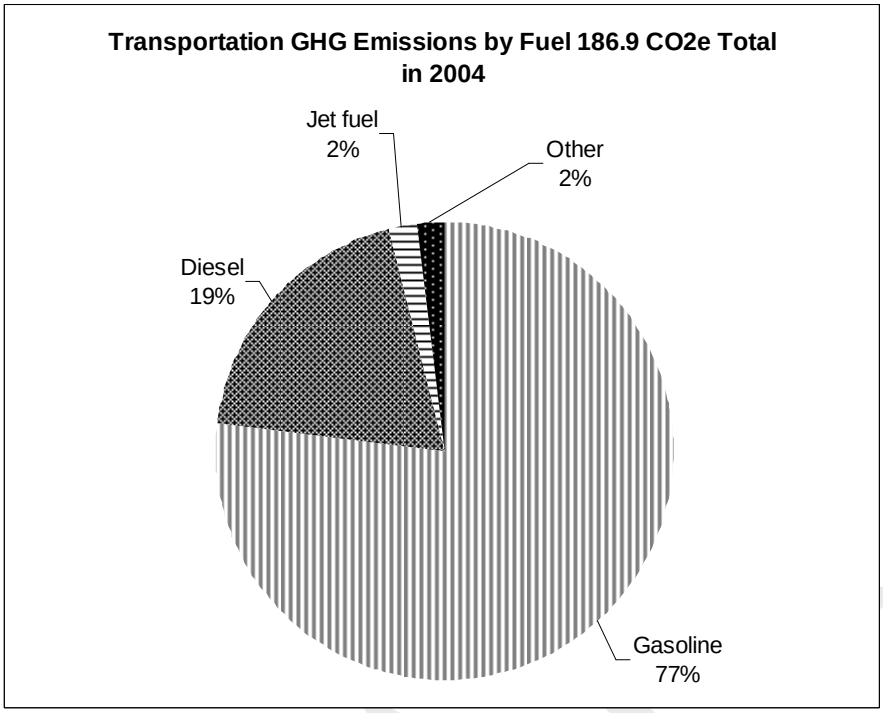



*Figure 3-2: California Greenhouse Gas Emissions by Fuel Type (CARB 2004 Inventory)*

Achieving California's AB 32 climate change goals will require addressing all three of these aspects of the transportation system. Some policies to address these three primary challenges in the transportation sector are already in place or are currently being developed. It is clear that ultimately solutions to global climate change will require setting a price on carbon as well as new and far-reaching motor vehicle and fuel technology standards. The ETAAC transportation sector subgroup recommends additional measures to achieve the following public policy goals:

- Conserving energy by lowering aggregate passenger and freight motor vehicle miles traveled (VMT);
- Substantially lowering GHG emissions released per VMT;
- Lowering the impact of fuels and technologies on California's massive transportation sector carbon footprint.

According to the California Department of Transportation (CalTrans), the number of vehicles in California is increasing at a proportionately faster rate than the state's population. There are many reasons why. Among them are rising standards of living -- which boosts vehicle ownership and global trade -- and increasing freight movement throughout California. The state's VMT figures also continue to rise, in part, due to longer commute distances. But expansions in non-work trips are playing an even larger role. Average on-road fuel economy has been declining, primarily because traditional family cars are being replaced with less efficient 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 per trip GHG emissions.

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

Forecasts regarding California's transportation fuel consumption need to accommodate a key piece of climate change legislation (AB 1493), which will reduce the GHG emissions from new automobiles by about 30 percent by 2016.[4] With this law in place, California's gasoline consumption is expected to be essentially flat through 2025, but diesel fuel consumption is expected to approximately double over this same period.[5]

There are already several policies intended to decrease transportation GHG emissions, as well as a number of factors that can potentially increase these same emissions. It is imperative for the State to develop and implement these existing policies while considering new policies needed to meet the goals of AB 32. Table 3-1 below summarizes key policies in place or under development in California.

*Table 3-1: Existing Policies Affecting Transportation GHG Emissions*

| | **Standards (Regulations)** | **Incentives** | **RD&D** |
|---|---|---|---|
| **Mobility (personal travel)** | • AB1493<br>• California Zero Emission Vehicle program<br>• California Zero Emission Bus program | • HOV lane access for hybrid vehicles (limited in numbers)<br>• Incentives for advanced vehicles<br>• Investments in travel alternatives<br>• Federal Tax Credit for hybrids<br>• Moyer Program (ozone precursor and black carbon contributions to climate change) | • State and federal R&D<br>• California Fuel Cell Partnership<br>• Advanced Battery Consortium (DOE)<br>• $H_2$ 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)<br>• Diesel Risk Reduction Program (in-use vehicles via black carbon reductions)<br>• Marine vessel speed reductions<br>• Port expansion* | • Electrification programs for ports and truck stops (and potentially increased use of CNG)<br>• State Emission Reduction Program<br>• 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

In order for California to continue to grow (and for California citizens and businesses to prosper) better options for personal and freight transportation are clearly needed. And yet, to avoid dangerous climate change, the State must reduce its transportation-related GHG emissions. Some of the policies described in this chapter may operate by limiting emissions or setting a more appropriate price on transportation options, while others create new opportunities for travel and freight shipment. All of these approaches are essential complements to the deployment of cleaner vehicles running on cleaner fuels. Thus, it is crucial that the State ensure that low-carbon travel options are expanded. Some of the new opportunities include:

- Smart Growth plans by local governments to make walking and cycling more feasible.
- Bus Rapid Transit (BRT) systems (which are operating successfully in many cities worldwide.)
- Personal Rapid Transit (PRT) systems (which could help relieve traffic congestion.)
- Smart Cards to ease the use of different transit systems.
- Low speed transit options such neighborhood electric vehicles (EV).
- Transit villages that make bus, rail and perhaps PRT modes preferable ways to travel.
- Electric passenger and freight rail systems that could also offer air quality and congestion benefits (but which require significant investments.)

The ETAAC collected and reviewed a substantial amount of information on technology transportation and other innovations. This material is included in Appendix V. Because research, development and deployment (RD&D) of new technologies in the

transportation sector 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). Table 3-2 below contains relevant AB 32 Early Action measures already being developed by CARB.[6]

*Table 3-2: Measures Contained in CARB's Draft Early Action Plan*[7]

| **Name** | **Summary** | **Estimated emission reduction (MMTCO2e)** |
|---|---|---|
| Low Carbon Fuel Standard | Require the carbon intensity of transportation fuels to decline 10 percent by 2020. | 10-20 by 2020 |
| Smartway Truck Efficiency | Require existing trucks and trailers to be retrofitted with devices that reduce aerodynamic drag. | Up to 6 by 2010 and 20 by 2020 |
| Tire inflation | Require tune-up and oil change technicians to ensure proper tire inflation as part of overall service. | 0.54) by 2010 and 0.20 by 2020 |
| Port Electrification | This early action allows docked ships to shut off their auxiliary engines by plugging into shore side electrical outlets or other technologies. | 0.5 in 2020 |
| New Passenger Vehicle GHG Standards | GHG Standards for post-2016 model year vehicles | 4 by 2020; 27 by 2030 |
| Heavy duty hybrid trucks | Lower GHG Emissions through heavy-duty hybrid trucks | 0.5 to 1.7 by 2020 |
| Air conditioning | Restrict HFC-134a sales to consumers | Options range from 0.1 to 2 by 2020 |

## II. General Policy Recommendations for the Transportation Sector

**Enhance Research Development & Demonstration**: The ETAAC transportation sector subgroup proposes a California Clean Transportation RD&D Program that substantially increases State investments in low-carbon and zero carbon technologies. These efforts should focus on RD&D to accelerate market adoption of on-road and non-road transportation and goods movement technologies. The end goal should be to achieve greater cost-reductions in technologies that reduce GHG emissions as well as improve durability, reliability, and product life. As motor vehicles are weaned off petroleum fuels, new ways of charging for the use of roadway infrastructure and operations currently underwritten by Federal, State and local gas taxes funds will need to be developed. Many methods for supporting such research exist, including direct grants, solicitations, State procurement policies, and more. AB 118 (Nunez) is a constructive new tool for guiding such RD&D activities, but additional funds may be needed, perhaps generated through auction revenue or other climate change related fees.

**Encourage Private and Public Investment:** The three key GHG emission reduction strategies identified in the Introduction of this chapter – reduce or shift demand for VMT, boost efficiency, and expand use of low carbon intensity fuels -- could be accelerated if California created financial mechanisms to encourage investment in advanced energy and manufacturing technologies. State and local bonding authority could be used to establish investment funds that are used to encourage development of clean technology companies to build new manufacturing facilities in California and add to the state's employment base. For example, The United Kingdom's (U.K.) Carbon Trust is an independent, not-for-profit company set up by the U.K. government to use public sector revenues to support low-carbon technologies using a private-sector approach.[8] As described in the Chapter 2 (the Financial sector) of this ETAAC report, California could set up something similar in the spirit of the California Institute of Regenerative Medicine.

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

**Coordinate Between Levels of Government and the Private Sector:** The transition to a low or zero carbon economy in California will require radical 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 still meets customer needs while enabling the development of many new cleaner vehicle technologies. Given the scope of the task facing California, effective collaborations will become increasingly important. Reductions in travel demand will certainly require common goals and strong ties between local, State and Federal agencies. As described below, the California Fuel Cell Partnership is just one of a number of examples of successful public/private partnerships.

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

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

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

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

Source: http://www.fuelcellpartnership.org

**Increase Consumer Education and Choice:** Consumer education on environmentally friendly technologies or habits has worked in California; both the State *Flex Your Power* campaign and Federal *Energy Star* labeling program have proved effective in shrinking energy usage. The State should emphasize the importance of public education and outreach programs for the transportation sector similar to existing efforts like "Spare the Air" to reduce or defer driving on bad air quality days. A much broader public outreach effort is needed, nevertheless, to address global climate change. As a greater range of choices of vehicles and fuels become available, it will become important to provide information to consumers so that they make educated choices to reduce GHG emissions. This information can complement market-based incentives. However, the evidence about the effectiveness of public education campaigns to achieve public polices is lacking.[9]

Thus, these programs will require monitoring, evaluation, and adjustment to make sure they are cost-effective.

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

**Realize Economic, Ecological and Environmental Justice Co-Benefits:** It is notable that each one percent reduction in transportation energy consumption (or rate of consumption growth) could add up to $440 million in annual savings. CalTrans calculates that every one percent reduction in GHG emissions from the transportation sector (through decreased VMT, improved vehicle technology or fuels) stops 1.81 million metric tons (MMT) of GHG emissions from being released into the atmosphere. This one percent reduction in energy yields a total statewide GHG emission reduction of 0.5 percent.[12] The decreased cost of purchasing fuels will also result in macro-economic benefits because of a shift of consumers' dollars from purchasing imported oil to purchasing more in-state goods and services. One study of climate change policies in California found that implementing AB 1493 would lower vehicle GHG emissions by 31 million metric tons of carbon dioxide equivalent ($MMTCO_2E$) in 2020 compared to a business-as-usual scenario. This equates to roughly 18 percent of this legislation's GHG emissions reduction goal. At the same time, the law could increase gross state product by about $50 billion (over a 2 percent increase) and the creation of about 22,000 jobs (a 0.1 percent increase) due to this macro-economic effect.[13]

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

The GHG emission reduction strategies recommended for the transportation sector are also expected, as a whole, to achieve significant public health and Environmental Justice benefits. Strategies to reduce GHG emissions in the transportation sector lower fuel consumption and generate significant air quality and other environmental benefits through reduced "upstream" emissions from oil refineries and fuel transport. Furthermore, important synergies exist between California's decades-long fight against air pollution and the current effort to respond to global climate change. Many of the

State's air quality strategies (e.g., anti-idling regulations, the Zero Emission Vehicle (ZEV) and Zero Emission Bus (ZEB) programs) offer key reductions in GHG emissions. Because many criteria air pollutants such as the black carbon in particulate matter and ozone also accelerate global climate change, air quality policies yield valuable contributions to AB 32's GHG emission reduction goals.

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

**Key Environmental Justice Issues for Transportation**

Several important environmental justice concerns are particularly relevant to transportation and deserve special attention as California proceeds to implement its climate change goals. These include:

- *Improve mobility.* Access to affordable, safe, and convenient travel is critical for economic development. Opportunities to improve access while reducing vehicle travel should be the cornerstone of transportation and land use planning.
- *Reduce existing air pollution.* Emissions from transportation vehicles (especially diesel equipment) and the facilities that fuel them (e.g., refineries and distribution networks) disproportionately impact low-income communities and people of color. The state should prioritize GHG reduction policies that yield cost-effective ancillary air pollution reductions in these communities. The development of a low-carbon transportation system, such as low-carbon fuel production, should be focused as much as practicable on delivering net air pollution reductions for impacted communities.
- *Create economic opportunity.* Policies and programs to lower GHG emissions in the state have the potential to generate green collar jobs, and these opportunities should preferentially benefit disadvantaged individuals and communities.

## III. Shifting Demand for Mobility and Goods Movement

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

**Travel Demand Approaches to GHG Emission Reductions**

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

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

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

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

Improving transit systems is another way to reduce GHG emissions in the transportation sector. Increased funding of public transit systems may be needed so that California residents have more travel options. These systems can be expensive if designed to provide reliable, affordable transit options to low-density neighborhoods.

New approaches to public transit are advancing rapidly, and deserve further study for suitability in California. Some of these feature improved technologies that can be used in current transit systems, such as electric-hybrid buses and fuel cell buses. Others are more

novel approaches that may have greater potential for GHG emission reductions, such as BRT and PRT systems. Due to limited time and resources, and because these approaches are developing rapidly, ETAAC was unable to conclusively evaluate these options. More study of these technologies and approaches are warranted. Each technology or approach is at a different stage of development and may merit a different type of evaluation. For instance, hybrid buses may be suitable for deployment today, while it may be more appropriate to develop PRT pilot projects. In conducting studies relevant to California's distinct transit needs, the ongoing research and experience from other parts of the world should be considered. For instance, several BRT systems are now in successful service in cities around the world, while the first modern PRT system is only now being installed at Heathrow airport. This suggests that BRT systems might be closer to deployment here in California than PRT systems. Nevertheless, near-term implementation should not be the only criteria to judge new clean transportation technologies. New technologies and approaches should also be evaluated on projected GHG emission reductions, costs, and associated benefits such as reduced congestion, greater transit access for all communities, and the potential for manufacturing and other employment in California.

This chapter identifies economic and technological innovations for transit systems linked to improved transportation planning and roadway pricing, but does not rank specific transportation system technologies. More information can be found in Appendix V.

**A. Planning: Smart Growth and Transit Villages**

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

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

- *Timeframe*: Implemented by 2012. Emission benefits will continue to increase through the 2020 and 2050 timeframes as new development incorporates these concepts.
- *GHG Reduction Potential*: CalTrans estimates that the average household living in a transit village could emit 2.5 to 3.7 tons less $CO_2$ annually than a traditional household.[19] These figures are based on a CARB study estimating transit village household private vehicle mileage reductions of approximately 20 to 30 percent annually.[20]

- *Ease of Implementation:* The obstacles to implementing smart growth policies will vary among regions, but ultimately will require each regional development agency to make reduction of GHG emissions a planning priority. State-level legislation requiring regional transportation agencies to address smart growth and then provide appropriate implementation incentives would enable regions to move closer to sustainability.
- *Co-benefits / Mitigation Requirements***:** Smart Growth policies play a critical role in reducing GHG emissions while improving the economy. Urban in-fill housing can be an effective tool to prevent creating more suburbs from existing farmland. Proponents point out that smart growth can reduce driving, increase walking, spur transit use, curb obesity *and* promote cleaner air.[21]
- *Responsible Parties:* Land use decisions are made at multiple levels of governance (e.g, building and urban design, local zoning and use separation, regional integration with land use patterns). It is therefore imperative that several interventions and policies are required at different institutional levels. Nonetheless, these should be consistent and complementary with Smart Growth priorities.
    - *State Government*: In June 2007, the CEC released *The Role of Land Use in Meeting California's Energy and Climate Change Goals*, a report addressing the need for land use planning to reduce the GHG emissions from the transportation sector.[22] CalTrans has also looked at ways to reduce VMT. One of its programs is the Regional Blueprint Process, which establishes 20-year goals to reduce VMT on a regional basis. The State Resources Agency should amend CEQA guidelines to recognize transportation impact measures that are not biased towards automobiles over other modes of travel. In addition, policies and requirements relating to CEQA, the California Transportation Plan, housing element updates, the California Water Plan, and storm water plans, can all affect local land use planning and development. These State agencies will be critical in providing incentives for linking ongoing State planning processes with local and regional GHG emission reduction strategies.
    - *Land Use Agencies*: Implementation of Smart Growth policies by local agencies to reduce VMT will be particularly important to meet AB 32's GHG emission reductions. California local land use agencies, such as San Diego's SANDAG, provide regional plans for more efficient land use. They can play key roles in implementing smart growth policies and then monitor the progress of these planning practices over time. They can also generate funding for smart growth incentives. Smart Growth blueprints have been completed for the Sacramento, San Francisco Bay Area and Southern California and are under development in other areas including the San Joaquin Valley.
    - *Land Use Advocacy*: Land use agencies such as the Smart Communities Network[23] provide information sharing and best practices for local government and regional planning agencies.

- *Regional Transportation Agencies*: The Metropolitan Transportation Commission (MTC) is an example of a regional transportation agency. MTC is the transportation planning, coordinating and financing agency for the nine-county San Francisco Bay Area. It is responsible for regularly updating the Regional Transportation Plan, a comprehensive blueprint for the development of mass transit, highway, airport, seaport, railroad, bicycle and pedestrian facilities. The latest Plan features Smart Growth development patterns. MTC has developed new policies, funding programs and technical studies to foster smart growth, including transit-oriented development, regional growth planning, station area plans, and parking policies.
- *Developers*: Developers are the integral part of smart growth implementation. Equipped with sustainable practices, developers can build structures that generate fewer GHG emissions due to upfront construction decisions as well as ongoing daily operations.

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

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

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

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

Incentives to provide residential housing close to employment centers, to support transit oriented development, to expand telecommuting, and to use video-conferencing in lieu of air travel, could all dramatically reduce VMT. Mixed-use development where shopping and services are within a comfortable walking distance for residents could also play a major role in cutting GHG emissions from the transportation sector.

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

**B. Pay-As-You-Drive Insurance**

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

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

more costly.[31] A 1 percent reduction in VMT typically lessens total vehicle crashes by about 1.2 percent.[32] Although it is difficult to predict actual congestion alleviation, even a small decrease in driving demand can limit congestion delays.[33]

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

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

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

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

**C. Congestion Charges**

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

- *Timeframe:* Initial project(s) in place by 2012; with additional potential projects feasible in time for 2020 targets.
- *GHG Reduction Potential***:** Exact reductions would depend on the areas covered and specific program design. Potential GHG emissions reductions of one million tons per year or more could be achieved if applied to areas responsible for 10 percent of the state's vehicle GHG gas emissions.[36] The City of San Francisco Climate Action Plan sets a goal of reducing 165,000 tons per year of $CO_2$ emissions by reducing VMT.[37] The San Francisco County Transportation Authority has identified congestion pricing as a key component of that strategy.[38]
- *Ease of Implementation:* Local planning authorities need legal authority from the State to implement congestion pricing. State support for planning and/or initial set-up of congestion mitigation pricing systems would also be beneficial.
- *Co-benefits / Mitigation Requirements***:** Reductions of pollutants such as fine particulates and ozone forming pollutants, and reductions in traffic deaths and injuries, are examples of major co-benefits. Revenues can be used for projects to accommodate increased demand for alternatives such as transit, walking, and bicycling. Public hearings and outreach can help focus these improvements to mitigate disadvantages and maximize improved transit and other transportation co-benefits to meet AB 32's Environmental Justice goals.
- *Responsible Parties:* The State Legislature would provide legal authority. Local transportation planning agencies would be responsible for evaluating potential projects, such as areas with existing effective transit systems or the potential for effective transit, with support and coordination from CalTrans and Regional Transportation Agencies as needed.

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

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

The City of San Francisco is currently seeking to move forward with a congestion charging project covering access to downtown and certain other areas of San Francisco.

San Francisco is also conducting a study to be completed by the 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 review process that includes a local public hearing. CalTrans and Regional Transportation Agencies should examine appropriate opportunities to support and coordinate potential projects within the state.

**D. Employer-based Commute Trip Reductions**

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

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

*Problem:* Just over one fifth of personal travel is for commuting to work. According to a 2000 US Census and National Household Travel Survey, just over three quarters of these US commuter trips are drive-alone trips. What that translates into is that roughly 17 percent of personal travel is drive-alone commutes that could be minimized through employer-based policies.

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

However, the cost-effectiveness of these programs is not clear. Policies that lower the per-mile GHG emissions of personal travel will tend to make policies to reduce VMT less cost-effective. (Of course trip reduction policies have other benefits such as lower levels of congestion.) Furthermore, placing a price on all GHG emissions may tend to reduce the need for trip reduction policies. Note that at present, there is *no* price attached to air pollutants. So if one is imposed on GHG emissions, the need for other policies like those discussed below will be less than the need to control air pollution. And in some cases,

eliminating commute trips may not reduce GHG emissions as much as it might first appear since the employee who does not commute may use energy in their home office and may make other trips (e.g. for lunch) that they would not have otherwise. ETAAC recommends that the CARB study the cost-effectiveness of all policies it proposes to undertake, incorporating the factors noted below in any analysis.

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

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

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

- *Telecommuting:* With its leading role in promoting information technology, California seems well suited to telecommuting, where employees work from a home-based office. (Telecommuting also includes satellite workplaces that are closer to home). This strategy can become a

compliance option for mandatory programs. Like the previous option described above, telecommuting can be promoted on a voluntary basis by employers for identical reasons. Home energy usage could potentially offset travel-based GHG emission reductions. ETAAC did not attempt to quantify these values.

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

  However, compressed work schedules are often not cost-effective for California employers because state law requires payment of overtime compensation for work performed by an hourly employee who works in excess of eight hours in a single day or more than 40 hours in a single work week. (This is more restrictive than Federal law, and all other states, where overtime pay is required after 40 hours in a week). As a result, employers have a disincentive to schedule a four-day compressed workweek schedule because the last two hours of each ten-hour workday incur time and a half wage rates. Split shifts for 24 hour operations (12 hours on, 12 hours off) are even more costly. California allows for "alternative schedules," but only 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 these "alternate schedule" rules.

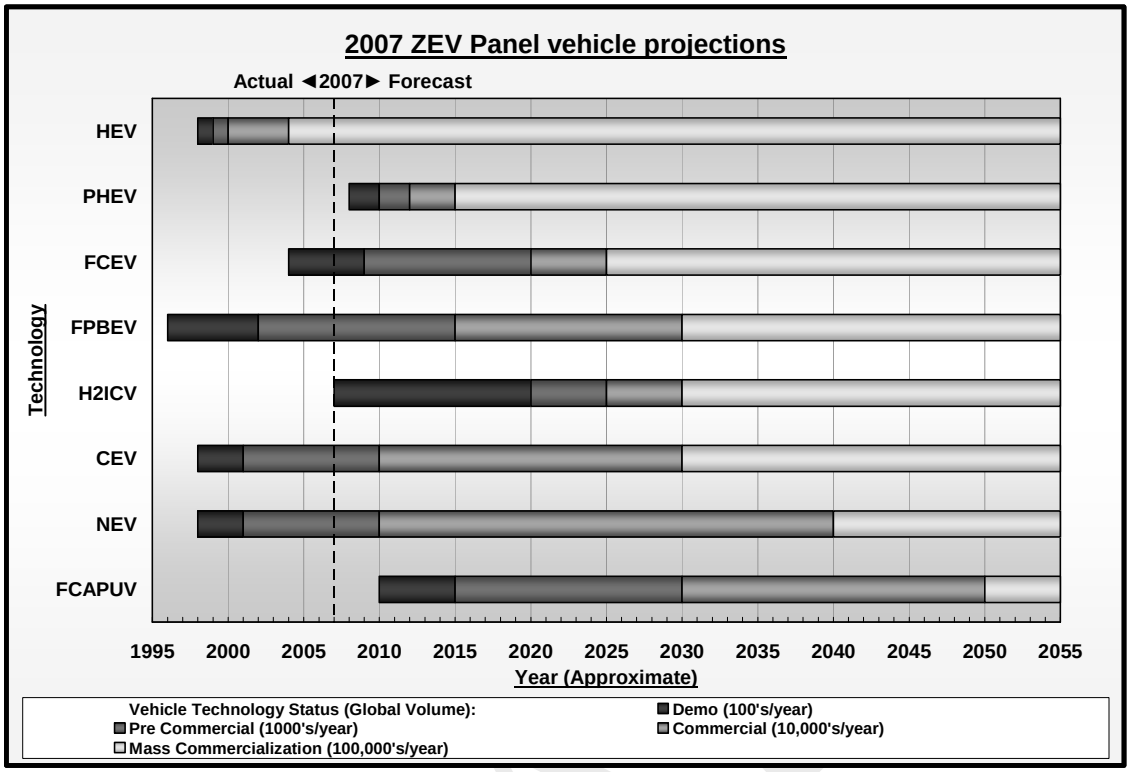
  Changes to state labor law are contentious and involve issues such as safety, flexibility, cost savings, and politics. ETAAC does not have the expertise or responsibility to consider all these factors and is therefore not able to make any specific recommendations. However, it is clear that CARB should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

## IV. Improving Vehicle GHG Emissions Performance

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

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

The section also describes complimentary pricing recommendations that will facilitate compliance with these standards. Incentives to exceed these standards will also be examined. Another key financial incentive for low and zero tailpipe emission vehicles is the "feebate" recommendation described in the Financial Sector Chapter (Chapter 2-E) of this report and below.[43]




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

## E. New Vehicle Technology Improvements

While forward thinking when written -- and vitally important for near term AB 32 compliance – AB 1493 does not capture the full potential for GHG emission reductions now technically possible from motor vehicles. For instance, the legislation covers only passenger vehicles and the cost-effectiveness analysis is based on gasoline prices ($1.74 per gallon) that no longer reflect real world conditions. A more comprehensive standard for post-2016 vehicles of all types would net even greater GHG emission reductions and can help foster partnership opportunities nationally and internationally.

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

- *Co-benefits / Mitigation Requirements***:** Very high co-benefits, including reductions in up-stream refinery emissions and reduced reliance on imported petroleum. A supporting in-state clean fuels infrastructure of would maximize these co-benefits.
- *Responsible Parties:* CARB; auto manufacturers.

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

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

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

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

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

Assuming that the new standards call for about a 50 percent reduction from pre-AB1493 levels beginning in beginning in 2017, this measure would achieve about a 4 MMT

reduction in 2020. The reduction achieved by this measure would significantly increase in subsequent years as clean new vehicles replace older vehicles in the statewide fleet. CARB staff estimates a reduction potential of 27 percent[48] -- 27 MMT[49] -- in 2030.

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

**Potential Heavy Duty Vehicle Near Term and Future Technologies**

- *Vehicle Technologies*

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

- *Engine Technologies*

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

- *Drive train Technologies*

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

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

## F. Low Carbon Fleet Standards and Procurement Policies

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

- *Timeframe*: By 2012, expanding to heavy-duty vehicles by 2020.
- *GHG Reduction Potential***:** This recommendation can complement the implementation of AB 1493 standards and post-2016 standards; as well as the ZEV program.
- *Ease of Implementation:* Potential barriers are the need to increase "market pull" for the continued development and implementation of low and zero emission vehicles, helping to 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; Federal, State, local and other fleet owners and managers.

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

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

A performance standard for fleet vehicle procurement would be similar to that of AB 1493, denominated in GHG emissions per mile. However, buyers of new vehicles instead of sellers would be responsible – and would also receive the benefits of more efficient vehicles. Such a standard may be subject to less procedural or jurisdictional challenges than the AB 1493 rule impacting vehicle manufacturers. This policy should be applied to State fleets immediately, and eventually all other public and private fleets that receive any funding through State tax or fee revenue and/or utility ratepayer revenue. In addition, the Energy Policy Act (EPACT ) now allows State and local agencies to achieve petroleum reduction goals relying on hybrids and other high-efficiency vehicles instead of purchasing lower-efficiency vehicles that could in theory burn ethanol blends such as E85 (but instead use higher levels of gasoline.) For instance, the State of California has recently completed a purchasing arrangement that will assist State and many local agencies to purchase gas-electric hybrids that achieve a minimum of 42 miles per gallon, instead of the State minimum standards of 26 miles per gallons for other vehicle of similar type.

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

As a second step, Federal, State, regional and local government agencies -- as well as utility and other private fleets – should participate in advanced technology vehicle demonstrations. This effort should start immediately. Targets should be set with the ultimate goal of reaching a 100 percent ZEV target by 2035 or sooner. Vehicle fleets would then be fully transitioned to zero carbon technologies before AB 32's 2050 deadline for cutting total GHG emissions by 80 percent. 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, among them the development of advanced vehicle technology and infrastructure and enhanced air quality.

## G. Vehicle Feebates, Registration Fees and Indexed Fuel Taxes

Fiscal incentives to promote more fuel efficient vehicles can complement carbon standards without restricting customer access to a full range of vehicle choices. Options include a revenue-neutral vehicle "feebate" program (see Chapter 2-E). Additional potential approaches include the idea of basing vehicle registration fees on GHG emissions. Yet another would be to base fuel tax levels on GHG emissions and indexed to match inflation and keep pace with VMT increases.

- *Timeframe*: By 2012.
- *GHG Reduction Potential***:** Indexed fuel taxes will affect about one-third of California's emissions (from gasoline and diesel fuel) and could have a significant impact. It is not possible to estimate the available GHG emission reduction potential at this time. The other measures are also expected to offer a substantial benefit by improving the GHG emission rates of California's entire vehicle fleet.
- *Ease of Implementation:* Potentially difficult.
- *Co-Benefits / Mitigation Requirements***:** Increased gas taxes could be used in part to increase transit opportunities for low-income and other communities; changes to registration fees could be phased-in to give consumers time to adapt.
- *Responsible Parties:* State Legislature; State implementing agencies.

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

*Potential Solutions:* Many countries create a market pull for more efficient and therefore cleaner vehicles through higher fuel taxes and registration fees levied on GHG emissions directly or on surrogate factors (vehicle weight, engine displacement). Upfront costs can be especially effective, such as vehicle purchase taxes that are reduced for low carbon vehicles and increased for high carbon vehicles. The U.K. indexes vehicle registration fees according to tailpipe GHG emissions, while Germany and Japan bases its fees on other factors that relate to GHG emissions, such as engine displacement and vehicle weight. Vehicle registration policies affect both existing vehicles as well as new vehicle purchases. A phase-in period for existing vehicles could be considered by State policy makers to facilitate a smooth transition to this new pioneering system. This approach would send the right price signal to consumers.

California's LAO[51] has observed that just to maintain current infrastructure, gas taxes should be increased by ten cents per mile. Boosting the revenue collected from fuel taxes can also provide fiscal resources for new public transit systems. These systems could be designed to serve regions where consumers may be most affected by increased fuel costs, regions where Environmental Justice has been an issue. Taxes on gasoline in Japan are approximately triple that of California's combined $0.63 per gallon for Federal and State excise taxes. Some Europe countries impose taxes as six times that level. A modest tax increase in California's fuel tax would provide critical maintenance of road infrastructure and transit while still falling well below fuel taxes imposed in most other developed countries.[52] Indexing fuel taxes to inflation and VMT (as fuel consumption per mile is likely to fall without reducing the need for infrastructure) is crucial to avoid future funding shortfalls. The State should also encourage similar policies at the Federal level.

## H. Air Quality Incentives Programs and Standards

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

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

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

*Possible Solutions*: The Carl Moyer Memorial Air Quality Standards Attainment Program provides incentive funds (currently $140 million per year) toward the incremental cost of new engines and equipment that go beyond State minimum air quality requirements for NOx, PM, and reactive organic gas (ROG).[53] Eligible projects include cleaner on-road, off-road, marine, locomotive and stationary agricultural pump engines. Forklifts, airport ground support equipment, and auxiliary power units are also eligible for State retrofit funds. The State, in partnership with local agencies, is also implementing a new Proposition 1B Goods Movement Program, to upgrade technology and reduce air pollution emissions and health risk from freight movement along California's trade corridors.[54] This State program is funded to provide $250 million annually over four years.

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

It is important that technology-forcing standards recognize GHG emissions just as climate change response incentives and measures must consider effects on other air pollutants. Tailpipe standards should consider less prominent GHG emissions such as nitrous oxide ($N_2O$) and methane ($CH_4$). Standards such as federal Clean Air Act Best Available Control Technology should evaluate GHG emissions as an environmental impact along with other air pollutant emissions. Exceptions can be rendered. (For example, the Federal Clean Air Act Lowest Achievable Emission Rate does not allow for evaluation of cost or co-benefits/dis-benefits). ETAAC encourages continued efforts by State and local agencies to coordinate and integrate GHG emissions into existing air quality programs.

# V. Low-Carbon Transportation Fuels

After VMT are reduced and the energy efficiency of motor vehicles is upgraded, there will still be a need for large quantities of alternative, cleaner transportation fuels. The lifecycle GHG emissions of transportation fuels are being addressed through the Low-Carbon Fuel Standard (LCFS) mandate being developed by CARB. The ETAAC transportation subgroup notes that other fuel tax incentives to encourage low carbon fuels are covered in Chapter 2 (the Financial sector). Likewise, biofuels production is covered in Chapter 6 (the Agricultural sector).

## I. Create Markets for Green Fuels

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

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

*Problem*: Biofuels and other new alternative fuel products can have either a positive or negative on global climate change depending on production methods and other factors. Current corn-based ethanol production often releases GHG emissions similar to, and sometimes higher than, traditional fossil fuel transportation fuels once all of the air emissions effects are accounted for. New technologies will be needed to significantly lower the GHG emissions of biofuels as well as improve co-benefits.[55] The LCFS should be designed so that it encourages technologies that drive down GHG emissions. One approach might be to encourage California farmers to collect and use agricultural waste as a bio-fuel feedstock to complement the existing CARB regulatory requirements.[56] International, Federal and State standards for sustainable low carbon bio-fuels are

currently being developed. So far, however, they do not offer any environmental performance information to consumers. With additional tracking standards, these systems could be used to engage consumer demand through a "Green Fuels Labeling Standard" in California.

*Possible Solutions*: A voluntary or mandatory Green Fuels Labeling Standard could be created to guide consumer purchasing preferences. This is especially important for biofuels because of the potential negative environmental and social implications of different feed stocks and cropping methods. Once waste-derived biofuels 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 blended with gasoline, renewable diesel blended with petro-diesel). This information could be included on fuel content labels.

**Next Generation Transportation Fuels**

Some next generation transportation fuels may require new refueling infrastructure and market rules. For example, the expected introduction of plug-in hybrid and full performance electric vehicles will probably require some new supply infrastructure (e.g. meters and appropriate tariffs). CARB's ZEV review panel projects that such needs will occur within the expected lifetime of the electric generation, transmission and distribution systems being planned today. Forward-looking planning will be necessary to capture the potential synergies between energy sources employed for traditional electricity use and new vehicle fuels. Similarly, the introduction of fuel cell vehicles would necessitate a refueling infrastructure.

Several different State agencies have roles to play to ensure that the private sector has the appropriate incentives and regulatory framework so that the next generation of transportation fuels can help California meet its climate change goals. Specific issues that require evaluation and action include appropriate energy procurement by the electricity sector -- enabling new vehicle technologies to be used as energy storage for the electricity grid -- and addressing how increased electricity demand for charging up vehicles does not add to California's overall peak demand for electricity.

## VI. International GHG Emission Sources

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

Aviation is both intrastate and international, and presents some unique opportunities. Because fuel is a major cost for the aviation industry, it has pursued significant energy efficiency improvements in recent decades. As is the case in other areas of the broad transportation sector, efficiency is only part of the solution. Better fuels and better infrastructure will also be needed. California should publicly support RD&D investigating biofuels and other alternative fuels for use in aviation applications. Increases in Federal support for RD&D for advanced air traffic management systems would help improve the air travel infrastructure and could provide modest reductions in aviation-related GHG emissions. Potential airport expansions should only be considered if the GHG emission effects are justifiable due to other co-benefits. The State of California could consider a detailed evaluation of how to reduce the carbon footprint of air travel in the state (or alternatives), including all three of these aspects: better aircraft, better fuels, and better infrastructure.

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

## VII. Priority Actions

| Item | Relates To | Who |
|---|---|---|
| 1. Introduce standards to dramatically reduce GHG emissions from both light and heavy duty vehicles | Improved Vehicle GHG performance | CARB, auto industry, heavy duty vehicle manufacturers, Federal government |
| 2. Implement requirements for low carbon fuels | Low GHG Fuels | CARB, Federal government, oil industry, electricity industry, auto industry, biofuel industry |
| 3. Place a price on carbon through a cap or tax | Overall strategy | CARB, Federal government |
| 4. Tie infrastructure funding to Smart Growth goals | Transportation Demand Management/ Transit/ Pedestrian & Cycling Friendly | State Government, Land Use Agencies, Regional Transportation Agencies, Developers |
| 5. Incentives for Transit Villages | Transportation Demand Management / Pedestrian & Cycling Friendly | Same as above |
| 6. Coordinate Air Quality Incentive & Standards with GHG Objectives | Improved Vehicle and Stationary Source GHG performance | CARB, local air Districts |
| 7. Replace Automobile Level of Service as the benchmark for CEQA transportation evaluation | Transportation Demand Management / Transit/ Pedestrian & Cycling Friendly | State Resources Agency; state, regional, and local transportation planning agencies |
| 8. GHG Based Vehicle Feebates | Improved Vehicle GHG performance | State Legislature, CARB |
| 9. GHG Based License Fees | Improved Vehicle GHG performance | State Legislature & implementing agencies |
| 10. Indexed Fuel Taxes | Transportation Demand Management and Low GHG Fuels | State Legislature, implementing Agencies |
| 11. Congestion Charges | Transportation Demand/ Transit/ Pedestrian & Cycling Friendly | State Legislature, local transportation planning agencies, CalTrans/Regional Transportation Agencies |
| 12. Pay-as-you Drive Insurance | Transportation Demand | Insurance Companies, State Insurance Commission, Transportation Agencies |
| 13. Employer Based Commute Trip Reductions | Transportation Demand/ Transit/ Pedestrian & Cycling Friendly | CARB, employers, employees |
| 14. Improve fuel LCA GHG measurement | Low GHGs | CARB, CEC, Universities, Federal Government |
| 15. Create Green Fuels Markets | Low GHG Fuels | CARB, oil and gas industry, biofuels industry, electricity industry, possible the auto industry |

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

[2] Notes:
-Cars and light duty truck emissions are almost entirely from gasoline (less than 1 MMTCO2E came from distillate.)
-Ships in California waters include intrastate, interstate and international trip emissions out to 24 miles.
-Heavy-duty includes trucks with a loaded weight over 8500 lbs, as well as buses and motor homes.
-"Other" is assumed to be proportionate to light and medium duty for split between CO2, N2O and CH4.

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

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

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

[6] 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.

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

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

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

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

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

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

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

[14] *2005 Urban Mobility Report*, (TTI).

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

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

[17] Noland Choo, S., Mokhtarian, P. L., et al., "Does Telecommuting Reduce Vehicle-Miles Traveled? An Aggregate Time Series Analysis for the US," *Transportation* 32(1) (2005) p. 37-64;

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Noland, R. B. and Quddus, M. A., "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.

[18] 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).

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[19] 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, CA (2002) p. 43. http://www.dot.ca.gov/hq/MassTrans/doc_pdf/TOD/Statewide_TOD_Study_Final_Report_Septpercent2002.pdf.

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

[21] Levine, Jonathan, *Zoned Out: Regulation, Markets, and Choices in Transportation and Metropolitan Land-Use*, Resources for the Future.

[22] http://www.energy.ca.gov/2007publications/CEC-600-2007-008/CEC-600-2007-008-SD.PDF.

[23] http://www.smartcommunities.ncat.org/landuse/tools.shtml.

[24] Brueckner, Jan K., "Urban Sprawl: Diagnosis and Remedies," *International Regional Science Review* (2000).

[25] Ewing, Reid et.al., "Relationship Between Urban Sprawl and Physical Activity, Obesity, and Morbidity," *American Journal of Health Promotion*, September, 2003.

[26] http://opr.ca.gov/index.php?a=ceqa/index.html.

[27] San Francisco Country Transportation Authority December 12, 2007 letter to Steve Church.

[28] Greenberg, Allen. *Applying Mental Accounting Concepts in Designing Pay-Per-Mile Auto Insurance Products*, US Department of Transportation, Washington, DC (2005).

[29] Litman, Todd., *Distance-Based Vehicle Insurance Feasibility Costs and Benefits: Comprehensive Technical Report*, Victoria Transport Policy Institute, Victoria, B.C., February 19, 2007 (available at www.vtpi.org).

[30] Greenberg, Allen, *Applying Mental Accounting Concepts in Designing Pay-Per-Mile Auto Insurance Products*, US Department of Transportation, Washington, DC (2005) p. 3.

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[32] Litman, p. 75.

[33] Ibid, p. 76.

[34] Greenberg, p. 3.

[35] http://www.vtpi.org/tdm/tdm79.htm.

[36] 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.

[37] San Francisco Climate Action Plan (2004.)

[38] SFCTA website: http://www.sfcta.org/images/stories/Planning/CongestionPricingFeasibilityStudy/PDFs/sfcta_maps_2007-07.pdf.

[39] Central London Congestion Charging, Forth Annual Report, June 2006: http://www.sfcta.org/content/view/415/241/.

[40] SFTA website.

[41] City of Stockholm (2006.)

[42] The King Review of low-carbon cars (2007) p.50.

[43] 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.

[44] Report of the CARB 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.

[45] The King Review of low-carbon vehicles (2007) p.47.

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

[47] 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.

[48] CARB Presentation, *Public Hearing to Consider Adoption of Regulations to Control Greenhouse Gas Emissions from Motor Vehicles*, September 23, 2004.

[49] California Climate Action Team report (2006).

[50] 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.

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

[52] Japan has arguably the most developed system of fiscal incentives for fuel efficient vehicles worldwide, levying an annual automobile tax based upon vehicle weight, auto registration fees and a sales tax surcharge both proportional to engine size, and tax breaks for fuel efficient vehicles. Combined with the higher fuel taxes common to other countries, these incentives establish a significant premium for operating large, inefficient vehicles -- on the order of an additional $1800 per year for a mid-sized SUV (ICCT analysis).

[53] http://www.arb.ca.gov/msprog/moyer/facts/about.htm.

[54] http://www.arb.ca.gov/bonds/gmbond/gmbond.htm.

[55] Farrell, A.E. and Gopal. A.R, "Bioenergy Research Needs For Heat, Electricity, And Liquid Fuels," *Material Research Society Bulletin* 33(4): Special Issue on Energy (2008).

[56] Turner, B.T., Plevin, R.J., O'Hare, M. and Farrell, A.E.. Creating Markets for Green Bio-fuels. University of California- Berkeley: http://repositories.cdlib.org/its/tsrc/UCB-ITS-TSRC-RR-2007-1/.

# 4. INDUSTRIAL, COMMERCIAL AND RESIDENTIAL ENERGY USE

## I. Introduction

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

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

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

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

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

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

Other important State policies and emerging technologies discussed in this chapter relate to end-use energy management tools and technologies, among them energy efficiency improvements, distributed generation, customer choice of energy supply, building and appliance standards, and different waste management programs and techniques. (Chapter 5 – devoted to electricity and natural gas -- contains utility and supply-oriented opportunities. Opportunities to shrink transportation fuel use and emissions are discussed in the Chapter 3). All of these tools, technologies and policies can reduce the carbon footprint of California's industrial, commercial and residential sectors of the economy. Also outlined in this chapter are some of the promising opportunities to capture and cut carbon on the demand-side of the energy equation.

# II. Industrial Technologies and Policies

## A. "Cleantech" Tax Incentives

Tax policies such as those addressed in Assembly Bills 1506, 1527 and 1651, all authored by Assemblyman Juan Arambula in 2006, 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 legislation and the development of new programs within State government.
- *Co-benefits / Mitigation Requirements:* Assists small business and encourages technology development in California.
- *Responsible Parties:* State Legislature; Board of Equalization.

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

*Possible Solutions:* 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 (BT&H) to study how to provide incentives for small businesses to adopt cleaner technologies. AB 1527 would provide research, development and deployment (RD&D) tax credits to small businesses doing research related to clean technologies. AB 1651 would give a 10 percent income tax credit for the purchase of Cleantech equipment by small businesses.

## B. Rebates for Load Reduction

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

- *Timeframe*: In place by 2012.
- *GHG Reduction Potential*: 0.1 to 0.4 million metric tons (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 power plants.
- *Responsible Parties*: Utilities.

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

*Possible Solutions*: Expanding load reduction rebate programs to include non-generation technologies are one possible solution. Examples include solar technologies that provide refrigeration or cooling services without combustion or compression, waste heat technologies that provide refrigeration or cooling, and energy storage technologies that allow peak reduction and demand response as an alternative to running polluting peaker units. (See the Appendices for descriptions of additional load reduction technologies.)

## C. Improve Policies for Combined Heat and Power Plants

California has yet to tap the full potential of Combined Heat and Power (CHP) facilities to decrease $CO_2$ and other GHG emissions. The Waste Heat and Carbon Reductions Act, AB 1613 (Blakeslee) signed into law in 2007, offers an opportunity for California to promote new CHP under 20 megawatts (MW) in size. The legislation seeks to reduce GHG emissions and achieve other benefits by promoting the combined generation of electricity and thermal energy (i.e. process heat) where it can be accomplished more efficiently than generating electricity and thermal energy through separate processes (please see the Combined Heat and Power section of the appendices for additional technical descriptions). This ETAAC recommendation covers policies to promote those CHP projects that "qualify" (discussed below) for improved treatment under State regulation, whether it is small new CHP under AB 1613, new larger CHP facilities, or existing CHP that will contribute to lower GHG emissions and criteria air pollutants.

- *Timeframe*: In place by 2009 for 2012 goals.
- *GHG Reduction Potential*: $CO_2$ reductions of 25-45 percent are possible with well-designed CHP systems, resulting in 0.6 to 1.5 MMT annually per 1,000 MW of installed CHP capacity. ETAAC estimates that California could add between 2,000 MW and 7,300 MW to the 9,200 MW of CHP capacity currently installed in California.
- *Ease of Implementation*: Moderate.
- *Co-benefits / Mitigation Requirements*: CHP will reduce criteria pollutant emissions from fossil fuel-fired electricity generation. CHP balanced in size with nearby demand can help avoid transmission bottlenecks, decrease transmission losses and provide other operational benefits. However, CHP cannot be "dispatched" (i.e. turned on and off) to match electricity demand, so it must be integrated with dispatchable power generation. The California Public

Utilities Commission (CPUC) must manage the fair allocation of costs and benefits of increased CHP on utility customers.

- *Responsible Parties*: State Legislature; California Air Resources Board (CARB); CEC, CPUC; private industry; utilities.

*Problem*: CHP installations can provide significant energy efficiency improvements in industrial applications by generating electricity to displace retail purchases while using otherwise rejected heat for process heating or cooling. A CHP project can contribute to AB 32 goals if it is designed to consume less fuel than the most common alternative: separate fuel combustion at on-site boilers and electricity generation from natural gas-fired combined cycle units. Consumption of less fuel translates into fewer GHG emissions. While CHP is not a new technology, current State and utility policies limit full deployment of cost-effective CHP into the industrial sector and commercial sectors.

*Possible Solutions*: ETAAC recommends that the State first define what constitutes qualifying CHP, determine the total amount of CHP potential that meets the qualifying criteria, and then adopt a statewide target to install a predetermined amount of qualifying CHP by 2020. While AB 1613 directs the CEC to use certain guidelines to establish criteria for new small-scale CHP, ETAAC recommends an effort to establish qualifying criteria for CHP facilities that are not under AB 1613's jurisdiction. Whether CHP projects are qualified could depend on the technologies employed, the equipment being replaced, alternative supply emission characteristics, utility operational issues, and other relevant factors. (Emission reduction requirements, cost-effectiveness, as well as other factors are requirements to qualify for the CHP programs established under AB 1613.)

The following actions would accomplish the goal of expanding qualifying CHP:

- ETAAC recommends that the CEC address in its next Integrated Energy Policy Report update -- and the CPUC and CEC include in their next joint *Energy Action Plan* – an explicit strategy for obtaining zero and low carbon electricity generation (see Chapter 5, Electricity and Natural Gas sector). This strategic plan should evaluate an appropriate target for qualifying CHP as a low carbon option and then determine whether a standard and/or incentives should be set for utility procurement of qualifying CHP.
- Small scale CHP was previously eligible for CPUC self-generation incentives, which have now expired for fossil fuel-combustion technology. Large scale CHP is also subject to some, although not all, departing load utility charges. These factors diminish the financial incentives for installing CHP and should be re-examined (along with impacts to other ratepayers) for opportunities to facilitate the objectives of AB 1613 for small scale CHP and AB 32 for all qualifying CHP.
- To maintain maximum CHP system efficiency and economic viability, CHP systems usually need to be sized to satisfy a facility's full thermal load. This may result in the generation of more electricity than can be

consumed on site. Consequently, California needs to maintain the current power purchase program administered by the CPUC for Qualified Facilities (QFs) to maximize CHP system efficiency and economic viability. In addition, California needs new CHP-friendly transmission tariffs from the California Independent System Operator (CA ISO) and a robust wholesale market able to purchase this excess power from appropriately sized CHP facilities

- Evaluate the GHG emission reduction benefits of CHP by comparing the facility's efficiency against a "double benchmark:" the combined efficiency of the separate production of electrical and thermal energy that would have occurred had the CHP plant not been developed.
- Provide incentives for utilities to participate in the development of qualifying CHP.

**D. Distributed Renewable Energy Generation: Solar PV**

Based on an assessment of California's solar resources, rooftop solar photovoltaics (PV) have the technical potential to generate 74,000 MW at peak output.[1] While the peak solar output is not a direct match with electricity system peaks in demand, solar PV can clearly make a substantial contribution to reducing the need for the most expensive (and often most polluting) peak power requirements. This technology has significantly higher than market costs today. If the right steps are taken, its costs are projected to drop below conventional grid power by 2020 in regions of the country featuring the best solar resources. ETAAC recommends that California build on existing solar incentive policies by reducing system installation costs and ensuring that residents and businesses receive compensation for the economic value of net excess electric generation.

- *Timeframe:* In place 2012-2020 for 2020 goals.
- *GHG Reduction Potential:* Every 1,000 MW of solar PV installed yields net reductions of 1 MMT $CO_2$ per year.
- *Ease of Implementation:* Difficult to reduce system costs to parity with grid costs or below; low to moderate once costs are reduced.
- *Co-benefits / Mitigation Requirements:* Increased distributed renewable energy resources will reduce pollution for peaking power plants and help avoid transmission bottlenecks. They will also create a potential clean energy source to charge-up zero emission vehicles. Increased deployment of solar PV will also likely lead to greater innovation and world-wide usage of this distributed generation option, further reducing costs and open up new markets for clean energy.
- *Responsible Parties:* State Legislature; CPUC; utilities; California residents and building owners.

*Problem*: The recent McKinsey Report[2] states that from a national perspective, there are several barriers to developing a vibrant solar PV market. These barriers lead to wide variations in predictions about the scale of future PV solar deployment. Cost compression and climbing up the learning curve on production and installation efficiencies are keys to expanding the solar PV market. Each doubling of manufacturing capacity drops solar PV cell costs drop by about 20 percent.[3] Despite a recent silicon shortage that created temporary price spikes, great progress has been made in decreasing solar PV cell costs. The future success of solar PV will also depend on the level of cost improvements achieved in module efficiency, DC-AC conversion efficiency, inverter design, installation, and interconnection compatibility.

The Silicon Valley Leadership Group created "SolarTech" as a means to address some of these challenges.[4] SolarTech discovered that U.S building and installation expenses comprise 20 percent of solar PV system costs compared to 10 percent in Germany and Japan, where workers are paid comparable wages. The greatest difference in costs was explained by differences in the building and installation standards of each respective market. SolarTech also found that building permit and utility interconnection costs in the U.S. are also a substantially higher proportion of total solar PV system costs than they are in European and Japanese markets.

*Potential Solutions*: California currently offers substantial subsidies to reduce the high initial capital costs of solar PV systems. Time-of-use metering recognizes solar PV generation provided during peak periods of demand has a higher economic value than off-peak generation. Another incentive is federal tax credits that expire at the end of 2008. One more opportunity to promote solar PV, which is identified in the McKinsey Report,[5] is to pay distributed generators for excess electricity production.

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

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

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

- Financing Tools (see Chapter 2-F)

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

## E. Customer Choice of Electric Service Provider

For many years, Californians have demonstrated a desire to purchase electricity from providers other than the incumbent utility. However, this option, known as "direct access," was suspended in California during the energy crisis of 2000-2001. The CPUC should examine whether the expansion of direct access can assist the state in reaching its GHG emission reduction goals.

- *Timeframe:* 2008 for 2012 goals.
- *GHG Reduction Potential:* Reopening direct access purchases would provide climate change benefits if customers voluntarily arrange with energy service providers (ESP) to purchase renewable energy at higher levels than required in the renewable portfolio standard (RPS) for the incumbent utilities (or take other actions to reduce GHG emissions.)
- *Ease of Implementation:* Low to Moderate.
- *Co-benefits / Mitigation Requirements:* The CPUC must ensure that utility ratepayers are protected and that ESPs are held to appropriate standards.
- *Responsible Parties:* State Legislature; CPUC.

*Problem:* The GHG emission reduction goals of AB 32 will be easier to reach with the support of many individuals and businesses.

Individuals can take personal responsibility for reducing GHG emissions by changing to Compact Fluorescent (CFL) bulbs or purchasing a hybrid vehicle, for example. An open retail electricity market expands this option to include electricity purchasing so they can choose to increase the level of carbon free renewable sources beyond current RPS levels.

Customers not grandfathered under the pre-2001 suspension date for direct access purchases may not directly contract for higher levels of renewables than the amount that their utility is required to procure on their behalf (i.e. 20 percent by 2010.) Such direct access arrangements can also include load management, energy efficiency and other demand-side system improvements to lower GHG emissions.

*Possible Solutions*: The CPUC is now conducting a proceeding to investigate lifting the suspension and re-opening direct access. The CPUC should examine whether offering the opportunity for customers to purchase electricity through direct access purchases could support AB 32 goals.

# III. End User Energy Efficiency

## F. Building Efficiency Programs and Incentives

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

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

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

*Possible Solutions*: The following are ideas are presented by the ETAAC industrial sector subgroup 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 the collection of climate change data and develop software to aid in building designs that would work well with regional climates to minimize energy use.
- Encourage CHP systems where appropriate.
- Maintain an online directory of California green building technology and service providers so that businesses and residents have easy access to this information.
- Provide education and training for contractors in energy efficient alternatives and green building technology.

## G. Combustion Devices: Energy Efficiency

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

- *Timeframe*: In place by 2012.
- *GHG Reduction Potential*: 0.3 to 1.3 MMT (assuming a 10-30 percent improvement in efficiency; implementation for 20-30 percent of industrial/commercial total state combustion; and total emissions of 14.5 MMT $CO_2$ for industrial/commercial combustion.)
- *Ease of Implementation*: Moderate.
- *Co-benefits / Mitigation Requirements*: Improved energy efficiency reduces costs to consumers and reduces criteria pollutants as well.
- *Responsible Parties*: CARB; CEC; local air districts; product manufacturers.

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

*Possible Solutions*: The CEC should establish energy efficiency standards for new combustion devices, especially for the commercial and industrial sectors. Regional air pollution control districts, CARB and CEC should then assess links and trade-offs between energy efficiency and air emission limits. These same air districts should also 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 the current practice of emission concentrations;
- Design of new units to maximize heat recovery;
- Fuel utilization and heat transfer optimization;
- Insulation of piping.

## H. Industry-Government Partnerships To Reduce Industrial Energy Intensity

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

- *Timeframe:* In place by 2012.

- *GHG Reduction Potential:* Between 10 and 25 percent from participating facilities.
- *Ease of Implementation:* Moderate. Requires staffing and development of such a program within the California Environmental Protection Agency (Cal/EPA) or the CEC (which already has some experienced staff). Cost share resources may be available from DOE.
- *Co-benefits / Mitigation Requirements:* Expands the market in California for energy efficiency services and technology. Increases the competitiveness of California industry in global markets. Creates exportable expertise in energy management and system optimization. Energy management techniques are also applicable to commercial, institutional, and governmental facilities.
- *Responsible Parties:* Cal/EPA; CEC; member companies.

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

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

**I. Revolving Fund for Technology Demonstration Projects**

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

- *Timeframe*: In place for 2020 targets.
- *GHG Reduction Potential*: Not estimated.
- *Ease of Implementation*: Easy to moderate.
- *Co-benefits / Mitigation Requirements*: Encourages the development and commercialization of new climate friendly technologies.
- *Responsible Parties*: CEC; State Legislature.

*Problem*: Companies are reluctant to be the first to adopt technologies coming onto the market, particularly when the technologies could jeopardize tried and tested traditional manufacturing processes. The risks are simply too great when a failure could threaten the health of the company, relationships with suppliers, the confidence of consumers, etc.

Until proven under actual operating conditions, emerging technologies will not pass muster with Federal, State or local permitting agencies, will not qualify for utility rebate programs, and may not qualify for financing. But without successful demonstration projects, cutting edge technologies will never gain a foothold in any market. At present, there are limited funds to overcome these barriers. Only eight percent of the current State Public Interest Energy Research program is allocated to industrial RD&D purposes. Yet another issue is that there is often uncertainty over appropriate reimbursement rates for the State portion of cost-share funding when a company wishes to retain equipment from a successful demonstration. The extent to which prevailing wage laws apply to further private investment in technology developed with some level of public funding is yet another sticking point.

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

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

## IV. Waste reduction, Recycling and Resource Management

ETAAC recognizes the hierarchy of waste reduction, reuse, and recycling to reduce GHG emissions. (According to CARB figures for 2004, 5.62 MMTPY of $CO_2$ was emitted from landfills alone.). These waste management strategies also avoid the energy use and other environmental impacts associated with extracting, processing, and transporting raw materials. Eliminating upstream emissions by reducing, recycling and composting can result in substantial climate change mitigation benefits. If California recycled all of its aluminum cans, High Density Polyethylene plastics (used for food containers, etc), corrugated cardboard, magazines, third class mail, newspaper, *and* composted its organics (e.g. food scraps and lawn trimmings), it would achieve GHG reductions equivalent to removing more than four million cars from the road![6]

ETAAC did not receive waste reduction/reuse proposals (such as product design for reuse/recycling or producer take-back programs) at a point in the report writing process when the Committee could adequately evaluate and then comment upon them. ETAAC strongly encourages CARB and its partner State agencies to fully consider these ideas as climate change mitigation opportunities. The full scope of benefits flowing from these programs should also be tabulated. In this section, ETAAC makes a number of recommendations that will help the State boost recycling and composting of organic material, which can also offer multiple co-benefits.

ETAAC also considered proposals related to energy production from waste materials that are already landfilled or would not be covered by the hierarchy described above. CARB subsequently decided to move ahead with developing a measure for landfill emission reductions, and thus we express support for reducing landfill GHG emissions through energy recovery without evaluating specific options. Technical information on landfill-to-energy is covered in the Appendix IV. In this Appendix, anaerobic digesters and high-temperature waste conversion processes are described. Potential demonstration projects are also identified that could illustrate further information regarding the technical, regulatory, and policy barriers related to these technologies.

### J. Develop Suite of Emission Reduction Protocols for Recycling

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

- *Time Frame:* 2008-2010 for 2012 goals.
- *GHG Reduction Potential:* Not Estimated.
- *Ease of Implementation:* Moderate.
- *Co-benefits / Mitigation Requirements:* Co-benefits include energy savings and greater waste management efficiencies.

- *Responsible Parties:* CARB; CIWMB.

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

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

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

- Direct GHG emission reductions attributed to energy savings attained through the use of secondary materials in the manufacturing process.
- Life-cycle emission reductions associated with recycling.
- Emission reductions from the production and/or use of compost.
- Local government protocols that include the life-cycle impacts of all solid waste-related decisions.

## K. Increase Commercial-Sector Recycling

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

- *Time Frame:* 2008 for 2012 goals.

- *GHG Reduction Potential:* A modest 25 percent increase in recycling of commonly disposed materials would generate over five $MMTCO_2E$ in emission reductions.
- *Ease of Implementation:* Moderate.
- *Co-benefits / Mitigation Requirements:* Co-benefits include meeting waste management goals; boosting residential and commercial sector participation in State recycling programs.
- *Responsible Parties:* CARB; CIWMB.

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

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

*Possible Solutions:* Recycling in the commercial sector could be substantially increased if CARB and CIWMB required any firm that generates 4 or more cubic yards of waste per week to implement a recycling program that is appropriate for that type of business. Businesses should also be required to comply with State-determined material-specific disposal limits that would restrict the disposal of recyclable materials -- such as cardboard, paper, or construction and demolition waste -- regardless of whether it is collected by a refuse company or hauled to the landfill by the business itself. Furthermore, owners of multifamily dwellings should be required to arrange for recycling services that are appropriate for the multifamily dwelling, consistent with State or local law requirements.

## L. Remove Barriers to Composting

Compostable organics make up 30 percent of California's overall waste stream, contributing over 12 million tons annually to the state's landfills. This material

undergoes anaerobic decomposition in landfills and produces significant quantities of methane, much of which is not captured by landfill gas systems. Composting offers an environmentally superior alternative to landfilling these same organics. Composting avoids these landfill emissions, offers greater carbon sequestration in crop biomass and soil, a decrease in the need for GHG emission-releasing fertilizers and pesticides, and a decline in energy-intensive irrigation. Compost has been proven to provide effective erosion control and to drastically improve the quality of ground water aquifers, both of which could be crucial elements of mitigating the impacts of climate change.

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

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

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

- The State could work with San Joaquin Valley Air Pollution Control District and the South Coast Air Quality Management District to ensure that they consider the net impact of any forthcoming regulations on the composting industry, including biogenic emissions and GHG emission impacts. If cost-prohibitive mitigation measure for criteria pollutants will become required by a regional air pollution control district, the State should offer financial incentives to keep compost operations in business.
- The State should consider adopting a per-ton GHG emission surcharge on landfill operators. This will minimize the competitive disadvantage that composting faces. By incorporating the externality of methane production into the cost structure of the landfill industry, other waste management

options with lower GHG emission impacts will be able to compete on a level playing field.

- The State needs to boost the procurement of compost for use by Cal Trans and other State agencies; it should also encourage procurement of compost by municipalities for use in parks, schools, and general landscaping.
- The State should work to increase the use of compost within California's agricultural sector.

**M. Phase Out Diversion Credit for Greenwaste Alternative Daily Credit**

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

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

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

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

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

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

**N. Reduce Agricultural Emissions through Composting**

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

- *Time Frame:* 2008-2020 for 2012 and 2020 goals.
- *GHG Reduction Potential:* Not estimated.
- *Ease of Implementation:* Moderate.
- *Co-benefits / Mitigation Requirements:* Agricultural compost utilization offers significant water quality and erosion co-benefits.
- *Responsible Parties:* CARB; CIWMB; California Department of Food and Agriculture (CDFA).

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

*Possible Solutions:* CARB could partner with CDFA and the CIWMB to develop specifications and demonstration projects for using compost on a variety of California crops. This would send the right signals to California farmers interested in using compost on their fields. In addition, farmers could also be given a direct monetary incentive for reducing irrigation, use of fertilizers, pesticides, and herbicides. Making this transition to a more sustainable operation could be funded by several different means, including a per-ton GHG emission surcharge on landfill tipping fees. Another option would by market cap and trade auction revenue.

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

# V. Priority Actions

*Note: Not Ranked in Priority Order*

| Item | Relates To | Who |
|---|---|---|
| 1. Encourage businesses to undertake measures through "Cleantech" tax incentives | Industrial Technology | Legislature, BOE |
| 2. Expand load reduction rebate programs to include non-electric generation technologies | Renewable Energy, waste heat use, energy storage | CPUC, Utilities |
| 3. Improved Policies for Combined Heat and Power | Waste heat use | CEC, CPUC, Industry |
| 4. Solar PV and cost reduction and purchase of excess generation | Renewable energy | Legislature, CEC and CPUC |
| 5. Customer Choice of electric service provider | Renewable energy | CPUC |
| 6. Building Energy Efficiency Incentives and Programs | Energy efficiency | CEC, building industry, building owners |
| 7. Industrial & Commercial Combustion Equipment Energy Efficiency Standards | Energy efficiency | CARB, CEC, local Districts |
| 8. Government/Industry Partnerships to Reduce Industrial Energy Intensity | Energy efficiency | Cal EPA, CEC, member firms |
| 9. Revolving Fund for Technology Demonstrations | Industrial Technology Demonstration | ÇEC, Legislature |
| 10. Develop Suite of Emission Reduction Protocols for Recycling | Recycling | CARB, CIWMB |
| 11. Increase Commercial-Sector Recycling | Recycling | CARB, CIWMB |
| 12. Remove Barriers to Composting | Composting | CARB, CIWMB, Cal Trans |
| 13. Phase Out Diversion Credit for Greenwaste Alternative Daily Credit | Composting | CARB, CIWMB |
| 14. Reduce Agricultural Emissions through Composting | Composting | CARB, CIWMB, CDFA |

[1] California Energy Commission, *California Solar Resources*, Staff Draft paper in Support of the 2005 IEPR, April 2005.
[2] McKinsey & Company, *Reducing U.S. Greenhouse Gas Emissions: How Much at What Cost?*, U.S. Greenhouse Gas Abatement Mapping Initiative, December 2007, p. 62-63.
[3] Solar cell costs have dropped by 19 percent with each doubling in manufacturing capacity (Dr. Richard Swanson, SunPower founder and CTO, June 2007.)
[4] SolarTech, *Creating a Solar Center of Excellence* (White Paper), June 2007, p. 5.
[5] McKinsey Report, p. 65.
[6] Ely, Charlotte, US EPA Region 9; figures based on the WARM model.

# 5. ELECTRICITY AND NATURAL GAS SECTORS

## I. Introduction

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

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

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

- Accelerating energy efficiency upgrades;
- Expanding renewable electricity supplies;
- Removing and storing carbon from residual fossil fuel and biomass electricity generation facilities;
- Developing enabling technologies to increase low and zero carbon transportation fuels from renewable electricity generators.

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

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

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

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

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

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

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

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

Development of renewable energy systems will have a significant impact on meeting California's GHG emission reduction targets as electricity load growth is met with carbon free fuels. As noted in Chapter 2 by the financial sector subgroup, Cleantech is also a major economic development opportunity for California.

Another available avenue to secure GHG emission reductions in the electricity generation sector is to capture and store the carbon emissions of fossil and biomass fuels. ETAAC recognizes this technology -- known as Carbon Capture and Storage (CCS) -- is not just a priority for in-state generation, but has broader applications nationally and internationally since coal-fired generation is much more prevalent outside of California. In respect to AB 32, CCS technology can offset GHG emissions associated with the coal-fired electricity imported into California. Development of CSS is currently viewed as one of several critical opportunities for broader national and international efforts to reduce carbon and other GHG emissions. ETAAC stresses the importance of continuing to focus California's efforts in this arena through partnerships at the national and international level to better assess the benefits, costs, and uncertainties still surrounding this technology.

Finally, ETAAC recommends a number of policies to foster the development of enabling technologies that can create a bridge between the electric utility and transportation sectors. These policies also support sufficient renewable energy development to achieve a 33 percent Renewable Portfolio Standard (RPS) by the 2020 timeframe. Electricity storage has the potential to enable higher percentages of intermittent renewable energy to penetrate California's power supply portfolio, allowing the state to take better advantage of its abundant renewable resource endowments. The potential for a transformative effect from electricity storage is truly "game-changing," and ETAAC recommends a high priority pursuit of these technologies. Pumped hydro storage, compressed air, thermal storage or batteries can potentially transform intermittent generation such as wind and solar power into dispatchable resources offering firm electricity supply to the grid, reducing reliance on polluting gas-fired peaker plants. Moreover, electricity storage in the form of plug-in electric vehicles has the potential to reduce reliance on fossil fuels in the transportation sector. ETAAC recommends an aggressive program to develop electricity storage technologies and infrastructure by the incorporation of aggressive storage goals into utility resource plans and the development of targeted incentives to stimulate storage technology RD&D.

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

## II. Utility-Level Programs to Accelerate Energy Efficiency

In the *2007 Integrated Energy Policy Report*, the California Energy Commission (CEC) recommends establishing a statewide target designed to capture 100 percent of the economically feasible energy efficiency resources. The CEC expects the state to achieve these targets through a combination of utility and non-utility programs. These efforts will include the following: more expansive State building standards; mandated energy improvements at the time of a building's sale; new Federal and State appliance standards; local ordinances or codes limiting energy consumption; emerging technology development; programs linking energy efficiency with renewable energy technologies; and improved compliance mechanisms.

The coordination of these statewide energy efficiency programs and the development of next generation solid state lighting technologies are the two primary ETAAC recommendations included in this section to support these aforementioned goals.

### A. Energy Efficiency Program Coordination

ETAAC recommends coordinating energy efficiency programs to maximize GHG emission reductions benefits as well as other State public policy goals such as improving air quality.

- *Time Frame:* 2008-2012 and beyond.
- *GHG Reduction Potential:* Not estimated.
- *Ease of Implementation:* Moderate.
- *Co-benefits/ Mitigation Requirements:* No mitigation required
- *Responsible Parties:* California Air Resources Board (CARB); CPUC; utilities.

*Problem:* New levels of coordination between utility energy efficiency programs and air quality strategies will be needed under AB 32.

*Possible Solutions:* State air quality programs benefited from increased energy efficiency in the utility sector in the past. However, these programs did not adopt specific energy efficiency requirements. Air pollution control technologies successfully achieved reductions in unwanted by-products of combustion, often cleaning more than 90 percent of criteria air pollutants. GHG emissions are fundamentally different because they are an inherent by-product of combusting fossil fuels, and not a contaminant that can be virtually eliminated through a cleaner combustion process or destroyed by using available stack-gas clean-up technology. Because of this dilemma, increasing the scope of energy efficiency programs could be a valuable strategy for cutting GHG emissions. For instance, one early action measure planned by CARB (cement plant energy efficiency) and another under consideration for the Scoping Plan (oil refinery energy efficiency) would specify energy efficiency as a measure to comply with AB 32.

While CARB considers these measures for the AB 32 Scoping Plan to be adopted in 2008, the CPUC will be considering utility energy efficiency program plans to be in place between 2009 and 2011. These CPUC programs promote voluntary industrial, commercial, and residential energy efficiency, excluding "free riders" taking mandatory actions, such as complying with Title 24 State building standards. It is extremely important for CARB and the CPUC to each provide clear guidance on how the implementation of AB 32 could affect who is eligible for California ratepayer-funded incentives. The CPUC has set a precedent in the case of the Governor's Green Building Initiative (GBI). In this case, State Department of General Service (DGS) projects undertaken under the GBI are not considered "free-riders." This allows DGS to receive energy efficiency incentives under the current CPUC rules governing utility energy efficiency programs. It will also be important to optimize investor-owned and public utility owned energy efficiency funding to maximize criteria pollutants and GHG emission reductions along with energy savings. The State might want to consider a short term transition program to provide alternative funding assistance for energy efficiency projects providing climate change response benefits but are not currently eligible for utility ratepayer-funded incentives.

**B. Aggressive LED Energy Efficiency Programs**

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

- *Time Frame:* 2007-2012.
- *GHG Reduction Potential:* Not estimated.
- *Ease of Implementation:* Moderate.
- *Co-benefits/ Mitigation Requirements:* No mitigation required.
- *Responsible Parties:* CARB; CEC; CPUC.

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

*Possible Solutions:* The State of California should work with utilities to aggressively deploy current LED technology. Furthermore, the State should invest in near-term development and demonstration of LED lighting suitable for general illumination, identify and prioritize advancement areas that meet mass market needs, support RD&D of other solid state lighting technologies, expedite knowledge transfer to the marketplace, and encourage open source sharing of intellectual property. The CPUC is considering the establishment of a California Institute for Climate Solutions, which could conduct much of the needed RD&D in this area. The State must act now to maintain the momentum and continue to "fill the pipeline" to garner additional energy efficiency savings and GHG emissions reductions. California can both show leadership and advance the LED market by committing to use market-ready LEDs in public sector buildings and other State-owned properties.

## III. Expanding California's Successful Renewable Energy Programs

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

This section of the ETAAC electricity/natural gas sectors subgroup report contains both policy recommendations for siting and permitting of new renewable energy resources as well as a brief status report on each specific technology making major contributions to the state's supply portfolio. Appendix IV contains additional policy recommendations addressing these issues: the trading of "unbundled" renewable energy credits for in-state renewable energy; CPUC renewable resource pricing parameters; production tax credits; and other policy recommendations. It also contains more detailed information on each major renewable electricity generation technology.

### C. Take Steps Necessary to Support an Increase in Renewable Energy to 33 Percent by 2020 to Reduce GHG Emissions

California has the country's most aggressive renewable energy development goals. More can be done, however, if supporting infrastructure and complementary policies are developed. Policy makers (the Energy Action Team, the Climate Action Team, Governor Schwarzenegger, and proposed legislation) are in support of increasing California's renewable portfolio standard (RPS) to 33 percent by 2020. There are a number of barriers to achievement of this goal that must be alleviated in order to realize significant GHG emission reductions through this change in State policy. A focused, massive commitment on the part of California's policymakers is essential. ETAAC supports exploring ways to increase California's renewable energy (or carbon-free equivalent) supply to 33 percent by 2020, contingent upon the following steps necessary to achieve this goal.

- *Timeframe*: 2008-2020
- *GHG Reduction Potential*: 8.2 $MMTCO_2E$ for investor-owned utilities and 3.2 additional $MMTCO_2E$ from municipal utilities by 2020 (based on calculation cited in the Updated Macroeconomic Analysis of Climate Strategies presented in the March 2006 Climate Action Team Report for a 33 percent renewable energy scenario.)
- *Ease of Implementation*: Moderate to Difficult.

- *Co-benefits / Mitigation Requirements*: Displacing fossil fuel generation with renewable energy will reduce criteria air pollutants over business-as-usual scenarios.
- *Responsible Parties*: CEC; CPUC; CA ISO; CARB.

*Problem*: California policy makers are currently considering increasing the State's RPS goal. While the resource potential exists to achieve greater renewable penetration, California currently does not have adequate infrastructure, the storage technology, nor integration processes needed to support such an increase. California also lacks the coordinated policy direction needed to remove implementation barriers and support additional renewable energy development. The CEC's "Intermittency Analysis Project: Final Report" dated July 2007 indicates that 33 percent renewable energy is feasible, "provided appropriate infrastructure, technology, and policies are in place." The CEC study determined that a significant increase in solar generation and wind generation will be needed, with approximately half of the 33 percent renewable energy coming from wind. According to the CA ISO's "Integration of Renewable Resources" report dated November 7, 2007, wind generation presents significant operational challenges in that it is extremely variable and hard to forecast. While the CA ISO report is focused on 20 percent renewable energy, it estimates that an increase to 33 percent renewable energy "could more than double the integration problems and costs" associated with wind generation. The CA ISO report also recommends the development of new energy storage technology that facilitates the storage of off peak wind generation energy for delivery during on-peak periods.

The current RPS does not explicitly encompass emerging renewable technologies that may develop over time. In addition, analysis of other non-renewable technologies with GHG emission reductions potential would be useful in expanding RPS targets, and integrating these technologies with the RPS and other policy goals in the future.

*Possible Solutions*: ETAAC recommends that California take steps necessary to support an increase of renewable energy to 33 percent by 2020 for all Load Serving Entities (LSE) as a way to meet the State's AB 32 climate change goals. In particular, the State should institute a process to resolve and examine issues related to increasing the RPS target. The actions that must be taken are:

- Establish a multi-agency taskforce to identify all existing and expected hurdles to increased renewable energy contributions and develop a coordinated action plan to alleviate the impediments.
- Institute a process to re-evaluate whether and how RPS targets should be modified, giving due consideration to: 1) resolution of key issues such as transmission development, CA ISO queue reform, and electricity storage; 2) existing utility resource portfolios, including ratepayer protection and other issues associated with sunk costs, and the mix of resources needed to accommodate other high-priority technologies as well as intermittent renewable generation; and 3) input from CA ISO, based on periodic review of how a modified RPS will affect system integrity .

- Resolve key issues such as coordinated renewable transmission development, and CA ISO queue reform. The inability to transmit power from new renewable facilities to load centers constitutes a challenge to achieving the 2010 RPS delivery goals. Successful reform of this process is central to achievement of current and future California RPS goals.
- Increase support for electricity storage, as articulated in this chapter's section IV.F, to integrate intermittent and baseload renewable energy resources, as well as consider other technology-specific recommendations made in this section and in the Appendix IV on energy technologies.
- Develop GHG emission reduction and cost effectiveness criteria for qualifying technologies under the RPS and institute a review process by the CEC to consider emerging renewable technologies and other technologies that may have equivalent or greater GHG emission reduction potential.
- Coordinate among State agencies (CEC, CPUC and CA ISO) to ensure that adequate transmission, interconnection, and storage technologies are established for increased renewable energy contributions.
- Conduct a feasibility analysis in determining how to achieve 33 percent RPS in a cost-effective manner while maintaining system reliability. The analysis should also consider potential ratepayer impacts and other cost effective means (including those from other economic sectors) to achieve the State's carbon reduction goals. It should also evaluate the interaction of 33 percent RPS with other policies advocated in this report, such as higher penetrations of Combined Heat and Power, recognizing that there is a physical limit to the amount of non-dispatchable, off-peak energy that can be accepted by the California grid.

Some ETAAC members believe that any mandate to increase renewable energy supplies must be contingent upon the successful completion of the steps described above.

**D. 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 in the way to sufficiently develop these non-carbon energy resources.

- *Time Frame:* 2007-2012.
- *GHG Reduction Potential:* 8.2 million metric tons of carbon dioxide equivalents ($MMTCO_2E$) for investor-owned utilities and 3.2 additional $MMTCO_2E$ from municipal utilities by 2020. (These total emission reductions are based on the calculation cited in the *Updated Macroeconomic Analysis of Climate Strategies Presented in the March 2006 Climate Action Team Report* for a 33 percent RPS. If renewable penetration exceeds 33 percent in 2020, GHG emission reductions would be higher.)

- *Ease of Implementation:* The resource zone designation process has commenced, and the CEC and the Federal Bureau of Land Management (BLM) have created a coordinated siting process. The transition to this new siting process will take time, effort, coordination and communication. It represents a paradigm shift in the planning, resource development and permitting.
- *Co-benefits / Mitigation Requirements:* Renewable energy sources release zero or near-zero emissions. Displacing fossil fuel generation with renewable energy resources will reduce all criteria air pollutants over business-as-usual scenarios, especially nitrogen oxide (NOx).
- *Responsible Parties:* CPUC, CEC and California Independent System Operator (CA ISO) and other State agencies such as the California Department of Fish and Game and the Regional Water Quality Control Board. The following Federal agencies would also be likely involved: BLM, Fish and Wildlife Service, National Park Service, Army Corps of Engineers, and Department of Defense land managers.

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

In order to begin developing any renewable energy generation project, land leasing and permitting are required. Specific permitting hurdles vary by type of renewable technology (e.g., wildlife impacts), and must continue to be fully assessed in the environmental review process. Multiple levels of jurisdiction (Federal, State and local) and associated processes for renewable development are common problems[1] across all renewable energy technologies.

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

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

common environmental documents and consolidated State and Federal permits within one year. The program has a sunset date of January 1, 2012.

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

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

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

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

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

The inability to transmit electricity from renewable resources to load centers constitutes a significant barrier to achievement of RPS goals. Currently, there are 118 renewable projects in the CA ISO queue, representing 57,686 MW. The CA ISO is exploring these options to "clean up" the queue: clustered interconnection studies; increasing the reservation payment from its current level of $10,000; increasing penalties for project delay or withdrawal; prioritizing requests for interconnection based on State policy objectives; and integrating generation interconnection planning with transmission system planning. Successful reform of this process is central to achievement of current and future California RPS goals.

The California Investment Incentive Program (CIIP) provides tax abatements for qualified manufacturing facilities based on the assessed value of the improvements exceeding $150 million. The optional program for counties is an incentive to encourage certain types of industries to construct manufacturing facilities in California. Renewable

energy projects are not considered qualified manufacturing facilities under the CIIP and therefore are not eligible for this potential tax relief. Adding renewable energy facilities to the program will encourage renewable energy developers to build more power plants in California, which will not only meet the goals of AB 32, but will also create employment and the attendant tax benefits that flow from job creation.

## E. Renewable Energy Technology Assessments

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

The technology assessment below addresses central generation technologies. Appendix IV of this report contains additional information on these and other technologies, including equipment converting animal and agricultural waste to clean renewable fuels and green electricity; distributed renewable technologies, like solar water heating, solar photovoltaics (PV) and solar heating and cooling; ocean tidal energy; and fuel cells that tap waste gas as fuel.

- *Time Frame:* See recommendation C above.
- *GHG Reduction Potential:* See recommendation C above.
- *Co-benefits / Mitigation Requirements:* See recommendation C above.
- *Ease of Implementation:* See recommendation C above.
- *Responsible Parties:* U.S. Department of Energy (DOE); CEC; CPUC; private sector; local governments and others.

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

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

- **Wind Power:** The CEC has estimated that there exists a total technical potential of 99,945 MW of wind generating capacity (including both high-speed and low-speed wind) in California, for a total estimated energy generation potential of 323.94 million MWhs.[2] These numbers translate into a technical potential to offset an estimated 130 million metric tons of $CO_2$.[3] (It is important to note that these figures do not capture estimates of the potential of off-shore wind resources, which are described in Appendix IV.) A substantial portion of this carbon-free energy is available through repowering of existing vintage wind facilities with new modern multi-MW turbines. Despite the availability of better wind technology, there has been little progress in replacing aging wind facilities with new and more efficient technology in California. CARB should actively investigate and promote repowering as an AB 32 compliance strategy.

- **Solar:** California boasts one of the greatest solar resources in the world. NREL[4] estimates of technical utility-scale solar potential in California are huge – 877,204 MW capacity to produce 2,074,763 gigawatt-hours per year – many times the state's own peak electric needs. Only a very small fraction of this resource has been developed – 354 megawatts – with more projects coming on-line in coming years from utility solicitations. Some policy and technology development efforts will be helpful to ensure further development of this resource. Extension of property tax exemptions or abatements would help lower the developers' cost and their power prices. Establishment of manufacturing investment credits (MIC) would encourage manufacturing and assembly in California, as opposed to other states. Extension of the federal PTC – which was not included in the recently passed Federal energy legislation - is also important to lower costs. Most utility-scale solar technologies require substantial amounts of water for cooling. Dry-cooled system development is underway to minimize water use. Storage system development is also underway, and should be available in the fairly near term. New parabolic trough plants will likely employ molten salt storage tanks that will have the ability to retain heat efficiently to generate power off-peak, if needed, for up to 12 hours. Solar farms are one option for utilizing Brownfield areas, such as regions of the Central Valley that have been damaged by excessive salt/selenium build-up.

  California also has substantial potential for distributed solar technology – both electric and thermal systems. According to the CEC, rooftop solar PV has a technical potential of more than 74,000 megawatts.[5] At present, there are about 198.2 megawatts of grid-connected PV systems.[6] The California Solar Initiative is a $3.2 billion, 10-year program that will bring on-line new solar PV capacity of approximately 3,000 MW. Solar PV requires consistency in, and eventual augmentation of, existing policy to continue development and deployment. NREL estimates that 65 percent of residential and 75 percent of California's commercial buildings could be outfitted with solar collectors for hot water systems and for space heating and cooling systems.[7] The huge potential to offset air conditioning peak load with solar-powered cooling systems is currently largely

untapped. This technology would benefit from additional study by the CEC and State incentives.

- **Geothermal:** California has the largest developed geothermal resources in the U.S. at approximately 1,900 MW. CEC studies have shown the potential for an additional 2,900 MW[8] using conventional flash and binary technologies in known resource areas. US DOE estimates California resource potential at between 12,200 and 15,100 MW.[9] In order to better pursue this valuable base load renewable resource, California should consider undertaking a number of steps. Resource identification is a costly and time-consuming process, one that might be assisted by targeted State intervention. The US Geological Survey is undertaking a new resource assessment, updating the last assessment which was completed in 1979. The new assessment, however, will not examine new technologies and their potential in California, nor will it examine direct uses, heat pumps, or other non-conventional geothermal resources (like oil field co-production or geo-pressured resources). The CEC should support its own complementary assessment to examine California's geothermal potential in a more comprehensive and up-to-date manner. Roughly one-half of the cost of a geothermal project is estimated by the Geothermal Energy Association to be related to subsurface exploration and resource characterization. These costs also raise the greatest risk to investors, and are usually not financially feasible. Cost-shared exploration drilling by the federal DOE has been successful in the past. It should be explored by the State of California in the future.

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

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

# IV. Enabling Technologies for Zero Emission Electricity and Vehicles

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

## F. Electricity Storage as an Enabling Technology for Renewable Energy

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

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

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

California grid. The IAP concluded that integrating an RPS with a 33 percent renewable energy contribution would require expansions in transmission infrastructure and changes to operation of the grid. This CEC analysis did report, nonetheless, that there was enough flexibility in the existing system of fossil resources and pumped hydro stock to provide this balancing function. The CA ISO has acknowledged the difficulty in planning for and integrating wind resources in its recent *Integration of Renewable Resources Report*. CA ISO concluded that more storage resources are necessary to integrate the expected increased penetration of intermittent renewables into the state's electricity grid.

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 generation costs up to the point of being uneconomic. At the same time, there is currently a lack of clear policy recognition of the role of energy storage in managing intermittent wind energy. Associated policy or regulatory direction to pursue development of these technologies is still lacking. The ability of electricity grids to absorb intermittent generation is currently limited. Without reforms, these limits could be reached before the full potential of these renewable resources is exhausted (unless other resources are added to compensate for times when wind generation output does not match electricity load profiles and CA ISO balancing requirements.)

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

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

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

- **Incentives for Technology Development:** Utilities should develop procurement plans to stimulate competition among storage technology providers, analogous to the "Golden Carrot" approach in demand-side management or the RPS program for renewable generation. Under this approach, regulators and utility planners would develop performance specifications for storage technologies – including

cost, reliability and environmental impact of the solution – and would establish a durable framework for the financial support of technologies that meet these specifications. For example, utilities could hold a competitive solicitation for a specified number of MW of storage capacity meeting these performance criteria, and technology providers would compete to meet the identified need.

**Energy Storage Background: Examples of Non-Vehicle Storage Technologies**

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

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

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

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

In both of these examples, costs are currently prohibitive -- $4,500 per kilowatt -- though prices are expected to drop within the next ten years due to the economies of scale associated with mass production. Flow batteries are a special class of battery where electrolyte is stored outside the main power cell of the battery, and circulated through it by pumps, like a reversible fuel cell. Flow batteries can have relatively large capacities and are gaining popularity in grid energy storage applications.

*Thermal storage*: These technologies store heat, usually from both utility-scale and distributed active solar collectors in an insulated repository for later use in space heating, domestic or process hot water, or to generate electricity off-peak. Some new utility-scale solar plants will likely employ molten salt and "flash" water storage technologies to store energy for as much as 12 hours off-peak, when the sun is not shining.

## G. Plug-in Electric Drive Vehicles as Storage Devices

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

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

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

Increased PHEV/EV penetration represents a potential cross-sector transfer of GHG emissions. Even though the charging of PHEV/EV will typically occur during off-peak hours -- when there is excess capacity on the grid -- the increased energy consumption still contributes to GHG emission reductions (albeit at a lower rate.) As demand for electric transportation options grows, GHG emissions that would otherwise have been the responsibility of the transport sector will shift to the electricity sector. This shift of GHG emissions between sectors does not frustrate AB 32's GHG emission reduction targets. Absent mitigating measures accounting for increases in electrified transportation, a carbon cap imposed on the electric sector could disadvantage advanced vehicle fuels that cut GHG emissions.

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

**H. Smart Grid as Enabling Technology for Renewables and Clean Vehicles**

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

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

*Problem:* Today's electricity grid is essentially 1950's infrastructure out of sync with modern telecommunications technologies and emerging on-site distributed generation technologies. Inadequate sensors limit transmission over congested lines. 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 Solutions:* California should actively investigate upgrades to distribution-level grid infrastructure that will be needed to support both greater penetrations of distributed generation renewables *and* the power flows associated with plug-in PHEV/EVs. In particular, the CPUC should work with utilities to ensure investments in smart grid are implemented on the most accelerated timeframe possible. Furthermore, State government can play a key role in improving information-sharing efforts, including making sure there is less of a proprietary effort by supporting developments of open standards and guidelines for smart grid interoperability, such as those being developed by the Electric Power Research Institute's (EPRI) Intelligrid Consortium and the GridWise Alliance.

# V. Carbon Capture and Storage

## I. Carbon Capture and Sequestration in Geological Formations

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

- *Time Frame:* Demonstration projects can be in place by 2012, with potential for full commercialization by 2020.
- *GHG Reduction Potential*: California has the technical potential to store 5.2 gigatons $CO_2$ in oil and natural fields, and the capacity in deep saline formations may be one or two orders of magnitude greater.[10] The Intergovernmental Panel on Climate Change (IPCC) estimates that CCS has the potential to abate $CO_2$ emissions by between 15-55 percent of the cumulative international mitigation effort needed by 2100.
- *Ease of Implementation:* Difficult.
- *Co-benefits / Mitigation Requirements:* Demonstration of this technology may facilitate large benefits if it results in commercial application in coal-dependent areas outside of California. The energy required for CCS would require additional fuel combustion (which could be offset to the extent that $CO_2$ injection displaces steam for oil production). Some technologies to capture $CO_2$ also reduce criteria pollutants like NOx and $SO_2$. If fuel combustion increases, without better emissions control, emission decreases may be required in areas that fail to meet California clean air standards. Leakage risk must be assessed at a general level for the technology and at specific potential storage sites.
- *Responsible Parties:* Federal and State governments and agencies; private sector.

*Problem:* Geological CCS refers to the separation (or capture) of $CO_2$ from industrial and power generation sources and then the transportation to storage locations for long term isolation from the atmosphere. (Biological storage is addressed in the Chapter 6-E and Chapter 7-B.) Many component technologies for CCS have already been developed, but both the size and number of demonstration projects are very small with respect to the scale necessary to mitigate significant future $CO_2$ emissions. Commercialization of CCS technologies will require a willingness to bear the initial high cost and potential risks of first-generation systems and continued technical advances to build up the required infrastructure. The low end of cost estimates ranges tend to start at $25 per ton or more for capture and compression. Cost estimates vary because, in part, the technology has not been demonstrated. Part of that cost can potentially be recovered if $CO_2$ is used for Enhanced Oil Recovery, while transportation and injection is an additional cost.[11]

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 still significant barriers for CCS that must be resolved before CCS could play any major role in meeting AB 32's GHG emission reduction goals. Access and liability issues present another challenge. Different states have different laws regarding land rights, pore rights, and mineral rights; therefore, developers of CCS projects face varying state regulations pertaining to underground storage. More importantly, the long term responsibility and liability associated with the CCS projects must be clearly defined. Monitoring techniques and standards that need to be approved at various governmental levels, and then accepted by the insurance industry, have yet to be put in place. The issue of long-term liability for gradual or catastrophic future leakage is clearly hampering demonstration projects.

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

- Testing technologies
- Assessing capacity
- Defining costs
- Assessing leakage risks
- Gauging public acceptance
- Testing regulatory requirements
- Validating monitoring methods[12]

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

The State should also work with the Federal government to address the legal, regulatory, and safety barriers and issues associated with CCS. One important issue is the development of a legal framework to address long-term liability associated with carbon sequestration.[13] Private insurers may lack a framework for evaluating CCS projects, especially multi-generational liability. The Federal and State government could play a productive role, while carefully balancing the interests of taxpayers and the need to maximize incentives for careful carbon management decisions by the private sector.

Currently, potential pilot projects are evaluated on a case-by-case basis under general Underground Injection Control permitting requirements. The Federal Environmental Protection Agency (EPA) has delegated to the California Department of Oil and Gas

Resources (DOGR) jurisdiction over California oil and natural gas fields. (The EPA retains regulatory oversight). The Federal EPA has responsibility for deep saline formations and DOGR is also developing its own regulations for deep saline formations (and can work with EPA to request lead permitting responsibility once that process is completed). Drawing on the lessons learned from the permitting process for pilot projects to develop standards and guidelines at the State and Federal level may also help CCS project developers navigate the permitting process.[14]

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

# VI. Low Carbon Electricity Planning; Unifying Program Standards

## J. Low Carbon Electricity Generation Plan

California needs to plan now for low and zero carbon power supplies that will serve the end-use needs of residential, commercial, and industrial customers while also achieving AB 32's GHG emission reduction targets.

- *Time Frame:* By 2012.
- *GHG Reduction Potential:* If the electricity generation sector is required to make reductions based on the AB 32 GHG emission reduction goals, this plan would assist in meeting a 25 percent reduction by 2020 and 80 percent reduction by 2050.
- *Ease of Implementation:* Moderate.
- *Co-benefits / Mitigation Requirements:* No mitigation required.
- *Responsible Parties:* CEC; CPUC; CARB; utilities.

*Problem:* Investments in power generation infrastructure today will "lock-in" GHG emission rates for 2020 and potentially 2050.

*Possible Solutions:* The State currently conducts long-range energy planning that can serve as a foundation for meeting AB 32's long-range goals for low and zero carbon resources. This planning timeframe will need to extend beyond traditional approaches that are geared towards power plants with a planning/construction cycle of several years. For instance, new centralized natural gas-fired power plants release less GHG emissions and other air pollutants than existing imported coal generated electricity and older natural gas power plants, but more GHG emissions than energy efficiency and renewable resources. As noted in the Industry/Commercial/Residential Use chapter, State efforts to increase CHP also need to be considered in planning for climate change mitigation and procuring reliable, cost-effective supply options. Power plants typically have a lifespan of 30 to 40 years. Decisions made today on new power supplies need to consider AB 32's 2020 and 2050 GHG emission reduction goals.

## K. Unifying Standards for Climate-Related Programs

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

- *Time Frame:* 2012-2020.
- *GHG Reduction Potential:* Not estimated. This policy initiative is intended to enable better coordination of multiple climate-related programs, which may

increase program efficiencies and hence increase GHG emission reductions over time.

- *Ease of Implementation:* Moderate; can be undertaken either as part of existing regulatory proceedings (i.e., IOU resource planning) or as a new, discrete proceeding.
- *Co-benefits / Mitigation Requirements:* Not estimated. Closer coordination and common frames of reference across climate change programs may reveal co-benefit opportunities.
- *Responsible Parties:* Principally CPUC, with input from CEC and CARB (i.e. for the Low-Carbon Fuel Standard).

*Problem:* Energy efficiency programs have individual budgets and targets, the RPS program stimulates particular technologies up to a certain percentage of the state's total electricity supply, 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 carbon savings become a higher public policy priority, there may be value in better coordinating these programs so that they are all directed towards a common end. Clear ownership rights and credits for early action, as recommended above, will aid in establishing this coordination, but other steps are needed as well.

At the same time, ETAAC recognizes that cuts in $CO_2$ are typically not the *exclusive* goal of these State 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 zero carbon energy supply technologies can ultimately be accurately benchmarked against each other.

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

*Possible Solutions:* CARB should pursue a uniform strategy for implementation of new carbon reducing technologies after 2012, with carbon-equivalent savings that would link all existing clean energy programs and mandates. All actions within the electricity and

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

## VII. Priority Actions

*Note: Items are not ranked by priority.*

| Item | Relates To | Who |
|---|---|---|
| 1. Create a process for the early valuation of carbon. (See report introduction Chapter 1) | Carbon valuation | CARB |
| 2. Ensure that Energy Efficiency programs are coordinated with AB32 strategies to maximize GHG benefits. (See Appendix 5.A) | Energy Efficiency | CARB, CPUC, utilities |
| 3. CARB can work with the building standards setting agencies, the CEC and CPUC to encourage rapid deployment of currently available LED lighting technology, as well as encourage development and demonstration of LED lighting suitable for general illumination. (See Chapter 5.B) | Energy Efficiency/ LED | CARB, CPUC, CEC |
| ~~4.~~ Allow for the use of unbundled Renewable Energy Credits (RECs) generated within California for Renewable Portfolio Standard (RPS) compliance. (See Chapter 5 section III and Appendix IV) | Renewable Energy | CPUC and CEC |
| 5. Revisit pricing structure of renewable portfolio standard and either modify or eliminate to simplify the structure. (See Chapter 5 III and Appendix IV) | Renewable Energy | Legislature, CPUC and CEC |
| 6. Authorize and implement development policy and plans for Competitive Renewable Energy Zones. (See Chapter 5.C) | Renewable Energy Development Zones | Legislature CPUC CEC, Ca./federal land use agencies |
| 7. The State of California should recognize the value of energy storage in advance vehicles and/or non-vehicle storage as an enabling technology for intermittent renewable sources. Storage in vehicles to provide zero low GHG vehicle energy and shift-off peak energy to on-peak may also facilitate both greater renewable energy. A "golden carrot" program or other technology push programs may be a good approach. (See Chapter 5.F & G) | Storage | CPUC |
| 8. Create legal framework for long term liability associated with carbon sequestration, including issues relating to legal rights, as well as regulatory framework for monitoring storage and ensuring compliance. (See Chapter 5.I) | Carbon Capture and Sequestration | Federal Government, California Legislature, energy and environmental agencies |

| | | |
|---|---|---|
| 9. Create financial incentives to spur CCS technology and implementation. (See Chapter 5.I) | Carbon Capture and Sequestration | Legislature |
| 10. 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 Chapter 5.D) | Renewable Energy | Legislature |
| 11. Consider the role of low-carbon power in the next version of the Energy Action Plan (see Chapter 5.M) | Other Technologies | CPUC, CEC |

| *Additional Recommendations Addressed in Other Chapters* | | |
|---|---|---|
| 12. Regulatory reform to encourage capture of methane from anaerobic digesters. (See Agricultural Chapter) | Biomass to energy | Water Quality Control Board |
| 13. Create incentives for unsupported distributed generation that reduces gas, like economic solar hot water and advanced solar thermal (solar heating and cooling). (See Industry, Commercial & Residential End-Use Chapter and Energy Appendix section G) | Solar water and space heating and cooling | CPUC CEC, Legislature |

[1] For example, resource exploration and identification of geothermal resources require land rights must 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.
[2] Yen-Nakafuji, Dora, *California Wind Resources*, Draft Staff Paper, California Energy Commission, April 22, 2005.
[3] Assuming an average emissions factor of 805 lbs. CO2e/MWh.
[4] U.S. Department of Energy, *Report to Congress on Assessment of Potential Impact of Concentrating Solar Power for Electric Power Generation*, February 2007.
[5] California Energy Commission, *California Solar Resources*, Staff Draft paper in Support of the 2005 IEPR, April 2005.
[6] 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.
[7] Denholm, P., *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.
[8] Sisson-Lebrilla, E., Tiangco, V., *California Geothermal Resources*, California Energy Commission, April 2005.
[9] U.S. Department of Energy, Energy Efficiency and Renewable Energy, *Geopowering the West – California State Profile*, http://www1.eere.energy.gov/geothermal/gpw/profile_california.html, January 17, 2007.
[10] California Energy Commission, Quarterly Report, West Coast Regional Carbon Sequestration Partnership, May 2005, p. 8.
[11] California Energy Commission, Quarterly Report, West Coast Regional Carbon Sequestration Partnership May 2005, page 15; *Reducing US Greenhouse Gas Emissions: How Much as What Cost ?* December 2007 page 59; *Carbon Dioxide Capture and Geologic Storage*, 2007, p. 33.
[12] Myer, Larry, *WESTCARB Regional Partnership Phase II: Providing Underpinnings for Deployment* California Energy Commission, May 11, 2006.
[13] The state of Texas, where $CO_2$ is used routinely for increased oil and natural gas production, has passed a law accepting liability for a potential "Future Gen" project with CCS that Texas is hoping will be located in Texas.
[14] Personal communication from George Robin, US EPA Pacific Southwest Region, Water Division, Underground Injection Control, to Ed Pike December 5 2007.

# 6. AGRICULTURAL SECTOR

## I. Introduction

Agriculture in California generates $31.7 billion in farm receipts. The state's agricultural sector utilizes nearly 10 million acres of irrigated cropland and 41 million acres of public and private rangeland to support significant animal production.[1] Agriculture also requires inputs that generate greenhouse gas (GHG) emissions and other pollutants. Among these inputs are energy sources such as diesel fuel, natural gas and electricity, which are used to power field equipment or processing systems. It is estimated that in 2004, all California agricultural sources accounted for about 30 million metric tons of carbon dioxide equivalents ($MMTCO_2E$).[2] It is estimated that raising these agricultural crops also absorb over 120 $MMTCO_2E$ annually via plant respiration and photosynthesis.[3]

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. Thus, the agricultural sector also offers the opportunity to reduce GHG emission reductions through the capture of carbon and/or production of renewable low-carbon fuels. Other specific farm-related GHG emission sources can also be controlled and mitigated. Technologies that can deliver these benefits already exist in many cases. Yet a concerted research, development and demonstration (RD&D) effort and new regulatory incentives and programs will be needed to meet the GHG emission reduction goals included in AB 32.

In this chapter, seven areas have been identified that offer the most promise for climate change mitigation in agricultural settings. A summary of these areas is given in Table 6-1, which includes current estimates of the gross and technical $CO_2$ reduction potentials for each identified technology. The ETACC agricultural sector subgroup projects that there is the technical potential to derive about 17 $MMTCO_2E$ of climate change mitigation 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 6-1: 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 Biofuels Crops | 1,000,000 | 500,000 | acres | 1.92 | *1.9* | *1.0* |
| Soil Carbon Sequestration | 10,000,000 | 5,000,000 | acres | 0.61 | *6.1* | *3.1* |
| Farmscapes Sequestration | 500,000 | 500,000 | acres | 5.80 | *2.9* | *2.9* |
| Fertilizer Use Efficiency | 10,000,000 | 5,000,000 | acres | 0.36 | *3.6* | *1.8* |
| ***Total*** | | | | | ***33.0*** | ***16.7*** |

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

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

The Agricultural Global Warming Solutions Program described below will net genuine GHG emissions reductions and carbon capture from the land based agricultural sector through technologies for energy production from manure and biomass, improved enteric fermentation, cropping systems for biofuels, sequestration of carbon in soil and farmscapes, and improved efficiency of fertilizer.

# 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 megawatts (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 $MMTCO_2E$; 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; operating these systems requires investment and expertise on the part of the dairy operation, thus the technical potential of 6 $MMTCO_2E$ 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***:** Digesters are effective at reducing volatile organic compounds (VOCs) 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 nitrogen oxide (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 ($H_2S$), which must be removed from the biogas before combustion in the engine if a NOx control device is used. If the $H_2S$ 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, California Air Resources Board (CARB) and local air quality management districts. For energy policy, pricing and funding, the California Energy Commission (CEC), California Public Utilities Commission (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 California Environmental Protection Agency (Cal/EPA) and member boards, offices and departments and the California Department of Food and Agriculture (CDFA).

*Problem:* Less than 1 percent of dairy manure is currently processed in digesters in California. In the current marketplace, it has been difficult for projects to realize a positive return on investment because they realize only a portion of the retail value for displaced electricity and receive little or no compensation for excess power delivered to the grid. On the regulatory front, projects can see uncertain and potentially cost prohibitive requirements for permitting new digesters and engines. Air and water requirements by the local air and water boards make digesters significantly more expensive to build and entail a lengthy approval process.

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

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

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

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

> **Water Quality:** A salt loading and compliance process for anaerobic digestion needs to be developed to address the salinity concerns of the Central Valley Regional Water Board (CVRWB). This will require research on the salt and nutrient content of liquid digestate to inform the development process, especially in co-digestion proposals. CVWRB should also develop a simplified design process to help assess and develop criteria to determine the potential need for pond reconstruction and pond/digester liners that is practical and clarifies regulatory oversight and approval processes. Consider the

possibility of potential sites for "Tier 2" type ponds to be grouped by site characteristics and each group can be assessed for leakage potential.[7]

**Air quality:** Need to develop a regulatory compliance mechanism at CARB for dairies with cow numbers below district permitting thresholds to use distributed generation equipment to produce electricity from biogas. The State should determine the net air and water quality benefits of digesters in order to promote this climate friendly technology.

**Electricity:** As of 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 generated 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 an attractive rate. To promote competition, the CPUC should also implement power purchase agreements that have flexible terms such as three-, five- and ten-year agreements instead of the sole offerings currently available from investor-owned utilities. Review existing agricultural tariffs to determine whether rate structures discourage distributed generation and modify rates where appropriate. Eliminating demand charges from NEMBIO (net metered biogas) operations that have only infrequent service interruptions due to routine maintenance is also recommended as long as maintenance is conducted off-peak. Finally, the CPUC should permit the owner/generator (i.e. the farmer) of an electricity generating biogas distributed generation system to retain the environmental attributes. These attributes include carbon reduction credits and any Renewable Energy Credits (RECs) not directly related to Renewable Portfolio Standard (RPS) compliance or other specific contractual arrangements. All RECs and carbon credits should accrue to the farmer generating the electricity. The generator can then own and negotiate the sale of those attributes, which are sure to become more valuable over time.

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

The CPUC should therefore assess existing interconnection processes and costs to determine whether they are appropriate for introduction of bio-methane into the natural

gas transmission system and develop uniform standards for introducing biomethane into natural gas distribution pipelines. Utilities should be required to interconnect biogas electrical generators under the Rule 21 process with a fixed time frame and with prescribed resolutions in case of delays. If purification and injection is a preferred use of biogas, monetary incentives should be given and interconnection costs shared among natural gas utilities. Whereas the potential generation of electricity and transportation fuel from biogas exists for the majority of farms in California given the right incentives, injecting biogas into natural gas supply system may only be financially feasible for five to ten percent of state farming operations, possibly creating an uneven market opportunity among 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 (CIWMB) 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.[8]
- *Co-benefits / Mitigation Requirements***:** One key benefit may be improved feed utilization which boosts the productivity of animal feeding operations. In addition, better feed nutrient utilization could also reduce manure impacts. Need to insure that all environmental impacts are considered before recommending the use of any productivity agent improvements.

- *Responsible Parties:* University of California and California State University systems (for developing a sound applied research program); CDFA for developing a statewide animal feeds and feeding program.

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

*Possible Solutions:* Efficiency of feed is an important ongoing effort for nutrition experts in the California animal industry. With additional research funding, these experts can continue their work with additional focus on cost effective methane emissions reductions. A significant research program that focuses on California conditions and diets as specifically related to the avoidance of GHG emissions and other air quality concerns is needed to develop new approaches and establish protocols for this technology. Once protocols have been developed, California Department of Food and Agriculture,, University of California and California State 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.[9] 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 biofuels each year[10] from 8 million tons of agricultural biomass; additional technically available resources including 14 million tons of forest residues and 9 million tons of other green biomass,[11] a total potential for over 16 $MMTCO_2E$ from 3,600 M MW or about 43 million barrels of oil equivalent could be derived from all available biomass.)
- *Ease of Implementation:* This program would require significant private and public investment in new biomass processing facilities. Whereas both biochemical and thermo-chemical technologies are projected to produce cost effective transportation fuels when RD&D targets are reached, thermo-chemical technology is likely to be more appropriate for California. (See Chapter 4 regarding other feed stocks.) Both technology and regulatory hurdles exist and are discussed below.

- *Co-benefits / Mitigation Requirements***:** These facilities would provide energy and national security because they would displace some imported outside fuel and energy resources. Emissions from open burning and other impacts of biomass waste disposal would be reduced by utilizing this resource for energy production. Depending on the technology, there could be some level of environmental impact that would need to be mitigated when developing new facility sites.
- *Responsible Parties:* For permitting, SWRCB and regional water quality control boards, CARB and local air quality management districts. For energy policy, pricing and funding the CEC, CPUC and CPCFA. For implementation and funding, private anaerobic digester technology companies, dairy owners, producer groups and local governments. For overall state policy, Cal/EPA and member boards, offices and departments and CDFA.

*Problem*: Power generation from biomass is well-established technology in the state with 30 existing biomass direct combustion power plants generating 569 MW.[12] However, the cost of producing wholesale electricity from biomass using these older facilities may not be cost effective because of low efficiencies. Advanced thermochemical technologies are being developed, some that possibly combine the production of electricity and renewable liquid fuels. However, a significant amount of investment is still needed to prove these technologies on a commercial scale. The ability of these facilities to sell power is not certain, however, as the utilities have not always been willing to buy power from third-party renewable generators. Ownership of the RECs is also subject to differing interpretations, particularly when it comes to the GHG emission reduction values that go 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 CIWMB under regulations that are designed for solid waste facilities, CARB and local air districts. Few plans for biomass conversion plants have been approved in recent years. It is estimated to take up to five years to permit and build a thermochemical conversion plant in California with the current uncertain regulatory process.

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

Both biochemical and thermo-chemical conversion technologies are being actively developed for conversion of biomass by many public and private actors. Biochemical conversion relies on specialized mixtures of enzymes or acids to break down a cellulosic material to derive desirable sugars that ferment into ethanol.[13] 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.[14]

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.[15] This spurred the industry on to manage rice straw though intensive non-burning alternatives that cost the California rice industry approximately $16-$18 million each year.[16] Other commodity providers in the San Joaquin Valley are facing the same regulatory pressure to reduce or eliminate open field burning. These regions are ideal for investment in a conversion facility capable of using rice straw or other locally-produced biomass. Such investment could contribute significantly to AB 32 objectives and address the economic burden experienced by rice growers and other farmers complying with burning phase-down legislation.

**D. Dedicated Biofuels 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 (LCFS) establishes a statewide goal of reducing the carbon intensity of California's transportation fuels by at least 10 percent by 2020. Biofuel crops grown and processed in California could help meet this new standard. As noted in the Transportation Chapter, it is important to steer biofuels development towards lowering the GHG emissions of biofuels on a life-cycle basis.

- *Timeframe:* 2012 (25 percent implementation) to 2020 (100 percent implementation).
- *GHG Reduction Potential***:** 1 MMTCO2E per year (assuming up to 500,000 acres could be available in the near term for starch, sugar and oil crops for producing biofuels;[17] this would result in an estimated 180 million gallons of ethanol or 2.6 million barrels of oil in biofuels 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 biofuel crop production in California to supply these facilities will require extensive crop production research and long-term market commitment by the facilities and the community. Much research on issues associated with renewable fuel production is new and ongoing and dispersed throughout the world. Funded by Federal, State and private monies, access to this research is of paramount importance for the agricultural and regulatory communities to make sound decisions regarding best-approaches for moving forward.

- *Co-benefits / Mitigation Requirements:* Using fall and winter cover crops could help reduce the potential for dust emissions in some cropping systems. There is also potential for growing biofuel crops with saline water or on salt-effected land that is moving out of conventional production in the San Joaquin or Imperial Valley.[18] For example, several winter cover crops being considered as biodiesel feed stocks can extract selenium and salt from the soil. New biofuels facilities would require permitting and mitigation of any local impacts.
- *Responsible Parties:* Cal/EPA and member boards, offices and departments; CDFA and the agricultural community should work with the private and public research community to coordinate and prioritize California biofuel crop production research needs. To avoid duplication, the U.S. Department of Agriculture (USDA) should serve as clearinghouse for biofuel crop production research. The CEC, CARB and CDFA should coordinate on biofuel crop lifecycle assessment. Private biofuel 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 biofuels 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 biofuel 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 biofuel field crop RD&D. Unfortunately, other Federal and private grants are not being directed to California biofuel field production research.

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

*Possible Solutions:* California government can send a strong market signal that there is a long-term biofuels 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 biofuel 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 biodiesel within its own borders in a sustainable manner. Winter cover crops, which can be grown as biodiesel 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 biofuels 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 biofuel 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 biofuels researchers and decision makers have access to the latest research will facilitate the development of the U.S. biofuels industry and make the best use of public and private investment in biofuels research.

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

- Changes in water needs, availability, and water quality impacts;
- Competition for grains and oilseeds, and impacts on food and feed availability and prices;
- Lifecycle assessment and GHG emission accounting for biofuels production;
- Recommended sustainable residue removal rates to maintain soil organic matter levels for soil health;
- Assessments of co-benefits of biofuel 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.[19] It contains twice as much carbon than terrestrial vegetation and the atmosphere *combined*. Though much work has been done on Midwest crops such as soybeans and corn, little is known about the sequestration potential of California's 400 agricultural commodities. California has abundant acreage of permanent crops such as wine grapes and fruit and nut trees that could benefit from further research to determine above and below ground sequestration potential. The term "conservation tillage" designates crop production systems that maintain a minimum of 30 percent plant residue cover on soil after planting, which has significant potential to reduce GHG emissions.

California's rangelands managed open spaces and oak woodlands may also serve as an expansive carbon sink via maintenance and enhancement of herbaceous materials and soil organic matter to effectively sequester GHG emissions. Current research suggests that the implementation of certain management practices to improve overall soil organic matter has a net benefit to the sequestration of range and pasture lands. [20] Practices include improving grazing management, using improved species, sowing legumes, fertilizing, and irrigating as appropriate or feasible. Unlike intensive agriculture, rangelands are untilled and may provide greater long term soil carbon sequestration benefits. Of California's 100 million acres, 41 million are range and pasture lands which represent a major statewide repository for GHG emissions. Preliminary

research demonstrates that rangeland and working landscapes have the potential nationwide to sequester 17.5 to 90.5 MMT annually.[21]

- *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;[22] if sequestration technologies were applied to all cropland in California, reductions could add up to about 6.1 MMT $CO_2E$ per year, not including the unknown potential from rangeland and open space; half of that figure is technically feasible since these approaches may be difficult to implement or quantify.)
- *Ease of Implementation*: Conservation tillage is currently used on less than 2 percent of California's annual cropland. There will be little to no ability to make any operational changes without financial support and incentives. Financial credits for GHG emission mitigation will greatly benefit a significant portion of the farm population in California. A simple, web-based interface, such as the Nutrient and Greenhouse Gas Evaluation Tool or NUGGET (see page 6-14) should be expanded to other California commodities and made readily available to growers and all interested parties to allow the selection and quantification of site-specific management strategies that are sustainable, reduce environmental impacts and are potentially more profitable. However, ranchers and land managers would require specific direction on what herbaceous species effectively sequester carbon and how to properly manage these living systems.
- *Co-benefits / Mitigation Requirements***:** Production practices that minimize tillage are gaining interest because they can provide many co-benefits that improve soil and water quality as well as reduce fertilizer, dust, water consumption and diesel fuel usage. Conservation tillage requires less fuel use compared to conventional tillage. Enhanced rangeland sequestration may promote the development of land use strategies that conserve open space and prevent urban sprawl.
- *Responsible Parties:* CDFA and the agricultural community should work with the private and public research community to coordinate and prioritize California soil carbon sequestration research needs and coordinate with USDA/NRCS to develop incentive programs. CDFA and the agricultural community should coordinate with CEC and the SWRCB on water and energy efficiencies of soil carbon production practices. CDFA and USDA/NRCS should work with the ranching community and those interested in funding additional research to evaluate what perennial or annual grasses sequester carbon. They should also investigate what management practices enhance overall soil organic matter in order to develop voluntary management practices to aid land managers on how to implement management strategies in an effective manner.

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

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

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

*Possible Solutions:* Quantifying soil carbon sequestration is only one part of a larger accounting puzzle that needs to address soil carbon and trace gas emissions of methane ($CH_4$) and nitrous oxide ($N_2O$) holistically to be valid and effective. When specific soil carbon sequestration recommendations are made based on the new research, this information will need be used in models and ultimately in web-based documentation tools that provide growers the mechanism to obtain support and incentives to make potential operational changes through carbon credits. A monitoring network integrated with modeling will be necessary and aggregation of credits on a commodity or regional basis is the likely way that farmers can participate in the carbon market.

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

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

- The USDA should convene a working group of university and government scientists and stakeholders to establish minimum protocol standards for the measurement, monitoring and verification of agricultural GHG emission reductions and carbon sequestration.
- USDA should establish a national network of on-farm soil measurements for carbon stocks to complement existing models and experimental data in order to develop a national inventory and baselines for soil carbon markets. This should be done in conjunction with the USDA NRCS Natural Resource Inventory.
- The Secretary of Agriculture should actively support a minimum of $15 million in funding annually for five years for research on GHG emissions and carbon sequestration in agriculture through a national effort such as the Consortium for Agricultural Soils Mitigation of GHGs (CASMGS) in the 2007 Farm Bill and ensure coordination among all participating CASMGS institutions and USDA agencies nationwide.

- The GHG Reduction through Agricultural Carbon Enhancement Network (GRACENET) should be expanded beyond its current 29 sites to better represent the geographic diversity and spatial variability of GHG emissions across the U.S. GRACENET represents a coordinated national effort by the USDA Agricultural Research Service to provide information on the status of soil carbon and GHG emissions related to current agricultural practices. It also can serve as a platform to develop new management practices to reduce net GHG emission and increase soil carbon sequestration primarily through improved soil management. The focus should be comparing common management scenarios at each location. The soils, crops and condition will be location specific, but consistent methods and detailed record keeping will be used to facilitate cross-location comparison and to ensure quality control.

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

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

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

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

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

With its unique Mediterranean climate, California dominates the nation with our 1.8 million acres of tree crops valued at $6.7 billion. These key agricultural commodities should take advantage of the Forest DNDC model that was developed by the United States Forest Service, which could be adapted for use on the state's tree crops. .

## F. Riparian Restoration and Farmscape Sequestration

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

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

*Problem:* The cost of installing an acre of re-vegetation could be prohibitive if done only for carbon credit generation. Based on estimates for woody hedgerow plantings,[23] 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.[24]

*Possible Solutions:* Conduct research to quantify the carbon storage from these practices and develop protocols that give landowners the ability to generate carbon credits (see Chapter 7 for more information). This research program should include an economic and technology assessment portion that develops the most cost effective approaches and looks at monetizing the other benefits. Additional support is needed for funding and then managing implementation and ongoing monitoring systems. As with all forms of carbon sequestration, commodity or industry programs to aggregate credits may be a suitable approach for marketing these credits, which, in turn, could provide fiscal support for development and performance monitoring.

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

## G. Fertilizer Use and Water Management Efficiency

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

- *Timeframe:* 2012 (10 percent implementation); 2020 (25 percent implementation); 2050 (50 percent implementation).
- *GHG Reduction Potential***:** 1.8 $MMTCO_2E$ (assuming reducing these emissions on typical California crops in the order of 0.4 $MTCO_2E$ per acre per year by reducing fertilizer input by 25 percent;[25] 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.[26] This makes extrapolation of the little available data measured across different cropping systems and climate zones highly suspect.
- *Co-benefits / Mitigation Requirements***:** Improving fertilizer efficiency and water management appear to be promising ways to reduce $N_2O$. These approaches should be further investigated to measure impacts on crop yield, air and water quality, and returns on investment for participating farmers. By combining field information, soil measurements, event-related $N_2O$ measurements, and simulation modeling, a reliable annual GHG emission budget could be calculated under current and possible future conventional and alternative cropping system scenarios for California.

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

*Problem:* One of the key barriers to reducing fertilizer inputs is the potential impact to crop yield that would reduce farm income and diminish the emissions benefit per net amount of crop produced. Substantial research needs to be conducted on the wide variety of crops and soils in California on $N_2O$ emissions, the effect of different cultivation practices, and ways to reduce inputs without impacting yield. Research on no-till soils generally shows an increase in nitrogen -containing trace emissions upon conversion from conventional tillage practices. This increase has been attributed to an increase in soil bulk density under no-till.[27] 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 32 percent of all agricultural GHG emissions ($CH_4$ accounts for 50 percent, and $CO_2$ for 19 percent[28]) there is great remaining uncertainty surrounding the $N_2O$ emissions inventory. There is therefore a need to not only quantify the amount of $N_2O$ emissions, but also the uncertainty around estimates of agricultural $N_2O$ emissions at multiple spatial and temporal scales.

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

This type of quantification requires accurate measurements of $N_2O$ fluxes and well validated and calibrated biogeochemical simulation models that can estimate annual $N_2O$ budgets for a range of representative cropping systems. A database of event-related and background $N_2O$ emissions, crop development and controlling factors (e.g. soil temperature, soil moisture, and soil mineral nitrogen) must be constructed in a range of representative Californian cropping systems, soils, and climates. This database could then be used to calibrate and validate the biogeochemical models. Costs estimates for constructing this database and developing a biogeochemical model validated with California crops and soils would cost on the order of two to three million dollars. The models could then be used for scenario and trade-off analysis of potential agricultural practices to minimize annual $N_2O$ and other GHG emissions in California agriculture. (Please see also the composting options in Chapter 4.IV.N.)

## III. Priority Actions

| Item | Relates To | Who |
|---|---|---|
| 1. Develop a salt loading and compliance process that apply to anaerobic digestion | Manure Mgmt | SWRCB/ CVRWB |
| 2. Develop a simplified process to help assess and develop criteria to determine the potential need for pond reconstruction; develop criteria for pond/digester liners that is practical and clarifies regulatory oversight and approval process | Manure Mgmt | SWRCB, CWRWB |
| 3. Develop a regulatory compliance mechanism for dairies with herd size below air district permitting thresholds to use distributed generation | Renewable Energy | CARB, CPUC |
| 4. Amend the Self-Generation Incentive Program to continue allowing incentives for electricity produced from biogas in anaerobic digesters and allow excess electricity sales | Renewable Energy | Legislature, CEC and CPUC |
| 5. Require electric utilities to purchase excess electricity from biogas production at an attractive rate and implement competitive power purchase agreements that allow a generator to keep RECs or compensate for them | Renewable Energy | CPUC |
| 6. Review existing agricultural tariffs to determine whether rate structures discourage distributed generation and modify rates where appropriate | Renewable Energy | CPUC |
| 7. Eliminate demand charges from net metered biogas operations who have only infrequent service interruptions due to routine maintenance | Renewable Energy | CPUC |
| 8. Allow the owner/generator (i.e. farmer) of an electricity generating biogas distributed generation system to retain the environmental attributes, including GHG value and emission reduction credits and any other not directly related to RPS compliance and specific contractual arrangements pertaining to RECs | Renewable Energy | CPUC, Legislature |
| 9. Conduct research to investigate type and level of biogas (including co-production) impurities to determine if bio-methane gas quality stds are needed | Renewable Energy | CPUC, Natural Gas utilities and bio-methane producers |
| 10. Develop a market price referent for biogas as exists for renewable electricity to help remove uncertainty in developing and contracting digester systems | Renewable Energy | CPUC |

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|---|---|---|
| 11. Assess existing interconnection processes and costs to determine appropriateness for introduction of biomethane into natural gas transmission systems; develop uniform standards for introducing biomethane into natural gas distribution systems | Renewable Energy | CPUC |
| 12. Share biomethane interconnection costs with natural gas utilities and develop monetary incentives if purification and injection is preferred use of biogas | Renewable Energy | CPUC |
| 13. Clarify jurisdiction regulatory authority over the biogas production and utilization process | Renewable Energy | CPUC |
| 14. Develop incentives for using biogas as vehicle fuel | Renewable Fuel | CARB |
| 15. Require utilities to interconnect biogas electrical generators under the Rule 21 process as opposed to FERC with a fixed time frame and a process to resolve delay | Renewable Energy | CPUC |
| 16. Determine net air and water quality benefits of manure digesters | Renewable Energy | CARB, local air districts, State and regional water board |
| 17. Develop a thermo-chemical conversion facility pilot project that utilizes agricultural byproducts (rice straw, tree and cane prunings, etc.) | Biomass | UC/CSU/ biomass industry |
| 18. Revise regulations to differentiate between solid waste facilities that Municipal Solid Waste from fuel and electricity generation facilities that use dedicated agricultural, forest, urban tree prunings and discrete feedstock | Biomass | CPUC |
| 19. Clarify ownership of RECs and GHG credits in future rulings and regulations | Biomass | CPUC |
| 20. Coordinate and prioritize CA biofuel crop production research needs | Biofuels | Growers w/private/ public research institutions, CDFA, CalEPA & member boards |
| 21. Develop a national clearinghouse for biofuel crop production research | Biofuels | USDA |
| 22. Coordinate bio-fuel crop lifecycle assessment | Biofuels | CEC, CARB, CDFA |

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|---|---|---|
| 23. Develop a hexane extraction process that meets the needs of the agricultural oil crushing industry and state environmental regulations | Biofuels | Biofuel and fossil fuel companies, growers, local air & water districts |
| 24. Establish state funding for biofuel field crop research | Biofuels | State/federal agencies, Congress, Legislature |
| 25. Regulatory oversight coordination for new biofuel facilities | Biofuels | State and regional water boards, CARB and local air districts, local land authorities |
| 26. Coordinate and prioritize research for soil carbon sequestration in CA crop production and ranching environments, including riparian and farmscapes restoration and any associated water and energy efficiencies | Soil C Sequestration | Growers, public & private research institutions, USDA, CDFA, CEC, SWRCB |
| 27. Develop soil carbon sequestration and fertilizer mgmt incentives | Soil C Sequestration | USDA/NRCS, CDFA |
| 28. Coordinate and prioritize CA fertilizer mgmt research needs and any associated water and energy efficiencies | Fertilizer Efficiency | Growers, public & private researchers, USDA, CDFA, CEC, SWRCB |

[1] California Department of Food and Agriculture, *California Agriculture Resource Directory*, (2006), www.cdfa.ca.gov; California Resources Agency, *Fire and Resources Assessment Program*,. October 2003.
[2]California Air Resources Board, *DRAFT California Greenhouse Gas Inventory*, updated 8/22/07, www.arb.ca.gov.
[3] For irrigated crops, using a total biomass yield (including roots) per acre of 5 dry tonne, a 41 percent carbon content for plant carbohydrates, gives an estimated $CO_2$ uptake per acre of 5 tonne x 0.41 x 44 lbs $CO_2$ /12 lbs C=7.5 tonne $CO_2$/acre. A biomass yield per acre of 2 dry tonne for rangeland is used in this calculation. Total estimated uptake = 120 $MMTCO_2E$ = 75 (cropland) + 45 (rangeland).
[4] California Biomass Collaborative, *Biomass Resources in California: Preliminary 2005 Assessment*, California Energy Commission, Contract 500-01-016, Sacramento, CA, April, 2005.
[5] California Climate Action Registry, *Livestock Project Reporting Protocol*, June, 2007.
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# 7. FORESTRY SECTOR

## I. Introduction

Forests cover 30 percent of California. Photosynthesis by forests is one of the few processes that remove and store a portion of California's ongoing greenhouse gas (GHG) emissions every day. Conversely, the loss of forests generates carbon emissions, accelerating the threat of global climate change.

Scientists estimate that deforestation is responsible for approximately 20 percent of global carbon dioxide ($CO_2$) emissions linked to human activity, adding almost two billion tonnes of carbon per year.[1] Most of this loss has occurred in tropical forests, but the United States and California are not immune. In the U.S., 1 million acres of private forest lands were lost to development annually by the 1990s,[2] and housing is expected to increase by about 25 percent on private land near national forests by 2030.[3] In California, nearly 3 million acres of private forest and rangelands are conservatively projected to be lost to conversion over the next four decades.[4] Forest loss has a dual emission impact: the loss of forest photosynthesis that removes atmospheric carbon; and the emissions of stored forest carbon going back to the atmosphere through combustion, decay and soil disturbance.

Similar to other ecosystems, forests are vulnerable to global climate change. As temperature and precipitation patterns change, some forest types will be lost and others will shift their location and diversity. Current stresses to forest health in California already compromise forest resilience. Earlier spring snowmelt coupled with unnatural stocking in some forests -- too many stems per acre -- from decades of fire exclusion now make some forests more vulnerable to wildfire, pests and water stress.[5] Other forests are under-stocked, the result of stand-converting wildfires or management practices that maintain carbon stocks below their natural potential. The effects of climate change will not hit all forests equally, and managing forests to improve resiliency requires a better understanding of processes in all forest types.[6]

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

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

The full extent of opportunities from forests to mitigate climate change has not yet been realized. Until recently, there has been little compelling reason to pursue forest projects for climate purposes. Additionally, many forest management projects have been stymied by broad disagreements over forest land management and low public trust that environmental values will be protected. Many project types that would produce climate benefits have already been debated, at least in part, in the context of other forest issues. Thus these topics are not entirely new and substantial literature is available for each.

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

## 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. Total sales value for California's primary forest products was about $2.3 billion in 2000, with approximately 112,700 workers -- earning $4.5 billion annually -- employed in the primary and secondary wood and paper products industry.[7]

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

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

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

## III. Key Policy Principles

The overarching theme to guide forest sector policies can be summed up as: "Enhance gain, avoid loss.[8]" In essence, this recognizes that forests already perform a critical role countering climate change 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.[9])

Ways to enhance gain include:

- Manage forests to develop larger carbon reservoirs in trees, wood products and soils;
- Reforest areas that could naturally support more trees;
- Utilize excess wood biomass from projects designed to restore forests to more natural conditions to generate electricity or serve as feedstock for future alternative fuels;
- Improve efficiencies in wood utilization (including harvest and mill efficiency, recycling of wood products, and productive use of current wood waste.)

Ways to avoid loss include:

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

Public comments have suggested various additional roles for forests. These comments also raised a number of important policy concerns: plantation afforestation to provide fiber for wood products or fuel; increasing small-scale wood-heat applications such as wood densification; reducing the consumption of wood products; natural re-seeding rather than re-planting following wildfire; and questions regarding the efficacy of forest thinning as a GHG emissions reduction measure. Each of these issues regarding how forests can be managed within the context of climate change can be explored as

knowledge and discussions mature. For each of these concerns or ideas, the net life cycle carbon benefits will need to be evaluated along with environmental and economic impacts. These policy issues need further development, but are beyond the scope of this ETAAC analysis.

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 and losses in GHG emissions from the forest sector should be tracked and included in the State's GHG emission inventory, in addition to whatever other important role forests 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 owners). It is not necessary to pit sectors and management objectives against each other or to promote one-dimensional goals under the guise of a climate benefit. This is similar to the approach recommended for low-carbon fuels, where specific technologies are not singled out as winners but rather are left to progress on their own merits.[10] If and when market options develop 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, regional or national cap and trade market is established, decisions will be needed to address these issues: *whether* offsets will be allowed for flexibility; *how much* of the cap obligation can be met with offsets; and *what kinds* of offsets will be permitted (i.e. will forests be eligible?)

The forestry sector argues it should be eligible as a legitimate offset candidate should a carbon market develop in California. The ETAAC forestry sector subgroup cautions, however, in its response to the Market Advisory Report,[11] that *"…in order for (an offsets) market to work properly, offsets must be real, additional, permanent, enforceable, predictable and transparent,"* all of which describe the current standards of the CCAR and CARB policy. As they develop, CARB and CCAR may also evaluate other registry systems to determine if they provide equivalent standards. Recognizing the hesitancy of the carbon market and many stakeholders towards accepting forest offsets, CARB must uphold rigorous and credible accounting in order for forest carbon credits to have meaningful market value. While California market decisions are in process, the forest sector will meanwhile continue to participate in the voluntary and Kyoto-based markets, receiving highest value from carbon credits that meet the highest standards.

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

**Recommendations on Forestry Sector RD&D Needs**

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

- Improve methods for assessing sequestration and emissions;
- Test more efficient remote assessment techniques for carbon inventory, e.g. lidar; spectral analysis from new satellite and conventional imagery;
- Model advances in the forest sector to inform state emission data;
- Examine how forests become carbon 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, wood utilization, and manufacturing in the near future. The State of California may want to consider how best to test incentives such as small changes in tax structure, electricity rates, positions in the regulatory queue, grant funding, and purchase preferences for their effect in stimulating climate- and energy-efficient forest projects .

## A. Link Forest Fuels Management and Biomass Utilization

Public support of forest fuel management projects can provide a three-way climate gain by restoring forest ecosystems to more resilient conditions, directing excess fuels to biomass energy production to help meet the State's Low Carbon Fuel Standards, and reducing wildfire emissions from intense crown fires. Decades of fire exclusion have left many forest stands in unnatural conditions, and sensible projects can be designed to utilize excess forest materials in ways that benefit both the forest and the climate. However, recognizing the strong public concerns regarding potential over-exploitation of forests for biomass fuels, CARB should consider means to bolster confidence in the ecological basis for fuels projects. A "Green Biofuels Index" may assist in this effort.

- *Time Frame:* Fuel management projects are now underway, but are quite limited. Develop a public process for Green Biofuels 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 biofuels. Estimate 3 million metric tons of carbon dioxide equivalents ($MMTCO_2E$) per year at 2020 (.09 avoided emissions; 1.9 power and fuels) assuming $400/acre average treatment cost; $37 million from existing sources; and an increase to $5 million for California Forest Improvement Program (CFIP) support.[12]
  *Ease of Implementation:* Several key barriers to biomass utilization prompt development of a Green Biofuels Index. A "chicken-and-egg" dilemma confounds success in linking fuel reduction projects to biomass facilities. Biomass facilities cannot be sited, sized and financed without some horizon of dependable supply. Dependable supply cannot be provided without public trust that forests will not be overexploited by fuel reduction projects. A federally-supported "Community Wildfire Protection Plan" process now encourages public input for community fuel breaks and defensible space, but challenges by stakeholders continue on larger forest projects and post-fire salvage. State support of a "green labeling" process could help identify projects that meet environmental standards and help firm up a supply of fuels to support biomass facilities. Efforts to combine urban, agricultural and forest waste streams would help stabilize supply. RD&D is also underway on alternate fuels from wood wastes. Wood products laboratories are currently exploring conversion of wood to alternate liquid and gas fuels (e.g. in-woods pyrolysis to bio-oils or gas).
- *Co-Benefits / Mitigation Requirements:* Multiple benefits can accrue to forest ecosystems, reduced wildfire emissions and biopower generation from appropriate projects designed to improve forest ecosystem health and resiliency, especially in face of climate change. Forest co-benefits include: improved water quality, reduced erosion, reduced sedimentation of stream habitats and downstream storage facilities; improved wildlife habitat diversity; improved air quality through a reduction in criteria pollutants and smoke emissions; reduced risk to life and property; and greater employment in rural communities. Increased biomass utilization also helps meet State biopower and biofuel targets while

reducing reliance on fossil fuels and other imported energy sources. In response to public concerns regarding potential over-exploitation of forests, CARB should emphasize the need for rigorous California Environmental Quality Act (CEQA) and National Environmental Policy Act (NEPA) review of fuel mitigation projects that incorporates a robust public process. (As a side note, forest carbon from the various aspects of fuel reduction, "wildfire avoidance," and electricity generation from biomass, should be accounted separately, and be cognizant of the importance of full accounting of upstream and downstream storage pools.)

- *Responsible Parties:* Ongoing international efforts by environmental stakeholders may provide a model "Green BioFuel Labeling" program for CARB to consider. The model could be adapted for California in cooperation with local and state environmental groups, the US Forest Service (USFS), and the California Department of Forestry (CDF).

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

*Possible Solutions:* Support for a Green BioFuels Index -- comparable to a green-labeling program -- developed with key stakeholders to increase public trust in appropriate projects and address the gridlock of project design and approval. A Green Biofuels Index[13] would rank projects and improve public confidence in biofuel sustainability. Based on the "green labeling" concept, the index develops a green biofuel protocol; uses environmental labeling to distinguish products; allows the market to reflect efficient labeling and claims; gives preference for green biofuels; offers incentives for environmental performance; and establishes aggregate green biofuels performance standards.

In some cases small price increases for biopower would mobilize more wood waste out of the forest, at least to a break-even point to support fuel reduction costs.[14] State support for technology development and demonstration of small-scale, mobile gasification (or other) units would be beneficial. State support for more efficient conversion technology to feed distributed generation plants one to five megawatts (MW) in size located near supply communities could also help the forestry sector contribute to AB 32 goals.

**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:* CDF estimates cumulative sequestration from reforestation projects of 15 $MMTCO_2$ by 2020 (assuming 0.53 $MMTCO_2$/year by 2010 from 117,000 acres of forest established on forest and rangelands; 1.98 $MMTCO_2$/yr by 2020 assuming 430,000 acres established on forest and rangelands.[15])
- *Ease of Implementation:* Reforestation is not limited by current technology, but proposals will need to assess project success in face of changing climatic conditions. Reforestation is a function of available funding. CDF already provides delivery programs and CEQA compliance via the California Forest Improvement Program (CFIP). The California State Parks system can deliver reforestation programs on State park lands. The building of carbon stores in established working forests is a landowner management decision. A high value carbon credit for additional stored carbon is emerging, established through the accounting standards of the CCAR California Forest Protocols and stimulated by the rapidly expanding voluntary carbon market. Development of national and international markets for forest carbon credits will further incentivize forest carbon storage projects.
- *Co-Benefits / Mitigation Requirements:* Multiple ecosystem and economic co-benefits result from reforestation and enhanced carbon storage in established forests. Active planting with native tree species and management of forest stands to store additional carbon can provide watershed improvement, wildlife habitat diversity, erosion stabilization, and forest health. Economic benefits include short- and long-term job creation in rural regions from forest management. The CEQA process is already in place for CFIP and forest management mitigation activities. CCAR Forest Protocols currently address "Forest Management" and "Reforestation" Projects.
- *Responsible Parties:* CDF for technical support and program delivery; CARB/CCAR for protocol adoption; State Resource Agency and California Environmental Protection Agency (Cal/EPA) in support roles; State Parks Department for reforestation on state park lands; State Legislature for potential tax and other incentives.

*Problem:* Millions of acres of native forests on private and state ownerships in California are estimated to remain below natural stocking capacity due to wildfire or forest management that maintains forests below their carbon storage potential. Only 3.8 percent of all acres burned in 2001 in California have been replanted. Nationally there is a growing reforestation backlog, now one million-acres and increasingly daily.

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

*Possible Solutions:* Gains from forest management in established working forests to increase carbon storage and sustain the long-term production of wood products are substantial. Forested land is now estimated to sequester approximately 14 $MMTCO_2E$ from the air annually. Total carbon stored in California forests is estimated to be 1.7 billion tons. To build upon this base of carbon sequestration, the ETAAC forestry subgroup offers the following recommendations:

- Augment support for reforestation on private and state lands via existing CDF cost-share programs and new forest carbon offset revenue (CDF suggests a $5 million CFIP augmentation).
- CCAR Forest Protocols establish accounting standards for reporting additional forest carbon from 'Forest Management' and 'Reforestation' projects. A forest carbon market would incentivize landowners to participate in carbon storage projects, producing forest carbon as a new "forest product," opting to increase rotation age, tree size and forest complexity with accompanying ecosystem co-benefits.
- Income tax credits or other incentives would accelerate reforestation/ sequestration efforts by landowners.
- Apply existing State Water Bond funds to reforestation of upper watersheds to help develop water-holding capacity of soils and vegetation and to mitigate effects of diminished snow pack on state water supplies.

**C. Urban Forests for Climate Benefits**

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

- *Time Frame:* Program delivery systems in place and expandable by 2012 and ongoing. Not technology limited.
- *GHG Reduction Potential:* The CDF goal is to plant 5 million trees by 2010 to deliver 4 $MMTCO_2E$ by 2030. The estimated GHG emission reduction potential is 0.88 $MMTCO_2E$/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:
  - The need for additional funding for tree planting at State and local levels;
  - Ongoing maintenance costs associated with planted sites.
  - How to best site biopower generation facilities linking urban forest waste streams with agricultural, forest and other wood wastes to serve as feedstock.

  Ways to overcome these barriers:

  - Pursue funding to augment tree planting: grants; bonds; and increased USFS, city and utility support (e.g. the Sacramento Municipal Utility District 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; and 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; California Department of Transportation.

*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 five million trees planted by 2010.

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

**D. Endorse "California Climate Solutions" Program**

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 CCAR 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*: Cal/EPA and CARB in conjunction with private sector Trade Associations can develop an umbrella "California Climate Label" for products and actions that result from (or are derived in compliance with) state climate policies and programs.

- *Co-Benefits / Mitigation Requirements*: Granting preferences for California entities where feasible will help counter competitive disadvantage of entities operating within an "early actor" state relative to non-regulated states. It will also promote public awareness of climate change, climate solutions and the California entities that are stepping forward.
- *Responsible Parties*: CARB; Trade Associations; California Business, Transportation and Housing Agency.

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

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

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# 8. WATER SECTOR

## I. Introduction

Water is one of the few sectors of California's economy where the same policies can serve both preventative and adaptive global climate change goals. Making more efficient use of water will reduce our demands on water resources and shrink the energy consumption associated with water conveyance, pumping, heating and treatment. California water policies can therefore help the State adapt to the effects of climate change while also minimizing GHG emissions.

California's current water use makes significant contributions to the State's current GHG emission inventory. The 2005 CEC report *California's Water-Energy Relationship* concluded that the water sector is the largest user of electrical energy in the state, accounting for 19 percent of all electricity consumed in California, 30 percent of non-power plant-related natural gas use, and 88 million gallons of diesel burned every year. That same year, Governor Schwarzenegger's Climate Action Team estimated that the energy used to move and treat water in California results in the release of approximately 44 million tons of $CO_2$ emissions annually.

The "embedded energy" of water -- which includes the energy consumption associated with water conveyance, pumping, heating, and treating -- varies significantly by location and use. Based on research performed by the CEC's PIER program, the following table reflects the embedded energy (apart from end use consumption) required for indoor and outdoor uses of water in Northern and Southern California.[1] The difference between indoor and outdoor water use in this table is attributable to wastewater treatment.

| | Southern California | Northern California |
|---|---|---|
| Indoor water use (kWh / AF) | 4,340 | 1,800 |
| Outdoor water use (kWh / AF) | 3,700 | 1,170 |

The CEC report further noted that energy applied in water end uses—typically, water pumping and heating—accounts for more than 50 percent of the water-related energy consumption. According to NRDC's *Energy Down the Drain*[2] report, end use energy is conservatively estimated at 3,900 kWh/acre-feet (AF), a figure that does not include outdoor water use. Total energy savings per AF (including end use energy) would be as follows:

| | Southern California | Northern California |
|---|---|---|
| Indoor water use, including end use (kWh / AF) | 8,240 | 5,700 |
| Outdoor water use (kWh / AF) | 3,700 | 1,170 |

There is some potential for a double counting of end-use energy savings between water efficiency programs and the electric and natural gas utility energy efficiency programs (e.g., for showerheads, faucet aerators, clothes washers, etc.). However, accounting for the full societal

benefits of these measures including water and energy savings *and* reduced GHG emissions -- larger customer incentives or more effective program delivery mechanisms are justified.

There is a growing imperative to accelerate water use efficiency in California. Likely impacts of climate change on California's water supplies, the precipitous collapse of the San Francisco Bay-Delta ecosystem, mounting evidence documenting the fragile state of Delta levees, and the recent federal court decision to limit freshwater exports from the Delta, all strongly suggest that the State must transform its policies in order to achieve major water savings through efficiency.

Despite some laudable progress in water use efficiency, California's efficiency potential remains largely untapped. A report from the Department of Water Resources (DWR) entitled *California Water Plan Update* (Bulletin 160-05) [3] estimates that water use efficiency can reduce urban water use by 1.1 to 2.3 million acre feet (MAF) per year, and agricultural water by 0.5 to 2.0 MAF per year by 2030. Accelerating investments to attain this level of water conservation savings by 2015 would result in total of approximately 30 million tons of GHG emission reductions through 2030. Incentive driven advances in water-saving technology over the next 25 years could potentially push savings well beyond these levels.

The CEC's May 2005 *Water-Energy Relationship Report* includes an avoided-cost based analysis in Appendix D of present water conservation and efficiency programs. This analysis shows that effective water conservation and efficiency programs can provide an entire string of benefits, including energy savings, reduced air emissions, and lowered natural gas prices. When a unit of water is saved, so too is the energy required to convey, treat, delivery, and safely dispose of that unit of water. Region, elevation and energy source all influence water energy intensity. A recent study[4] by Environmental Entrepreneurs estimated that up to 5 million acre-feet of water and up to 7 million tons of $CO_2$ equivalent emissions could be cost-effectively saved by 2020. This study examined existing studies by multiple public and private entities to derive its estimates within the following categories:

- *Water metering and tiered pricing:* Move to 100 percent metered water use and tier pricing to create an incentive to reduce high consumption;
- *Indoor water use:* Utilize fixtures and appliances that require less water;
- *Outdoor water use:* Rely upon more efficient landscape irrigation;
- *Non-revenue water:* Eliminate water that is lost or consumed, but not measured, and fix water losses due to leakage, evaporation and storage overflows;
- *Agriculture:* Increased use of drip or other micro-irrigation technologies and more efficient conveyance and delivery systems can dramatically cut consumption.

The categories of energy efficiency include:

- Solar pre-heating for hot water applications;
- Conversion of biogas to energy at wastewater facilities;
- Water processing plant optimization.

The categories for water recycling include:

- On-site conversion of wastewater for irrigation and toilets. (Wastewater recycling can also save energy when it displaces a more energy-intensive water supply.)
- Capture of storm water to recharge groundwater or to convert into irrigation or consumption supply.

The solutions listed above represent many cost-effective opportunities to reduce the GHG emission impacts from water use in California. The CEC *2005 Integrated Energy Policy Report* noted that the State could achieve all of the savings forecast for the 2006-08 utility energy efficiency program portfolio at 58 percent of the anticipated cost by investing in water efficiency instead.[5] New policies, such as efficiency and GHG emission guidelines for the use of energy-intense ocean water desalination facilities, could achieve additional savings at virtually no cost.

In January, 2008 the CPUC approved $6.4 million for pilot water-energy projects and associated studies. This is the first use of electric ratepayer funding applied to water efficiency improvement projects. Included in the new program is $341,000 for emerging technologies, plus another $100,000 for evaluation of these same emerging technologies.[6] It is hoped this program can verify the benefits of technologies that save both water and energy.

By identifying cost-effective opportunities to reduce water sector energy use through water conservation and efficiency programs, California can also reduce its vulnerability to the effects of climate change. Governor Schwarzenegger's 2006 biennial report on climate impacts in California entitled *Our Changing Climate* projected a 30–60 percent loss in Sierra snowpack by the end of the century under its lower GHG emission scenario. Those severe snow pack losses would be even greater at higher GHG emission scenarios. Additional climate impacts on California's include the effects of sea level rise on the fragile Delta levee system, a key component of the state's water supply infrastructure, and an increase in evapo-transpiration due to higher temperatures. By reducing our dependence upon our scarce water resources today, California will be better prepared to withstand these projected changes in the future.

However, the State is not on target to achieve its identified water savings potential. A 2004 analysis by the CALFED Bay-Delta program revealed that in the urban sector, the voluntary process based on the Memorandum of Understanding Regarding Urban Water Conservation in California "is not working as intended and its impact on urban water use remains well below its full potential."[7] The analysis noted that the agricultural water use efficiency program received only 10 percent of the Federal and State funding expected in the CALFED Record of Decision, and the program is expected to achieve only 3 percent of the identified ecosystem and water supply reliability benefits.[8] In evaluating the water-energy nexus, the CEC noted that water efficiency policies, programs, and funding lag far behind those of energy efficiency. As the state faces the emission reduction mandate of AB 32 and the prospect of reduced water supplies due to climate change, these policy shortcomings must clearly be adequately addressed.

# II. Recommendations

## A. Establish a Loading Order for Water

The State Legislature, the State Water Resources Control Board (SWRCB) and the CPUC can adopt a "Loading Order" policy for water that would prioritize cost effective efficiency and recycling measures over traditional supply options. Such a phased approach by water agencies and the State is entirely consistent with a contemporary increased emphasis on integrated regional water management.

- *Timeframe:* In place by 2012.
- *GHG Reduction Potential*: The Climate Action Team estimates that each reduction of one million acre-feet nets GHG emission reductions of 1 million MTCO2E. The ETAAC water subgroup estimates a reduction of up to 5 million acre-feet or 5 million MTCO2E.
- *Ease of Implementation:* Moderate. Unlike the energy sector, where most of the energy is delivered by investor-owned utilities that are regulated by the State, most water in California is sold by public agencies under a different regulatory structure.
- *Co-benefits/Mitigation Requirements*:
    - Reduced demand for water will improve water quality in the Bay Delta;
    - Improved irrigation efficiency will reduce pollution runoff into bays, rivers, and streams;
    - Reduced water consumption will make it easier to manage natural water shortages and the alterations of California's hydrology caused by global climate change;
    - Reduced energy usage will cut air emissions contributing to unhealthy levels of ozone and fine particulates;
    - Disadvantaged communities can reap economic benefits if prioritized for access to water use efficiency projects.
- *Responsible Parties:* SWRCB, DWR, CPUC, State Legislature, Dept. of Health.

*Problem:* California currently does not have a procedure for prioritizing water efficiency and other alternative sources of water over traditional energy-intensive water supplies.

*Possible Solution*: Model water resource planning and supply development after the successful electricity resource Loading Order established in 2003 by California's principal energy agencies, most notably the CEC and CPUC. The Loading Order requires the utilities to: (1) pursue all cost-effective energy efficiency savings; (2) meet new generation needs with renewable and clean distributed generation resources; and (3) fill in remaining supply gaps with clean and efficient fossil-fueled generation. This Loading Order was re-adopted by the energy agencies in 2005 and endorsed by the Governor. The Legislature codified energy efficiency as the top priority electricity resource in 2005, requiring that all utilities "first acquire all available energy efficiency and demand reduction resources that are cost effective, reliable, and feasible."[9] The Loading Order builds on the 30 years of success with State energy efficiency programs. Those

programs have been a major reason why California's per capita energy consumption is one half the national average.

The Loading Order for the water sector would look like this:

- First, decrease demand through improved water efficiency as the preferred approach to addressing water supply reliability;
- Second, meet additional supply needs with alternative sources, including water recycling, groundwater clean-up, and conjunctive use programs;
- Third, use environmentally responsible traditional supply options.

The Loading Order for water would first require agencies to seek cost-effective water efficiency measures over new sources of water. The ranking of efficiency measures should take into account the GHG emissions embedded in the water usage. Measures that maximize the reduction of both water and GHG emissions would be prioritized. If demand for water cannot be met though efficiency, the next step would be to meet demand through alternative sources such as water recycling (processing used water or storm runoff) to produce water suitable for irrigation, toilets, or in some cases, consumption. Such alternatives can be compared both on the cost of water delivery and also on the GHG emission reductions. Agencies that demonstrate that they are on track towards maximizing their efficiency potential could simultaneously pursue these alternatives if necessary to meet demand. Finally, if demand cannot be met through efficiency or alternative sources, new supplies could be tapped.

While a Loading Order would make an important first step to establish a climate-friendly State water policy, it by itself it is not enough. The State must take these steps to put these policy goals into operation: establish a process for determining the efficiency potential and corresponding efficiency targets; standardize evaluation, measurement and verification of savings; and adopt regulatory and incentive programs to achieve those targets.

A Loading Order would also need to be harmonized with existing policies including (but not limited to) the California Water Code (sec 10631), which requires an evaluation of measures or combinations of measures that offer lower incremental costs than expanded or additional water supplies; AB 1420 (Laird), which requires consideration of demand management measures as a condition for water management grants or loans; and other existing policies that the ETAAC water subgroup did not have time to identify.

The State currently has voluntary water efficiency programs, among them the California Urban Conservation Council. The intention of this ETAAC recommendation is to develop enforceable policies modeled on the State's proven and effective programs in the electricity and natural gas sectors.

**B. Establish a Public Goods Charge for Funding Water Improvements**

The State should establish a program that collects a public goods charge from water users for investments in water efficiency as a cost-effective water supply measure and a GHG emissions reduction measure.

- *Timeframe:* Programs in place by 2012.
- *GHG Reduction Potential:* This financing would accelerate implementation of the water "Loading Order." (See estimates of the one-for-one link between water and energy savings in recommendation A above.)
- *Ease of Implementation*: Similar effort to that used by the public goods charge in the electricity and natural gas sectors.
- *Co-Benefits/Mitigation Requirements:*
    - Can benefit disadvantaged communities by funding local water efficiency projects;
    - Reduced water demand will improve water quality in the Bay Delta;
    - Reduced water consumption will make it easier to manage seasonal natural water shortages;
    - Reduced energy usage limits unhealthy levels of ozone and fine particulates pollution.
- *Responsible Parties:* SWRCB, CPUC, State Legislature

*Problem:* There is a lack of systematic public funds to encourage water efficiency and recycling in a cost-effective manner.

*Possible Solution:* A Public Goods Charge on consumption of water can be collected on water bills and then used to fund end-use water efficiency improvements, system-wide efficiency projects, and water recycling. The charge can be modeled after the program used for energy efficiency and managed by the California Energy Commission[10]

A Public Goods Charge is financed by a small surcharge on rate payers. Despite these upfront costs for ratepayers, the existing CEC energy program has demonstrated an ability to generate a positive return, which ultimately lowers customers' bills. A study by the RAND Corporation on California's energy efficiency program showed it resulted in an increase in the State's economy of $875 to $1,300 per capita between 1977 and 2000, a 40 percent decrease in air pollution emissions from stationary sources, and a reduced energy burden on low-income households.[11]

The use of the Public goods Charge would need to be harmonized with other funding, particularly the funds created by the recently passed Proposition 84.

[1] Navigant Consulting, Refining Estimates of Water Related Energy Use in California, prepared for the California Energy Commission, Public Interest Energy Research Program (December, 2006) CEC 500-2006-118
[2] http://www.nrdc.org/water/conservation/edrain/contents.asp
[3] http://www.waterplan.water.ca.gov/previous/cwpu2005/index.cfm

[4] http://www.e2.org/ext/doc/E2C2WaterReductionsSummary.pdf
[5] California Energy Commission, 2005 *Integrated Energy Policy Report*, CEC-100-2005-007CMF, (Sacramento, CA. November 2005) p.150.
[6] http://docs.cpuc.ca.gov/PUBLISHED/FINAL_DECISION/76926.htm#P108_3558
[7] CALFED Bay-Delta Program, *Water Use Efficiency Comprehensive Evaluation*, (Sacramento, CA: August, 2006) p. 3
[8] Ibid. p. 2
[9] Senate Bill 1037 (Kehoe, 2005).
[10] For a general description of the program, see: http://www.energy.ca.gov/reports/1999-12_400-99-020.html.
[11] http://www.rand.org/pubs/monograph_reports/2005/MR1212.0.pdf

# 9. ETAAC Review of MARKET ADVISORY COMMITTEE REPORT

## I. Introduction

CARB requested that ETAAC provide a consensus view on how various policy mechanisms referenced in the Market Advisory Committee (MAC) report might affect investments in -- and the implementation of -- technologies and other solutions designed to help meet AB 32's GHG emission reduction goals. CARB directed 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 emissions 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, ETAAC acknowledges that there are additional factors that policymakers should consider when designing new markets for carbon and other GHG emission reductions.

The rationale for focusing on Early Action, Innovation and Clear Price Signals is summed up below:

1. **Early Action:** It is imperative that California implement policies that encourage early action investments in climate change mitigation prior to the imposition of GHG emission 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 clean technologies. CARB therefore asked ETAAC to comment on how various market design features either encourage or discourage the establishment of these critical and clear price signals.

ETAAC commented on eight different market design issues that will impact whether California meets 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 to a narrow one 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. Ways of accomplishing this are to either allow offsets or direct funds from auction proceeds through a mechanism such as the proposed California Carbon Trust (see Chapter 2, section IIA).

*Clear Price Signals:* A broader scope will likely provide greater liquidity in carbon markets. Including many sectors of the economy under the carbon cap should also stabilize prices due to the increased diversity of characteristics, needs, and risks among capped entities. This approach would also boost the number of GHG emission reduction opportunities available under the cap. By increasing the breadth of these opportunities throughout California's economy, the true cost of GHG emission reductions will be revealed over time. Furthermore, the higher number of entities covered by a broad cap should increase liquidity, thereby improving confidence in market signals. Ultimately, this stability and liquidity should attract more capital and consequently lower costs.

## B. Point of Electricity Regulation

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

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

## C. Allowance Allocation Method

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

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

*Innovation:* Allowance auctions provide the strongest financial incentives for innovation within capped sectors. With auctioning, permits are allocated efficiently and all parties have an incentive to innovate so as to reduce the number of permits they must purchase. Auctions are also an easy way to permit the entry of innovative new firms into the market. The revenue from auctions can be used to encourage innovation. However, it was mentioned by some ETAAC members that firms have limited available capital. Money expended for purchasing permits may 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 GHG emissions. This would also reduce the need to purchase additional allowances. All ETAAC members agreed that if a free allocation method is to be used, output-based free allocation methods are preferable to grandfathering. Any free allocation method should be designed in such a way that the setting of baseline emissions levels does not discourage early reductions.

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

**D. Use of Auction Revenues**

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

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

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

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

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

If auction revenues exceed the level where they can be efficiently applied to abate carbon and other GHG emissions, these revenues can be used to reduce distorting taxation or payments to ratepayers. This represents another potentially important policy option because it could improve the economic efficiency of the overall California economy. Alternatively, these revenues could be used to make the California economy more equitable, in particular by assisting communities or industries that are disproportionately affected by climate change or by climate change mitigation. Any such assistance should not eliminate the incentive created by placing a price on carbon, but instead should help with short-term transitions to a more competitive, low-carbon economy.

## E. Offsets

Offsets allow a capped entity to claim credit for emissions reductions achieved outside the cap and trade system. Offsets can help contain costs and target sectors outside of those subject to a mandatory cap, while taking pressure off of those entities within the carbon cap's jurisdiction. The development of an offsets market may therefore be beneficial. Yet in order for this market to work properly, offsets must be real, additional, permanent, enforceable, predictable and transparent. ETAAC agrees that a standards-based approach to offsets is preferable to case-by-case review since this approach reduces transaction costs as well as increases predictability, both of which encourage early action, innovation, and clear price signals. ETAAC received significant input on the subject of offset rules. Specific comments can be seen at the ETAAC website (see www.etaac.org after February 10, 2008). The focus here is on the use of offsets for compliance with AB 32. There is also an important role offsets play in the voluntary market. If a California Carbon Trust is established, it can also be a buyer in the voluntary market, bringing more capital to the table.

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

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

*Innovation:* There is a tradeoff between incentives to innovate and the cost of compliance. The increased flexibility provided by unlimited offsets would reduce AB 32 compliance costs, but could also reduce the pressure to be creative within a given sector and weaken price signals for would-be innovators. Limits on offsets are therefore useful for encouraging new technological advances within specific capped sectors.

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

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

*Clear Price Signals:* By providing increased flexibility for compliance, offsets can lower prices. 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. Banking lets companies take advantage of lumpy investments in step-change emission reduction technologies and measures. Some members argued that time and quantity limits on banking would limit this innovation incentive. However, others noted that the buildup of a large bank in the early years could decrease the pressure to innovate in later periods. Limits might therefore be helpful to prevent the banks of offsets from growing too large to thwart near- and long-term innovation.

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

## G. Borrowing

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

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

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

*Innovation:* By allowing firms to delay compliance, borrowing delays technological innovation and the diffusion of advanced solutions. A few ETAAC members felt that limited borrowing might be necessary for innovation in order to encourage longer-term investments. The use of a longer compliance period could serve the same purpose, however, and eliminate the need for borrowing.

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

## H. Cost Containment Mechanisms

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

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

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

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

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

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

# 10. APPENDICES

## APPENDIX I: Brief Biographies of ETAAC Members

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

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

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

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

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

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

**Bill Gerwing**
Mr. Gerwing is the BP America General Manager of Regulatory Affairs. He is responsible for regulatory issues management process, government regulator and non-government organization stakeholder engagement strategy, and leads advocacy efforts on

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

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

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

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

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

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

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

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

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

**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 | Campus of University of California at Merced, Merced | Reviewed the draft final report. Received public comments. |
| December 13, 2007 | Cal-EPA Headquarters, Sacramento | Reviewed the draft final report. Received public comments. |
| January 25, 2008 | Cal-EPA Headquarters, Sacramento | Reviewed the draft final report. Received public comments. |
| February 11, 2008 | Cal-EPA Headquarters, Sacramento | Reviewed the draft final report. Received public comments. Considered report for adoption. |

## APPENDIX III:
**Inventory of Current Funding Programs Related to Climate Change**

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 | Grants leveraged funds | Grants critical to projects |
|---|---|---|---|---|---|---|---|---|
| SBIR | | 100's | 25% * | ~4 yrs | | | | |
| ATP | 145 | 100's | | | 8:1 | | 33% | 16% |
| PIER | 62 | 34 | | | 1.3 to 3.4:1 | | | |
| CalTIP | ~5 | 75 | 31% | 2 yrs | | 3 /yr | >38% | 31%** |
| *ICAT* | *~0.9* | *15* | *53%* | *1.7 yrs* | | *1 /yr ^^* | *37%* | *50%* |

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

** derived by staff from data in CalTIP report
^^ $1.2 million revenue in 2004 among 6 grantees who received $1.1 million in grants

*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

This Appendix contains information on a number of energy technologies and other energy-related subjects including: energy efficiency; renewable energy; enabling technologies; and low carbon generation technologies.

## A. Summary of Existing Energy Efficiency Standards and Programs

California has taken a leading role in setting standards for buildings (Title 24) and appliances. California has also adopted inverted block electricity rates (also known as tiered rates) for residential customers. This means the cost per kWh increases as electricity consumption increases, thereby encouraging energy efficiency and conservation. California has taken regulatory action to ensure that investor-owned utilities (IOU) are not penalized financially for implementing effective energy efficiency programs by decoupling utility sales and revenues. Also, California fully integrates energy efficiency options into utility resource planning. The California Public Utilities Commission (CPUC) has allocated major resource for IOU utility energy efficiency programs from 2009-2011; publicly-owned utilities generally have their own energy efficiency programs.

The California Energy Commission (CEC) in its *2007 Integrated Energy Policy Report* (IEPR) recommends a statewide efficiency target set at 100 percent of economic potential, which will reduce total statewide demand below baseline levels. The CEC expects the state to achieve these targets through a combination of utility and non-utility programs coordinated at the State level by the CEC and the CPUC. These efforts will include more expansive building standards, legislation or regulations requiring energy improvements at the time of a building's sale, local ordinances or codes affecting energy use, pursuit of emerging technologies, programs combining efficiency with renewable energy resources, new Federal and State appliance standards, improved compliance mechanisms, and other programs that will result in long-term, sustainable savings.

The U.S. Energy Information Administration projects that residential energy consumption is expected to rise on average one percent per year between 2001 and 2025, with the most rapid growth expected for computers, electronic equipment, and appliances. Commercial energy demand is projected to grow at an average annual rate of 1.6 percent between 2001 and 2025. The most rapid increases in demand are projected for computers, office equipment, telecommunications, and miscellaneous small appliance uses.[3] In addition to efficiency standards for consumer audio and video equipment in standby-passive mode, the CEC has implemented standards for external power supplies which went into effect in 2007 and which will ratchet down farther in 2008. Still, additional technology and policy efforts are needed to improve product efficiency.

The California IOU 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 technology development is advances in lighting emitting diodes (LEDs).

The *2007 IEPR*[4] found that improving residential lighting in California constitutes one very important opportunity for cost-effective energy efficiency improvements. The greatest opportunity for savings in lighting energy in California lies in addressing the continuing prevalence of incandescent lamps. The majority of sockets in existing houses are still occupied by incandescent lamps, which have an efficiency of approximately 10-17 lumens per watt. When compared with the 45-70 lumens per watt of currently available compact fluorescent lamps (CFL), incandescent lamps are clearly very inefficient. (The efficiency of incandescent lamps could be increased by 30 percent with technology presently available, such as halogen capsules with infrared coatings. Industry stakeholders suggest that, with additional technological improvements, incandescent efficiency could even exceed 40 lumens per watt.) Commercialy-available "cool white" LED sources can currently achieve 84 lumens per watt, and warm white devices can reach 59 lumens per watt under optimal conditions (real world numbers are about half that for actual output when used in a lighting fixture). Based on research, development and demonstration (RD&D) results and industry consensus, these numbers are projected to increase by 75 percent for cool white LEDs by 2010, while the efficiency of warm white LED devices will double. The U.S. Department of Energy's (DOE) long-term RD&D goal for white-light LEDs is to produce 160 lumens per watt (lm/W) in cost-effective, market-ready systems by 2025.[5] LED lights are mercury free (unlike CFLs), and are therefore more environmentally-friendly.

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. LEDs are very efficient at producing single-color light directly. White LEDs are entering niche markets such as retail displays, under-cabinet kitchen lights, and backlighting for liquid crystal displays on laptop notebooks.

**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 several years. In addition to energy savings from LEDs, the co-benefits for California 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 as of 2006 from emerging commercial LED lighting in California (2006-2016) is estimated to be 297 megawatts (MW) and 1,312 gigawatt-hours (GWh).[6] Improvements in the efficiency of warm lighting for residential usage will increase this potential further.

### 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 or long 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 obtaining certification from the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) program (or if buildings are labeled for energy usage at time of sale).

*Regulatory:* Energy efficiency programs and standards can provide a boost for LED technology.

## 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.[7] The areas with the highest wind potential 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 (GWh) of electricity in 2006.[8] California also imported 443 GWh of wind energy from out-of-state that same year. The CEC map (Figure 10-1) below illustrates California's wind resources.

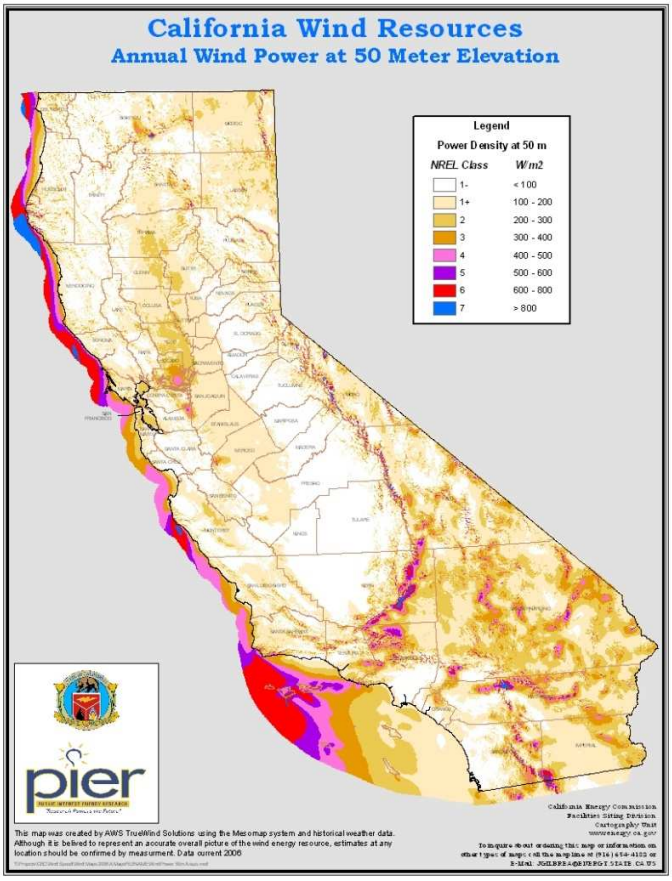


*Figure 10-1: California's Wind Energy Resources*[9]

Preliminary data suggest that there exists a huge and untapped potential for more than 100,000 MW of offshore wind power capacity, 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 CEC published the *Intermittency Analysis Project: Final Report* in July, 2007. The California Independent System Operator (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 for 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 MW 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 gas (GHG) emissions or criteria pollutants. In 2006, wind turbines generated 5.37 million megawatt-hours (MWh)[10] of power. The CEC has estimated a total technical potential of 99,945 MW 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.[11] Wind power developments at California terrestrial sites could offset an estimated 130 million metric tons of $CO_2$.[12] 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. 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 Power

Geothermal power can be used to generate energy 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[13] using conventional flash and binary technologies in known resource areas. DOE estimates California resource potential at between 12,200 and 15,100 MW.[14] 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.[15] Fifteen geothermal projects are currently in some form of development in California, 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 (Figure 10-2) below illustrates the known geothermal resource areas in the state.


*Figure 10-2: Known Geothermal Resource Areas in California*

## Technological Developments

Investing in RD&D to improve geothermal power conversion technologies could help expand new renewable energy resources from the following:

- *Lower-Temperature Resources:* Improving the heat-transfer performance for lower-temperature fluids (below 212°F) in order to make lower-temperature geothermal resources more viable. There could also be opportunities to use hot water, available in large quantities of up to 212°F or more in temperature 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.[16]
- *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 emissions, except for geothermal systems using water cooling (which may result in approximately 60 pounds per megawatt-hour of $CO_2$.[17]) They do not emit conventional power plant emissions such as nitrogen oxides (NOx) and carbon monoxide (CO), but typically emit hydrogen sulfide and often exit ammonia in amounts that can vary depending on the characteristics of the geothermal fluids used to generate power. Based on DOE estimates of total potential, the committee estimates that geothermal has the total potential to offset 37 million tons $CO_2$ per year.

### Technology-Specific Barriers

Geothermal development shares the barriers faced by all renewable technologies. There are some barriers that are specific to geothermal development.

*Technological*: Significant advances in exploration technology are needed. Resource assessment work supported by the U.S. Department of the Interior and DOE can help overcome the initial barrier to geothermal development. The U.S. 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 is 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 Geothermal Energy Association (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 DOE has successful in the past, and is being proposed for expansion in HR 2304 now under consideration in the U.S. Congress.

*Institutional*: There are a wide variety of geothermal resource types in California, but there are a restricted number of capable exploration entities. The Federal 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 Action 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 RD&D effort supported by the CEC's Public Interest Energy Research (PIER) program, has proposed that such a plan be developed focusing on addressing the barriers to developing new geothermal resources in the state.

## D. 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 solar energy 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. Figure 10-3 below[18] shows solar quality for California and the entire United States.

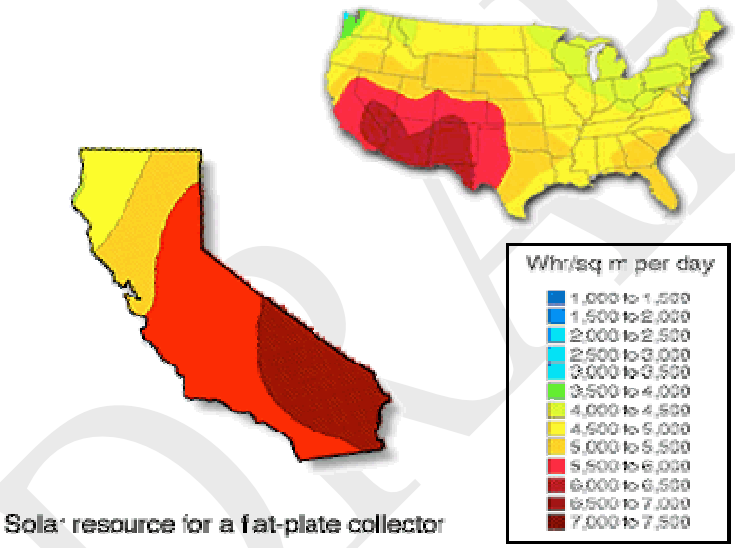


*Figure 10-3: Solar resources in California and the U.S.*

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),[19] technical estimates of concentrating solar power (CSP) potential in California are phenomenal: 877,204 MW

of capacity able to generate 2,074,763 GWh 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 (CPV), 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, Pacific Gas & Electric (PG&E) announced the largest solar power purchase agreement in the world – a 553 MW parabolic trough plant in the Mojave 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 are no commercial power tower facilities currently in operation in California, though the new PG&E contract features next generation power tower technology of modular design. To date, there are no dish-engine systems in operation in California either, though Southern California Edison (SCE) and San Diego Gas & Electric (SDG&E) signed power purchase agreements in 2005 for 500 and 300 MW dish-engine systems, respectively. To date, there are no CPV systems in operation in California, though a few have been proposed in utility Renewable Portfolio Standard (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.[20] 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 carbon or criteria pollutants, and provides valuable peak power.

**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 MWh for cooling and 37 gallons per MWh for cleaning the mirrors.[21] Power towers require 739 gallons per MWh for both cooling and mirror washing.[22] 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 were eligible for a 30 percent Federal investment tax credit through December 31, 2007, at which point the tax credit expired. 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. 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**

Solar 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. [23] California has the largest concentration of solar PV 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-MW installation at the Sacramento Municipal Utility District's (SMUD) 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.[24] In 2006, the legislature passed 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. [25]

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 million metric tons (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.[26] These figures suggest a substantial untapped potential for a greatly expanded solar PV portfolio with the potential to provide an estimated 74 MMT $CO_2$ 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 solar 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. Solar PV installations in California could be curtailed once this level is reached. In January 2007, the CPUC ordered that renewable energy credits (REC) that are attributable to power produced from a distributed PV system fully belong to the owner of that PV system.[27]

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.

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.[28] 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[29] 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 emission 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 does not include the price of environmental externalities such as $CO_2$, 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 (see below).

*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*: The Solar Water Heating and Efficiency Act of 2007 (AB 1470), requires the CPUC to evaluate data from its current pilot program for solar water heating in the San Diego area for possible design and implementation of a broader statewide program. The pilot program is run by the California Center for Sustainable Energy in San Diego, and runs through 2008. The pilot focuses on understanding what the market most needs to take off in California, such as quality equipment, trained and certified installers,

performance warranties, or targeted advertising. If the pilot program looks promising, the CPUC expects to design and implement a program of incentives for the installation of at least 200,000 solar water heating systems in homes and businesses throughout the state by 2017. The program would target natural gas savings, the primary energy source used for water heating in California. The program would be funded by a surcharge on natural gas utility bills. The CPUC will oversee this for IOUs, but the law also directs local publicly-owned utilities to offer similar programs.

## E. 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 shoreline systems are intended for shallow water and are actually built right on the coastline.

The Electric Power Research Institute (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 Federal Energy Regulatory Commission (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 installed in US waters.

### 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 operations and maintenance (O&M) costs 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 value.

*Institutional*: The cost for a small demonstration site to test the first few wave energy devices 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 4 meters 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 kilovolt (kV) transmission links and usually offer no more than 50 MW of available capacity.

*Regulatory*: There is a lack of Federal government support. The U.S. government 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.

**F. 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. A proxy GHG emissions adder was included in the 2007 MPR. That adder is proposed to escalate over time, but does not substantially change the overall MPR calculation. The CPUC will further examine the application of a GHG emission adder to the MPR for future years. Other environmental values are not included in the MPR. 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 (PGC) 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 electricity/natural gas sector 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 Load Serving Entities (LSE) 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 for renewable energy delivered to California 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, LSEs 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 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. The credits will expire in 2008 unless extended, which would result in a significant barrier for solar PV projects.

## G. Enabling Technologies: Energy Storage

Energy Storage is key to California achieving higher penetrations of variable output renewable energy such as wind power in California's supply portfolio. Other types of renewables – such as geothermal and biomass – are base load resources. These technologies do not require storage, although the value could increase if stored for delivery during periods of peak demand. For instance, some CSP projects may be built with heat storage to store energy for later afternoon or early evening peak electricity demand. The ability of today's 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, and 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 emit more $CO_2$ than wind turbines. 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 may help 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.

## H. 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 to reduce the transportation sector with electricity generated from low and zero carbon renewable resources. It is likely that light-duty PHEV/EVs will reach 200,000 new vehicles sold per year within the coming decade.

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 another 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. Electric vehicles are more energy efficient than internal combustion engines, even considering the efficiency of a natural gas combined-cycle power plant. The average US electric grid is a lower-carbon resource than petroleum, although powering plug-in hybrids with conventional coal electricity can actually result in more emissions of $CO_2$ and other pollutants. An EPRI/Natural Resource Defense Council (NRDC) nationwide analysis of climate change impacts of PHEV/EV technology concluded that switching to them can reduce GHG emissions significantly, potentially reaching a maximum cumulative reduction of 468 MMT by 2050 in the mid-range scenario outlined (62 percent PHEV fleet penetration by 2050, electric sector $CO_2$ intensity decreases 41 percent by 2050). A December 2006 study by the DOE's Pacific Northwest National Laboratory (PNNL) concluded that such off-peak utility generation and transmission could power 84 percent of the 220 million PHEVs in the U.S..

The actual GHG emission reductions attached to a comprehensive PHEV/EV program depends upon how clean the regional electricity grid is. (This fact means PHEV will be cleaner than hybrids! A PHEV with a 40-mile range could cut $CO_2$ 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 RD&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 would shift to the electric sector, even though the overall impact to the environment is positive. For instance an AB 32 carbon cap for only the electric sector, absent mitigating measures, would make this otherwise desirable shift a liability for the complying entities. This would serve as a powerful disincentive for the energy sector to take actions that encourage the use of electricity to support the transportation sector.

## I. 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 ten 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.

## J. 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[30]. 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[31]. 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. California can continue to cooperate with these types of projects, with the Federal government taking a lead role consistent with the national importance of this technology. The project will validate the sequestration potential of California Central Valley sediments, focusing on overcoming current monitoring challenges.[32] Monitoring is an important issue to ensure that $CO_2$ injected into geologic formations remains securely in safe storage.

One interesting sequestration technology 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.[33]

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. Testing multiple

methods of using the same technology will help determine what variables are the most valuable in creating a sustainable carbon reduction technology.[34]

Other proposals presented to the ETACC electricity/natural gas sector 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.[35]

**$CO_2$ 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 $CO_2$ 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 EOR 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.[36] 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 $CO_2$ 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 help address 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.[37] 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 U.S. 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 very large $CO_2$ 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 U.S. 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*: Evaluating the safety of potential CCS projects will be very important for both regulators and communities located near where CCS projects may be located. Regulatory uncertainties currently pose a barrier for CCS. For example, it is not clear whether underground injection of $CO_2$ is under Federal Environmental Protection Agency (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: 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.

## K. Fuel Cells

Fuel cells operate on natural gas, methane, diesel, syngas, hydrogen and other fuels. They range in size from tiny – less than one watt -- to as large as 1 MW, with larger systems currently in development. Fuel cells are scalable, and there are some utility-scaled fuel cell projects of greater than 20 MW.

These stationary fuel cells "electrochemically" generate clean, base load electricity and heat. 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 U.S., fuel cells operate as utility-owned power plants or on-site distributed generators. California has installed almost 15 MW of fuel cell capacity 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 negotiation.

### Technological Developments

Fuel cells are generally characterized by the electrolyte employed in the device. Fuel cells are also characterized by their operating temperature, i.e. low or high temperature. There are dozens of types of fuel cells, with four 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. Proton exchange membrane fuel cells are commercial in small scale backup power systems and specialty vehicles.

**$CO_2$ Abatement Potential**

Renewable fuel cell projects operating under the auspices of the Self-Generation Incentive Program deliver GHG emission reductions that depend on whether the unit is used for combined heat and power and the displaced carbon emissions of the local utility. For instance, PG&E has a carbon intensity of about 800 lbs $CO_2$ /MW-hr, with SCE substantially lower and Los Angeles Department of Water and Power (LADWP) substantially higher. Substantial deployment potential currently exists for grid support and for large buildings with base load power needs: schools, hotels, hospitals, office buildings, jails, and industrial buildings.

**Technology-Specific Barriers**

*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.

*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 climate change abatement, were properly valued. Furthermore, fuel cell operators that use natural gas must absorb the fuel cost and volatility risk. 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 low carbon and 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 lack of familiarity with the technology. Lack of workforce training for utility employees on technology operations and best applications is a barrier.

*Regulatory*: A number of regulations impact that cost-competitiveness of the technology. Created in 2001, the Self-Generation Incentive Program (SGIP) provides funding for fuel cells and other clean Distributed Generation (DG) technologies. Rebates are limited to the first installed MW of a maximum total project size of 3 MW. This restriction on SGIP is too low to incent economies of scale and wide-scale deployment. Increasing this subsidy 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 build demand to accelerate installations.

## L. Biomass/Landfill/ Digestion/ High Temperature Waste Conversion

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 used for energy in California are agriculture, forestry, and municipal wastes (which also contain non-biomass materials). 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. Almost all of the current ethanol supply is created from corn, with most of it grown in the Midwest. 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 of biofuels, 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 of development.

There is no single market driving biomass development. New markets will offer additional outlets for biomass energy, 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 metric dry tons (MDT), four to five MDT of solid biomass resource was used in 2005. In addition, an estimated 90 billion cubic feet (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.[38]

**Technological Developments**

There are several pathways for converting biomass to usable energy:[39]

*Biological Conversion*

| Source | Conversion Process | Primary Energy Product |
|---|---|---|
| Agricultural crop | Fermentation of sugars | Ethanol |
| Any lignocellulosic* biomass | Cellulose to sugars, then fermentation | Ethanol |
| 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 (for Individual Technologies)**

*Anaerobic Digestion:* California has 1.7 million cows on 2,100 dairies, with 75 percent located in Northern California, and 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 (the biogas could also displace natural gas for heating and other uses). 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. Another opportunity for reductions is the conversion of organic material that would otherwise by landfilled via digesters to produce fuels for electricity production or other uses.

*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 MW. The electrical potential from an additional planned 26 landfills was about 39 MW. 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 significant amounts of electricity while reducing the contribution to climate change of the methane emissions. Additionally, some of the existing LFGTE projects are operating below their rated electricity generation capacity. Significant electrical potential could be added by expanding existing landfill gas to energy projects in California.

*High Temperature Waste Conversion*: High temperature waste conversion can avoid landfill emissions, and create a fuel for electricity generation, for both biomass and other materials in MSW that can be converted to a fuel. The effectiveness of this technology would depend on a life-cycle analysis of whether greater climate change benefits can be achieved through waste reduction or recycling methods instead of conversion; and on avoided GHG emissions of electricity that could be displaced by high temperature waste conversion. Similar types of analysis would be needed if high temperature processes were used to convert waste to other fuels for heating and/or transportation.

**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. Gasification of MSW is challenging due to both variability and uncertainty in feedstock composition.

*Financial*: Due to their small size, biomass power plants have relatively high capital and non-fuel Operations and Maintenance (O&M) costs per MW 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, including: agriculture; forest products; 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 facilities that covert municipal waste to electricity face through high-temperature processes face substantial public concern over air toxics emissions.

*Regulatory*: Any form of combusting fuels to generate electricity will be subject to regulations and permitting for pollutants such as NOx in California. Strong public barriers to acceptance over concerns such as dioxin emissions for high temperature waste conversion may block political and regulatory approvals.

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. Also, permitting waste conversion demonstration projects is a lengthy process that may limit the availability of further data regarding these processes.

Landfill operators are required to destroy methane emissions from their facilities. They may simply flare the gas. The flaring would set 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 controlled. 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.

**M. Next Generation Advanced Gas Turbine Technologies**

Clean, flexible, natural gas-fueled resources are necessary to tie the state's 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 by offering these firming up services.

New technologies have been proposed to improve the efficiency of new and existing gas turbines in base load and peaking applications. One type of strategy is increasing the energy efficiency of gas turbines. They are used for both simple cycle and combined cycle (where waste heat is used to generate steam for additional electricity generation). Another is improving systems to increase the efficiency of combined cycle systems, and optimizing systems so that they can achieve highly efficient combined cycle operation more quickly. They face a common hurdle in the energy sector: the cost and risk of trying new technologies. The capital investment is high, so new facilities or hardware that adds any performance risk is difficult to bring to market.

CARB maintains a user-friendly database of Best Available Control Technology (BACT) decisions that includes power generating equipment such as gas turbines and boilers. This database should be expanded to include greenhouse gas emission rates, now that $CO_2$ has been recognized as an air pollutant, to facilitate technical information sharing for permitting within California for new. For instance, existing EPA guidance requires consideration of GHG emissions when selecting air pollution emissions controls as BACT. Thus, establishing this information will facilitate evaluations by California permitting agencies. (In areas that violate health-based standards, achieving the lowest achievable emission rate of the pollutant(s) contributing to the violations is the over-

riding concern.) In addition, GHG emission rates will also be important for other U.S. and international agencies that intend to allow new natural gas electricity generation and want to determine the lowest carbon options.

CARB, the California Air Pollution Control Officer's Association and member air Districts, the CEC, and EPA should agree on a standard format and the CEC and air Districts should include this information with every permitting action for fossil-fuel fired electricity generation. Other agencies such as South Coast Air Quality Management District (SCAQMD) and EPA should also seek to include this information as well in their air pollution control technology databases for facilities within their jurisdiction. CARB should also consider the feasibility of providing data for existing units to the extent that it is readily available.

## N. Combined Heat and Power

Combined Heat and Power (CHP) plants -- also known as co-generators – generally is 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. (As noted earlier, fuel cells are another technology offering the potential for CHP applications.) 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. Figure 10-4 below illustrates the greater efficiency of CHP configurations.

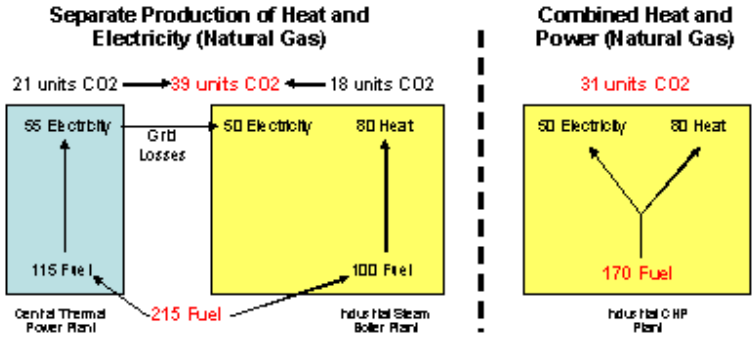


Figure 4-10: Illustration of CHP efficiency.

There are two main 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 plant. A related process is a "Bottoming Cycle" plant that is 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 MW of CHP installed at 900 sites throughout California. By 2020, California could add between 2,000 MWe and 7,300 MWof 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 if CHP owners are asked to bear the costs of electricity generation directly, while other industrial sites experience carbon mitigation costs that are partially absorbed by upstream producers..

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

Oxyfuel Combustion offers several advantages compared to capturing carbon from natural gas power plants using ambient air for combustion. $CO_2$ separation is expected to be more costly for post-combustion clean-up for natural gas/ambient air natural gas power plants 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 isolated more easily by cooling the flue gases instead of a process to separate $CO_2$. 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.) Oxyfuels have already been used in glass plants in California, where they have reduced NOx emissions while achieving the very high temperatures needed to produce glass.

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). 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. There is an opportunity 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. 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. Sulfur dioxide ($SO_2$) 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 $CO_2$. Commercial processes from the chemical industry can remove $CO_2$ 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[40] 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;[41] however, none of these plants captures or sequesters $CO_2$. 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 U.S.

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.[42] 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 U.S. 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 such as 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. Integrated Gassification Combined Cycle 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 fuels. There are a variety of "pre" and post combustion" mechanical, chemical, and natural carbon capture technologies that are current available or under development.[43]

### 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 $CO_2$ may 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 (see Figure 10-5 on the next page.) It may 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.

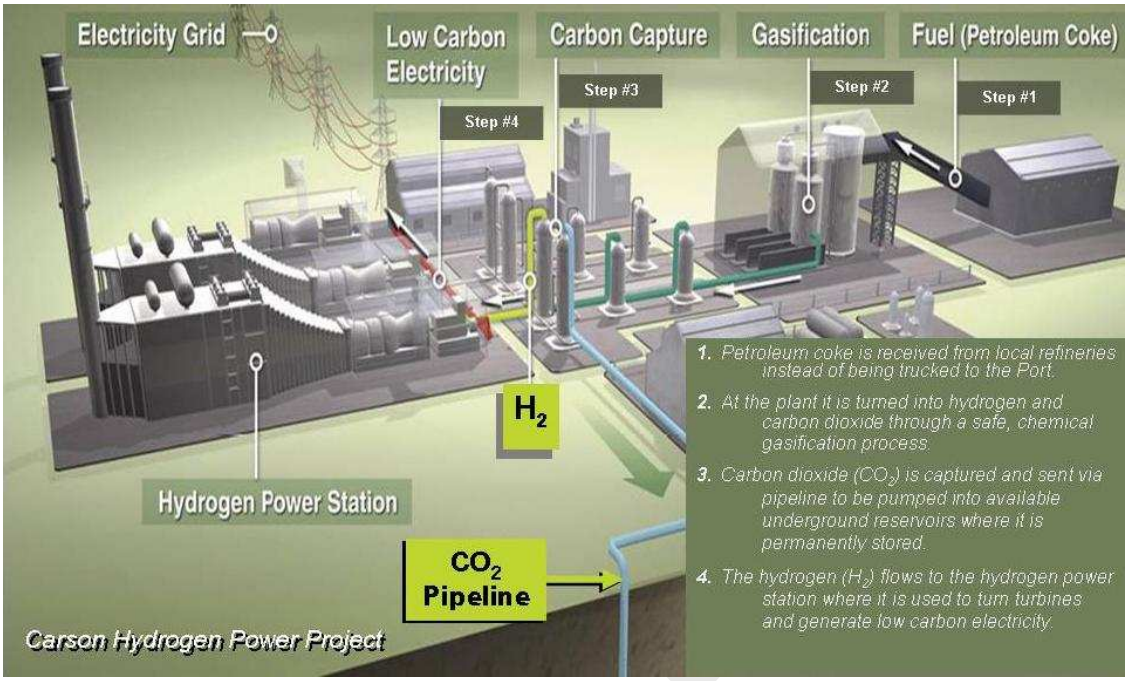


*Figure 10-5: Illustration of Carson Hydrogen Power Project and CCS*

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.[44]

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, 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 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 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, has been 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 would help direct the industry toward this higher risk technology investment. This support could take the form of accelerated depreciation; investment and production tax credits; research, development and commercial demonstration funding; performance certainty guarantees; and/ or 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 2,220 MW Diablo Canyon; San Onofre, a 2,254 MW facility operated by SCE; and the 3,810 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 re-licensing 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 re-licensing 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. DOE 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 that create 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 Barriers**

*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.

In addition to the recommendations in the Electricity & Natural Gas Chapter 4, the electricity & natural gas sub-group recommends the following:

Additional Electricity & Natural Gas Sub-Group Recommendations
*Not ranked by priority.*

| **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 |
| 2. Cap & trade or other regulations should not put electricity at a disadvantage compared to traditional petroleum fuels. | PHEV/EV – Transport |
| 3. 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 |
| 4. 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 |
| 5. Organize and expand the current level of effort in the science and business of CCS, with the federal government taking the lead. 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 |
| 6. Coordinate potential plant capacity additions and retrofits with ongoing program objectives to maximize the commercialization potential of CCS technology | CCS |
| 7. Fostering interactions between consuming and coal producing/generating States should include:<br>a) Closer collaboration between all utility commissioners<br>b) Support "Capture-Ready" requirements for all new coal generating facilities. "Capture-Ready" refers to IGCC and PC power plants that are located in immediate proximity to a suitable sequestration site, and existing | CCS |

| | |
|---|---|
| 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.<br>c) | |
| 8. Investigate incorporating storage into the grid to balance out variable output renewables – solar and wind. | Renewable; Storage |
| 9. Ensure full valuation of CO2, environmental and other benefits. Synchronize different valuations among programs and technologies. | Renewable |
| 10. Continue existing incentives for distributed technologies, and adjust to account for actual energy performance, environmental attributes, and economies of scale. | Renewable |
| 11. State support for development of new technologies for geothermal exploration. | Renewable |
| 12. Accelerate research into material cost-reductions. | Renewable |
| 13. 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 |
| 14. Workforce training for utility procurement officers, field operators and other employees on technology characteristics and operations. | Renewable |
| 15. Expansion of funding to RD&D incubation centers. | Renewable |
| 16. Incentives for landfill operators to use landfill gas for energy generation. | Renewable |
| 17. Simplify permitting for renewable project developments through coordinated decision-making process between State and Federal agencies such as coordinating permitting activity within interagency coordinating bodies or through master agency agreements, establishing a clearer permitting pathway, and/or fast-tracking permitting efforts. | Renewable |
| 18. 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 |
| 19. Improve transmission access for renewable energy. | Renewable |
| 20. 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 | IGCC with CCS |

| | |
|---|---|
| abundant. | |
| 21. 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 |
| 22. Address legal and regulatory barriers/issues associated with CCS. | IGCC with CCS |
| 23. Provide financial incentives for permanent geologic carbon dioxide sequestration. | IGCC with CCS |
| 24. Develop a regulatory framework for injection wells and carbon dioxide pipelines. | IGCC with CCS |

Appendix V: Background Status Report on Transportation Sector Solutions

This appendix was compiled by the ETAAC Transportation sector subgroup as a reference document for strategies that can reduce greenhouse gas (GHG) emissions from the transportation sector. It contains summaries of specific technologies and a set of references in endnotes. Material was contributed by both ETAAC members and the general public. This inventory of solutions to global climate change is arranged according to the following categories:

A. Vehicle and Fuel Technologies
B. Transportation Planning and Incentives
C. Mobility Options
D. Traffic Flow Improvements
E. Goods Movement
F. Other
G. References and Notes

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## A. Vehicle and Fuel Technologies

*A.1 Conventional Vehicles and Fuels*

Many technologies exist that can improve the fuel efficiency of contemporary vehicles that burn fossil fuels in internal combustion engines, thereby substantially lowering GHG emissions, as has been documented elsewhere by CARB and others.[48] Many of these technologies involve improvements to internal combustion engines, hybridization of vehicles, and similar incremental changes. Many have already been introduced into transportation markets outside of the United States, notably Europe. In general, technologies to reduce emissions from conventional vehicles can be integrated fairly easily into new vehicle design and manufacturing. They also require no changes in infrastructure.

Current trends to use lower-grade resources (e.g. Canadian tar sands) for fuel production are leading to fuels which have higher GHG emissions per unit of fuel, although technologies can be developed to limit or to capture and store additional GHG emissions used in resource extraction.[49] These include improved efficiency in oil production and refining, the storage of carbon dioxide in depleted oil fields and reservoirs, and possibly even the capture of carbon dioxide from the air after fossil fuels have been combusted.

- *Timeframe:* Near to long term growth potential.
- *GHG Reduction Potential:* Potentially very large, especially if carbon storage is feasible.
- *Ease of Implementation*: From very simple to very challenging.
- *Co-Benefits / Mitigation Requirements*: Can reduce the need for petroleum imports. May have negative costs.

- *Responsible Parties:* Federal and State governments, private sector.

*A.2 Electric Vehicles*

Vehicles that draw electricity from the grid have been in development and use for some time and may be an important option in the future.[50] The electric vehicles category (EVs) includes a wide range of configurations, from different plug-in hybrid electric vehicles (PHEVs) to neighborhood electric vehicles (NEVs) to high performance battery electric vehicles (BEVs). Generally speaking, the key challenge for EVs is improved battery technologies since relatively little infrastructure is needed.

Some of the key advantages of EVs are: they have zero tailpipe emissions of GHG emissions; they tend to be very efficient in terms of energy consumption; they have low operating costs; they diversify the transportation energy supply; and they have the potential to support the electric power system through vehicle to grid (V2G) technologies.[51] However, they are currently very expensive -- largely due to battery costs -- although these costs may be mitigated by advanced vehicle designs that use smaller batteries (e.g. vehicles with relatively short all-electric ranges, like 5-10 miles). Other important challenges for EVs include development of low-cost manufacturing technologies, appropriate technologies and methods for charging, and potential infrastructure for rapid re-charging. Because EVs constitute such a wide range of vehicles, the relative importance of these challenges varies greatly according to vehicle type.

- *Timeframe:* Mid to long term.
- *GHG Reduction Potential:* Potential to eliminate substantial GHG emissions.
- *Ease of Implementation*: Moderately to very challenging.
- *Co-Benefits / Mitigation Requirements*: Can reduce the need for petroleum imports. May have negative costs. Eliminates tailpipe emissions.
- *Responsible Parties:* Federal and State governments; private sector; electricity providers.

*A.3 Biofuels*

Transportation fuels produced from biological feedstocks (biofuels) are currently used in California and may offer important opportunities for GHG emission reductions, but there are also significant concerns about biofuels.[52] Currently, gasoline in California contains about 5.7 percent ethanol by volume, which implies annual consumption of about 900 million gallons. Much smaller quantities of biodiesel are consumed. A major advantage of biofuels is that they require smaller changes in fuel infrastructure and vehicle technology than do other low-carbon options. However ethanol does not blend perfectly with fossil fuels, so it requires special distribution infrastructure, which is currently strained at both the national and state levels. In addition, the carbon intensity of biofuels varies greatly with production method, and some of today's biofuels can have higher GHG emissions than fossil fuels. As biofuel production has expanded, concerns about

the environmental and social implications of using food crops for such expansion have risen.

Most experts agree that for biofuels to contribute significantly to lowering GHG emissions, advanced (or "second-generation") technologies will be needed because they offer two key advantages over today's biofuels. First, they will enable the cost-effective use of feedstocks such as grasses, trees, wastes, and possibly algae in place of crops like corn and sugarcane. Second, they may yield fuels that are readily blended with (and may be virtually identical to) fossil fuels, minimizing the need for any special infrastructure or vehicles to use biofuels. Recently, the U.S. Department of Energy (DOE) sponsored six pilot plants to produce cellulosic ethanol, one of the earliest of the second-generation biofuels. This technology offers the first advantage, but not the second.

Measuring the lifecycle carbon content of biofuels and developing appropriate regulations is a challenging undertaking that the State of California is currently addressing, as are the U.S., the European Union and other national governments. Increased support for the collection and analysis of data (including development of better analytic methods) will be crucial to successful deployment of low carbon biofuels. A near-term step that would be very valuable would be a U.S. National Academies study of this issue. The State of California should consider recommending such a study on the best methods of lifecycle analysis for the measurement of GHG emissions from biofuels, including the effects of indirect land use.

- *Timeframe:* Near to mid-term.
- *GHG Reduction Potential:* Unclear, but possibly large with technology improvements.
- *Ease of Implementation*: Very easy to somewhat challenging.
- *Co-Benefits / Mitigation Requirements*: Can reduce the need for petroleum imports. May have negative costs.
- *Responsible Parties:* Federal and State governments; private sector.

*A.4 Hydrogen*

A more long-term possibility is elemental hydrogen as a fuel, either in a combustion engine or fuel cell.[53] Because deriving energy from hydrogen only water vapor (a greenhouse gas that is already saturated in the atmosphere), it does not contribute to global climate change. There is some variability between hydrogen production processes in regards to their GHG emissions, but assuming the appropriate production methods are in place, a hydrogen-based economy could have an extremely low carbon footprint. However, the hydrogen economy requires integration of an array of technologies: hydrogen production, compression and storage; distribution and delivery; dispensing at fueling stations; vehicle utilization; and establishment of codes and standards for safety, measurement and environmental regulations.

- *Timeframe:* Long term.

- *GHG Reduction Potential:* Potential to eliminate significant GHG emissions.
- *Ease of Implementation*: Very challenging.
- *Co-Benefits / Mitigation Requirements*: Can reduce the need for petroleum imports. May have negative costs. Eliminates tailpipe GHG emissions and other pollutants.
- *Responsible Parties:* Federal and state governments; private sector.

*A.5 Other*

A number of other vehicle and fuel technologies may lower GHG emissions in California.[54] One is hydraulic hybrid technology, which uses a pair of reservoirs operating at high and low pressure, hydraulic fluid, and a pump/motor to store energy. This system transfers the vehicle's kinetic energy to the high pressure reservoir during braking and uses the stored energy to supplement or substitute the engine's power during acceleration. Hydraulic hybrid technology is less expensive that electric hybrid technology, and may be particularly applicable for heavy duty vehicles with frequent stops and starts (such as buses, refuse trucks, etc.). Other fuels may help lower GHG emissions from transportation as well, such as natural gas, which is currently used in both heavy duty and light duty vehicle applications in California. In addition, ammonia could be used as a fuel, either for fuel cells or for internal combustion engines. While there are challenges to using ammonia as a fuel, further evaluation, especially as an additive to hydrocarbon fuels, may be warranted.

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**B. Transportation Planning and Incentives**

Demand for transportation services is linked to GHG emissions. Many opportunities exist to reduce this demand by providing more transportation options in a way that reduces demand for automobiles and other energy-intensive modes. Some of these mechanisms use incentives to shape the choices facing travelers today, some involve changes in land use and infrastructure development, and some are wholly technological in nature.[55] These opportunities are divided into three categories: correct incentives, improved transportation planning, and advanced transportation systems. These approaches to lowering GHG emissions will have important co-benefits in terms of less congestion, neighborhood designs designed for high quality of life instead of just convenient parking, and others.

*B.1 Incentives: Road Pricing*

Road pricing policies can reduce congestion and vehicle GHG emissions by inducing demand shifts from autos to public transportation and by reducing discretionary travel. They include cordon pricing (toll rings in high-activity centers like central business districts that charge drivers for entry into a specific area), "FAIR" lanes (fast and intertwined regular lanes that charge drivers to use express lanes and transfer a portion of the collected money to drivers using the non-express or regular lanes), and "HOT" lanes (or high occupancy toll lanes that enable drivers without the minimum number of

passengers to access high occupancy vehicle lanes for a fee). Roadway pricing makes drivers more aware of the true cost of driving in a way that may encourage them to switch modes or reduce travel, and ultimately ease congestion.

Transport for London reports that the central London congestion-charging program was responsible for a 16 percent reduction in $CO_2$ traffic emissions within the charging zone during 2002 and 2003 (annual averages)[56]. In addition, the city of Stockholm implemented a six-month trial of cordon pricing in January 2006, including provisions for expanded transit services and park-and-ride facilities. Using emission models, the Stockholm trial is estimated to have reduced $CO_2$ and particle emissions by "approximately 100 tons per weekday 24-hour period or by 14 percent.[57]"

- *Time Frame:* Near to mid-term.
- GHG Reduction Potential: Modest.
- *Ease of Implementation*: Technically not too difficult, but may be unpopular.
- *Co-Benefits / Mitigation Requirements*: Reduced congestion and increased revenue.
- *Responsible Parties:* Local, regional, and State governments; private sector.

*B. 2 Incentives: Parking Cash Out*

Parking cash out offers "commuters the option to "cash out" their employer-paid parking subsidies. [It gives] commuters the choice between free parking or its equivalent cash value….The cash option also rewards those who carpool, ride public transit, walk, or bike to work.[58]"

- *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[59].
- *Ease of Implementation:* Medium to high challenge. Policies are needed to prompt behavioral change; could be linked to road/value pricing.
- *Co-Benefits / Mitigation Requirements*: Reduced vehicle miles traveled, parking demand, and increased transit ridership.
- *Responsible Parties:* State and local/regional governments; employers.

*Problem:* Some employers or employees may not be aware of or may not be fully implementing the employee cash-out program.

*Possible Solutions:* CARB should proactively inform employers and employees of parking cash-out programs, covering as many employers and employees as possible.

*B.3 Planning: Improved Transportation Impact Analysis*

Traditional transportation planning tools and metrics tend to under-estimate the benefits of transit and other alternatives in a way that leads to greater road construction for automobile use. These processes should be dramatically improved with new tools and larger public sector budgets.

- *Timeframe:* Planning processes implemented by 2012. On the ground effects will become more visible over time as the cumulative effects of project decisions become greater in 2020 and 2050.
- *GHG Reduction Potential***:** Each 1 percent of VMT shifted to non-polluting modes of travel is likely to result in reductions of one million or more tons of GHG emission reductions.[60] 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[61] and quality of life.
- *Responsible Parties:* State, regional, local transportation and environmental planning agencies.

*Problem:* There are inherent trade-offs between different forms of transportation and accessibility of goods and services. Roadway design and land use patterns that are designed for maximum motor vehicle traffic are generally less suitable for other modes. Traditional transportation planning metrics such as automobile Level-of-Service (LOS) compare existing and expected motor vehicle volumes to estimates of roadway capacity. "LOS" is convenient due to its simplicity, but it fails to recognize the environmental benefit of improving mass transit and non-motorized modes of transportation. Despite the limitations of LOS, CEQA guidelines give great weight under case law to LOS and related measures as a proxy for significant transportation-related air quality impacts. [62]

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.[63]

CEQA guidelines are not established in the CEQA code, but rather by local agency action. However, 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 Solutions:* Local and regional planning agencies should prioritize reductions in VMT over increases in motor vehicle traffic and pollution, while maintaining access to goods and services. Recognizing this under CEQA guidelines will facilitate a shift to Smart Growth planning practices. To the extent that access to goods and services should be addressed by CEQA guidelines, per capita congestion delays and travel times are examples of meaningful measurements. The ETAAC transportation sector subgroup also offers the following recommendations:

- Local, regional, and other transportation planning agencies should use alternatives to LOS whenever possible.

- The California Resources Agency should recognize, under CEQA guidelines, the benefits of using alternatives to LOS, or abandon traffic congestion as an indicator of environmental quality and instead evaluate motor traffic-related air quality impacts directly.

*B.4 Indirect Source Rule*

An indirect source rule applies to land development or other projects that will lead to increased vehicle use (whether VMT for individual travel or ton-miles of goods movement) and requires the developer to at least partially offset the transportation-related emissions that their project will create. Currently, at least six California Air Pollution Control Districts have indirect source rules for air pollution (Colusa, Great Basin, Mendocino, Placer, San Joaquin, and Shasta). This idea could be extended to GHG emissions so that developers of projects that will increase vehicle use would be required to at offset at least some of the associated GHG emissions.

- *Timeframe:* Could be implemented by 2012.
- *GHG Reduction Potential***:** Potentially large.
- *Ease of Implementation:* Low to moderate.
- *Co-benefits / Mitigation Requirements***:** Unclear.
- *Responsible Parties:* State, regional, local transportation and environmental planning agencies.

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**C. Mobility Options**

*C.1 Bus Rapid Transit*

Bus rapid transit (BRT) is the application of a series of ITS technologies, route planning, exclusive rights-of-ways, and management to improve bus service—each of which can reduce travel times. Increases in bus ridership associated with BRT implementation have been reported in the U.S., Australia, and Europe. If a mode shift occurs from a single occupancy vehicle to BRT, there is an efficiency benefit. If the previous mode was non-

motorized, such as walking or cycling, the impact on fuel efficiency/$CO_2$ emissions is negative. If additional riders are attracted from another bus route, the impact is neutral.

- *Timeframe:* Near to long-term growth potential.
- *GHG Reduction Potential*: Bus ridership increases due to BRT implementation in five cities ranged from 18 to 76 percent (Houston, Los Angeles, Adelaide, Brisbane, and Leeds).[64] Furthermore, faster journey times and reduced acceleration, deceleration, and idle times—resulting from fewer stops and signal priority—have been shown to reduce fuel consumption. Signal priority modeling results indicate a five percent reduction in fuel consumption.[65] Using data from the 2001 National Household Survey and emissions data from the Department of Environmental Protection and the Energy Information Administration, Vincent and Jerram (2006) concluded that a BRT system -- employing 40-foot compressed natural gas buses -- provides the greatest decrease in $CO_2$ emissions when compared to light rail and 40- and 60-foot hybrid diesel BRT buses.[66]
- The 40-foot CNG buses used in BRT exceed light rail $CO_2$ reductions by approximately 300 percent.
- *Ease of Implementation*: Moderate to challenging
- *Co-Benefits / Mitigation Requirements*: Increased transit ridership, traveler satisfaction, reduced congestion; mitigation challenges include land use requirements and rights-of-way.
- *Responsible Parties*: Transit agencies, regional and local governments; Caltrans.

*Problem:* BRT systems require changes to current road use (dedicated lanes) and access infrastructure. Also, GHG emissions will depend on what sorts of mode shifts occur. Do travelers simply shift from ordinary buses to BRT or from personal vehicles? How much additional travel is induced by the addition of a BRT system?

*Possible Solutions*: California should support an evaluation of a BRT demonstration system. In conducting such an evaluation, the ongoing research and experience with BRT should be considered. Relevant criteria for evaluating a demonstration project include projected GHG emission reductions, costs, and associated benefits such as reduced congestion, greater transit access for all communities, and the potential for manufacturing and other employment in California.

*C.2 Personal Rapid Transit*

Personal Rapid Transit (PRT) is a system of elevated tracks (or guideways) and small vehicles that offer automated, on-demand transportation. Most examples look like small train or monorail systems, sometimes seen at airports. In general, PRT is designed to be a public transit system that is more personalized and avoids many of the undesirable features of ordinary public transit. A government-funded, first generation PRT has been operating in Morgantown, WV for over 25 years and at least one is under construction at London's Heathrow airport. Nonetheless, no commercial PRT system are in commercial

operation today. Costs are estimated to be similar or lower than those for light-rail systems at $30-$50 million per mile. However it appears that most potential customers (cities or regional transportation boards) seem unwilling to take the risk on building the first such system.[67]

In a PRT system, individual riders or small groups order a vehicle ahead of time and would have exclusive use of their vehicle during their trip, which would take them directly to their stop. This provides a level of privacy and safety (perceived, at least) that ordinary mass transit does not, and avoids the need to rely on scheduled service. PRT vehicles would be electrically powered, like a subway or light rail system, and could lower GHG emissions relative to cars if the electricity provided to them had a lower GHG emission profile than the fuels that were displaced.

- *Timeframe:* Unclear. Firms and advocates involved with PRTs claim it is possible to proceed with the design and implementation of PRT systems in the near term, but a recent study for New Jersey noted that "PRT systems are approaching but not yet ready for public deployment."[68] However, the development of the PRT system at Heathrow and possibly other locations in the near future may provide those first examples of public deployment. Construction times are thought to be similar or less than those for light rail, although the use of new technologies may cause delays.
- *GHG Reduction Potential***:** Depends on the carbon intensity of liquid fuels and electricity.
- *Ease of Implementation:* Unclear, in part because elevated guideways are needed.
- *Co-Benefits / Mitigation Requirements***:** Added transportation capacity.
- *Responsible Parties:* Cal-Trans; local and regional transportation planning organizations.

*C.3 Smart Cards*

Smart Cards contain electronic chips that contain information that can be used for a variety of applications such as transit, tolling, and parking payments. Stockholm is interested in integrating smart cards for use on transit, taxis, and carpools throughout the city. The city estimates that this approach could reduce $CO_2$ emissions by 1,500 tons per year by 2030 – 2050.[69]

- *Timeframe:* Near to long term.
- *GHG Emission Potential*: Stockholm is interested in integrating Smart Cards for use on transit, taxis, and carpools throughout the city. This approach is estimated to reduce $CO_2$ emissions by 1,500 tons per year by the 2030 to 2050 timeframe.
- *Ease of Implementation:* Moderate to challenging.
- *Co-Benefits / Mitigation Requirements:* Less travel time associated with payment for parking and transit (e.g., idling), encourages transit use, and less/no time waiting at toll facilities.

- *Responsible Parties*: State (standardization of Smart Cards) and local/regional governments; transit agencies; and taxi companies.

*C.4 Telecommunting*

Telecommuting is generally defined as work at a remote location or home office rather than working at a fixed employer-provided site or office. Estimated fuel savings per telecommuter range from 49 to 177 gallons per year across three studies from the 1990s. [70] This range converts to approximately a 0.5 to 1.7 ton $CO_2$ reduction, per year per telecommuter, using a standard assumption of 19.4 pounds of $CO_2$ emitted for every gallon of gasoline combusted.[71] However, more recent and more comprehensive analysis to evaluate the greenhouse gas emissions from business-sector energy (e.g., commuting, office temperature control, lighting, and electric office equipment) in telecommuting and non-telecommuting scenarios suggests that while telecommuting could potentially reduce GHG emissions related to commuting, reductions may be offset by increased home office energy use and/or commercial electricity use at the business office.[72] In addition, workers that do not commute to the office may take other trips from home and back that they would not have if they had commuted that day.

- *Timeframe:* Near to long term.
- *GHG Reduction Potential*: Unclear and dependent on other factors such as energy consumption in the home office and travel behavior during tele-work days. The overall effect may be small.
- *Ease of Implementation*: Requires support from employers and public sector (e.g., incentives and pricing of parking/roads).
- *Co-Benefits / Mitigation Requirements*: Congestion will be reduced.
- *Responsible Parties*: Employers, State and regional agencies (e.g., large employers, metropolitan planning organizations, Cal-trans, business, transportation and housing agency).

*C.5 Car Pooling*

Ridesharing (or carpooling) is an arrangement where two or more individuals agree to share a vehicle to their destination (typically commute trips). Frequently, the motivation for this is to save money, spend less time in traffic (via congestion-free high occupancy vehicle lanes), or reduce hassle (e.g., searching for a parking space at the office). A carpooling project in Stockholm, Sweden allows carpools of three or more people to use bus lanes for destinations in the city. The city government there estimates that this effort will reduce $CO_2$ emissions by 15 tons per year by 2050.[73]

- *Timeframe:* Near to long term growth potential.
- *GHG Reduction Potential:* Modest.

- *Ease of Implementation*: More challenging without value/road and parking pricing policies. Nevertheless, an increase in ridesharing often occurs with higher fuel prices.
- *Co-Benefits / Mitigation Requirements*: Reduced VMT and parking demand.
- *Responsible Parties:* Regional government; Cal-Trans; employers.

*C.6 Park-and-Ride Facilities*

Park-and-ride lots are public parking facilities that enable commuters to leave their personal vehicles in such lots and transfer to transit or a carpool for the rest of their trip. Private vehicles are parked in the facility throughout the day and they are picked up when travelers return at the end of the day. Typically such facilities are found in the suburbs of large metropolitan areas. Development and management of park-and-ride lots is an important way to promote sustainable transportation.[74] Increasing park-and-ride facility capacity in Stockholm is estimated by the city to reduce $CO_2$ emissions by 600 tons per year by the 2030 to 2050 timeframe (City of Stockholm, 2002).

- *Timeframe:* Near to long term (growth potential)
- *GHG Reduction Potential*: Moderate to large.
- *Ease of Implementation:* Low to moderate challenge, depending on facilities/spaces needed and required oversight.
- *Co-Benefits / Mitigation Requirements*: Less VMT, less parking demand, and greater transit ridership. This could divert individuals away from transit to ridesharing and increase the need for more park-and-ride facilities to accommodate a greater number of parking spaces (i.e., land use impacts).
- *Responsible Parties*: Caltrans; regional planning organizations; employers; transit agencies

*C.7 "Low-Speed" Modes*

"Low-speed" modes are motorized and non-motorized devices that travel at lower speeds, such as bicycles, electric bicycles, Segway Human Transporters, and neighborhood electric vehicles. Some of these modes use human propulsion and do not produce $CO_2$ emissions. By enhancing the bicycle and pedestrian environment, it is possible to encourage travelers to take entire trips or partial trips with non-motorized modes that link with mass transit. One way to encourage bicycling as an alternative mode is through a better low-speed mode infrastructure, particularly on-street bike lanes.[75]

The city of Stockholm's long-term plan to reduce GHG emissions includes replacing 30 million short car trips with cycling annually. For longer trips, the city's goal is to encourage an additional 2,000 cyclists to give up car travel or public transit use every day during the summer months. Not surprisingly, this will require improving the low-speed mode infrastructure. Stockholm estimates that such improvements will reduce $CO_2$ emissions by 2,900 tons per year by 2050 (City of Stockholm, 2002).

- *Timeframe:* Near to long term growth potential.
- *GHG Reduction Potential*: Moderate.
- *Ease of Implementation:* Low to high (depending upon available land and political support.)
- *Co-Benefits / Mitigation Requirements*: By enhancing the bicycle and pedestrian environment, it is possible to encourage travelers "to take entire trips or partial trips with non-motorized modes that link with mass transit[76]"
- *Responsible Parties*: Regional and local government; transit providers.

*Problem:* Urban transportation systems are often inconvenient for pedestrians and cyclists.

*Possible Solutions:* Development of pedestrian and bicycle friendly infrastructure at the local and regional level should be a priority. Federal law should also be revised to define bicycling as a "qualified" form of transportation eligible for the transportation fringe benefit, subject to specific incentive caps. The Bicycle Commuters Benefits Act of 2007 would amend the Internal Revenue Code to include a bicycle commuting allowance as a qualified transportation fringe benefit, excludable from gross income. The public sector can play a key role. For example, all State and other government buildings should provide bicycle parking whenever feasible to do so. Municipal governments should try "bike sharing" programs like the one in Paris, France, which provides conveniently located public bicycles for a small fee.

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**D. Traffic Flow Improvements**

*D.1 Traffic Signal Control*

Traffic signal controls can integrate freeway and surface street systems to improve traffic flow and vehicular and non-motorized traveler safety and provide priority services for transit or high occupancy vehicles. They can manage traffic speeds, vehicle merging and corridor crossings, as well as interactions among vehicles and low-speed or non-motorized modes—such as bicycles, pedestrians, and wheelchairs—at intersections.

- *Timeframe:* Near to mid-term.
- *GHG Reduction Potential:* Studies suggest that improved traffic signal control can produce fuel savings. [77] Results from a signalized intersection, using a real-time control strategy, resulted in a "four percent reduction for $CO_2$ emissions in peak traffic, corresponding to a 14 percent reduction in the part of costs due to stops and delays." These effects are reduced by approximately one half when traffic is fluid.[78]

- *Ease of Implementation*: Within a jurisdiction less challenging; providing transitions from one jurisdiction to next is more challenging.
- *Co-Benefits / Mitigation Requirements*: Smooth traffic flow, reduced stops and fuel use.
- *Responsible Parties*: Local and regional governments

*D.2 Incident Management*

ITS traffic surveillance technologies—such as radar, lasers, and video image processing used to collect information—can help to reduce detection and incident clearance costs. Incident management consists of three key areas: traffic surveillance (incident detection and verification), clearance, and traveler information. Also covered within this area are emergency management services, which coordinate local and regional incident response to traffic accidents, security threats, and hazardous material spills. ITS technologies employed can include traffic surveillance, digital and dispatch communications (including route guidance to the site of an incident), and signal priority (optimization of traffic signal timings along routes traveled by emergency vehicles). ITS contributions to incident management include improved surveillance, verification, and dispatch to manage an incident. The use of a changeable message sign (CMS) and personal communication devices, such as cell phones and personal digital assistants (PDAs), can assist with early notification for upstream drivers resulting in reduced incident-related congestion, as drivers have more time to select an alternate route.

- *Timeframe*: Near to mid-term.
- *GHG Reduction Potential*: Improved incident management has the potential to decrease fuel consumption by reducing the delay and congestion associated with blocked traffic. While data on incident delay reductions are limited, model calculations for a Maryland initiative (called CHART) have shown fuel savings of 5.06 million gallons per year. [79]
- *Ease of Implementation*: Low to moderate.
- *Co-Benefits / Mitigation Requirements*: Reduces traffic congestion and accidents.
- *Responsible Parties*: Caltrans; regional and local governments; California Highway Patrol.

*D.3 Electronic Toll Collection*

Electronic toll collection (ETC) allows for electronic payment of highway and bridge tolls as vehicles pass through a toll station. Vehicle-to-roadside communication technologies include electronic roadside antennas (or readers) and pocket-sized tags containing radio transponders (typically placed inside a vehicle's windshield).

- *Timeframe*: Near to mid-term.
- *GHG Reduction Potential*: Studies show that ETC saves time and reduces energy consumption and emissions by reducing the stop-and-go traffic associated with

vehicle queues approaching toll plazas, stopping to pay a toll, and accelerating to rejoin regular traffic flow. [80] One recent study along the New Jersey Turnpike found savings of 1.2 million gallons of fuel per year due to reduced delays at toll plazas employing ETC. Approximately three-fourths of the reported savings accrued to passenger cars and one-fourth to commercial vehicles.[81]

- *Ease of Implementation:* Low to moderate.
- *Co-Benefits / Mitigation Requirements*: Reduced congestion, accidents; potential equity effects (due credit card billing to ETC account, some may not have access to credit card.)
- *Responsible Parties*: Metropolitan planning organizations; Caltrans (as appropriate).

*D.4 Traveler Information*

ITS-based traveler information technologies—such as traffic surveillance and transit management systems—support the collection, processing, and dissemination of real-time information about travel modes and conditions. The objective of traveler information is to provide the traveling public with information regarding available modes, optimal routes, and costs in real time either pre-trip or en-route via in-vehicle information and CMSs along roadsides or at transit stations. Effective traveler information requires the accurate collection and dissemination of real-time travel information to transportation managers and the public to aid them in making informed decisions about travel time, mode, and route. A wide array of ITS technologies assist with traveler information including: in-vehicle guidance; web sites; cell phones; PDAs; and CMS technology.

- *Timeframe*: Near to mid-term.
- *GHG Reduction Potential*: The actual impact of traveler information on fuel consumption and $CO_2$ emissions depends on a number of factors. For example, if ITS technologies assist drivers with route selection and guidance, benefits will likely be greater the less familiar a driver is with an area. Fuel economy benefits of route guidance systems could reduce non-optimal route driving and save up to 10 percent of miles driven and proportional fuel consumption.[82]

  The timeliness and delivery of information will also influence the degree to which travelers use it and subsequent energy/$CO_2$ emission impacts. Benefits might result from mode shifts (e.g., from a single occupancy vehicle to transit or bicycle) and savings proportional to travel time reductions achieved by taking alternate routes.
- *Ease of Implementation*: Moderate to challenging; the infrastructure to collect real-time information is necessary.
- *Co-Benefits / Mitigation Requirements*: Traveler satisfaction, reduced delays, increased transit ridership/alternative transportation modes; potential for privacy concerns (monitoring of travel times from toll tags.)

- *Responsible Parties*: Metropolitan planning organizations; local governments; and CalTrans.

## E. Goods Movement

*E.1 Alternative Fuels*

GHG emissions from diesel fuel consumption are produced by three specific transportation uses identified in California's GHG inventory: onroad (28.6 $MMTCO_2E$), railroad (3.1 $MMTCO_2E$) and other (0.5 $MMTCO_2E$) (Bemis and Allen 2005).[83] These uses consume approximately 3.9 billion gallons of diesel fuel in California.

Both biodiesel (fatty acid methyl ester, or FAME) and biomass-derived Fischer-Tropsch diesel (BFTD, referred to simply as low-GHG FT diesel earlier in this section) can be used in current diesel vehicles. The American Society of Testing and Materials has approved a standard for FAME at blends levels up to 20 percent by volume but some engine manufacturers caution about blends over 10 percent.[84] A third type of biomass-derived diesel fuel can be produced by the hydrogenation of animal or plant oils, possibly including both waste oils and crop-derived oils.[85] BFTD and hydrogenated oils are extremely similar to ordinary petroleum-derived diesel, being sulfur-free hydrocarbons. These fuels have energy densities and other properties very similar to those of ordinary diesel fuel so their introduction is likely to be relatively simple and require little in the way of infrastructure. However, these fuels are relatively new and there is little information about their global warming impact in the open literature, and none in the peer-reviewed literature.[86]

Natural gas is also a heavy duty vehicle fuel and can be is available in California as both a compressed and liquefied gas. There are over 125,000 natural gas vehicles in the U.S. today, and about 200 natural gas refueling stations in California. The carbon intensity of natural gas is about 25 percent less than that of diesel fuel, although this advantage is diminished somewhat because natural gas engines tend to be less efficient than compression ignition engines using diesel fuel. Advances in natural gas engine technologies and increasingly stringent diesel engine emission requirements tend to reduce this gap. Thus, heavy duty vehicle use of natural gas may also help lower GHG emissions in the transportation sector.

Off-road electric vehicles in California could contribute to state GHG reductions by 2020. These technologies can be applied in logistics (also known as freight handling and goods movement) as well as other applications such as small lawn and garden engines, which are numerous in California. Jackson (2005) evaluated two applications at ports: the use of shore power instead of ships' engines for electricity and heat (a practice called "cold ironing") and the use of electric-drive cranes instead of diesel-powered cranes.[87] Two truck-related electric applications were also evaluated: electric truck refrigeration units (e-TRUs) instead of diesel-powered devices; and the supply of electricity at truck stops as a substitute for engine idling.

*E.2 Electric Freight Rail*

Cargo transport is responsible for 8 percent of state $CO_2$ emissions and is forecasted to increase rapidly in the future. Meeting California's climate goals will require policies that lower these emissions. One possibility is to substitute electric rail for highways for goods movement. Another possibility is to develop electric powered guideways (similar to PRT systems) for freight shipments.

Electrification of the freight rail system in California would be a significant undertaking, and would probably require significant system upgrades, including both infrastructure and locomotives. For instance, in order to maintain productivity and efficiency in the Ports of Long Beach and Los Angeles, electrification out to distances as far as Barstow, Yuma, Arizona and Bakersfield may be necessary. Such an upgrade might also allow for continued growth in rail traffic and perhaps even a shift in mode from road to rail freight, even in the face of increasingly stringent GHG emission reduction targets. Such an expansion would be expensive and might well require new land rights of way for increased trackage, but if it encouraged mode shifts, these electric rail systems would also tend to relieve congestion for motorists on California's 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 electricity generation). High-speed electric rail could reduce GHG emissions considerably.
- *Ease of Implementation:* Most rail systems are privately owned. For the most part, Amtrak operates on private rail Rights-of-Way, with freight transport taking precedence. Creating new tracks that allow for the separation of passenger and freight operations would be a first step toward improving both transport delivery systems. However, electrification of rail systems would require major infrastructure and locomotive investments.
- *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 Solutions:* Standard rail transport systems emit far fewer $CO_2$ emissions per ton-mile than long-haul trucking (the exact benefit varies with distance). Electrified rail travel -- including shipments from truck to rail as well as from diesel rail to electric rail --

would reduce emissions *and* lower oil imports. Coordination with the high speed rail authority would be needed.

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**F. Other**

*F.1 Alternative Fuels for Aircraft*

Because fuel is a major cost of flying, the aviation industry has improved its energy efficiency significantly in recent decades, but as in other areas of transportation, efficiency is only part of the solution. Better fuels and better infrastructure will also be needed. There is significant RD&D activity investigating the possible use of alternative and/or renewable fuels for aircraft. This research is inadequately supported especially since it may be possible to gain significant GHG emission reductions from the aviation sector. Firms like Boeing and Virgin are already testing algae-derived biofuels in flight, some of which have performance equal to or better than current kerosene-based fuels. Of course, safety concerns in aviation are paramount, adding slightly to the challenge of low carbon aviation fuels.

Better infrastructure for aviation may include upgraded air traffic management systems, which industry groups suggest could lower GHG emissions by 10 percent-15 percent. Unfortunately, Federal RD&D support for these technologies has fallen recently. Airport expansion is another potential aviation infrastructure improvement, but will tend to increase air travel much more than improve operating efficiencies, allowing GHG emissions to increase.

- *Timeframe:* Long-term.
- *GHG Reduction Potential*: High.
- *Ease of Implementation:* High to medium.
- *Co-Benefits / Mitigation Requirements***:** There is potential for air quality benefits near airports as well as reduced radiative forcing impacts from co-pollutants such as nitrogen oxides and particulate matter.
- *Responsible Parties:* CARB; CEC; California universities.

*Problem:* Improvements in engine and airframe efficiencies are likely to be outpaced by projected increases in demand for passenger air travel. While aircraft engine and airframe efficiencies have historically improved over time, they are not sufficient to overcome projected increases in passenger miles. That role may ultimately need to be filled by low-carbon fuels. Potential improvements in air traffic management systems have been slowed recently by reductions in Federal RD&D support. Airport expansion plans are not evaluated in terms of GHG emission implications.

*Possible Solutions:* California should publicly support RD&D into bio- and alternative fuels for use in aviation applications. According to Boeing, the use of "bio-jet" fuel from the same feedstocks as vehicle fuels like biodiesel and ethanol is possible in the near term

as a blend to stretch supplies of Jet-A refined from crude oil. Feedstocks with potentially lower land-use impacts -- such as switchgrass and algae -- have also been identified as possible options.

Integrated Gasification technology is another potential option for producing fuels from renewable sources. Kerosene suitable for aviation can be co-produced with other liquid fuels, diesel and naptha. Wood is considered a potential feedstock, and the value of electricity co-produced can bring down the cost significantly while the $CO_2$ emissions equal to the content of the fuel would be removed from the atmosphere as crops are grown. According to scenario studies, $CO_2$ emissions could be just a few percent of conventional kerosene.[88] Under a high electricity value and other favorable assumptions, one UK study found that gasification could bring prices closest to petroleum Jet - A. The CEC has also recently funded a gasifier demonstration project in Northern California using wood waste as a feedstock.

In the long-term, hydrogen is another potential fuel sources that can be produced from renewable resources. Hydrogen as a fuel is considered a very long term bet, due to the need to re-design aircraft to accommodate this fuel. To the extent that a hydrogen fueling infrastructure is developed for ground transportation, this would also support any future shift in the aviation industry to hydrogen as a fuel source.

Increases in Federal support for RD&D of advanced air traffic management systems would help improve the air travel infrastructure and could provide modest reductions in aviation-related GHG emissions. Potential airport expansions should be considered only if the GHG emission effects are considered justified. The State of California might consider a detailed evaluation of how to improve the carbon profile of air travel in the state, including all three of the following operational aspects; better aircraft; better fuels; and better infrastructure.

## Appendix VI: Summary Table of Public Responses to Request for Climate Change Emission Control Technologies

**In May 2008, ETAAC solicited input from the public regarding suggestions for greenhouse gas emission control technologies. The responses received are summarized below.**

| ID | Suggestion | Pollutant saving | Cost | Contact Last Name | Contact First Name | Organization |
|---|---|---|---|---|---|---|
| 1 | direct photoelectrochemical H2 generation from Water | CO2 | $2.08/kg H2 | Oakes | Thomas W | Solar Hydrogen Co. |
| 2 | increase recycling and materials-specific waste limits | 5mmtCO2-eq | | Smithline | Scott | Californians Against Waste |
| 3 | petroleum coke to H2-fueled turbine for electricity generation | CO2, sequestered | $2B capital, 2 percent /yr operating | Rau | Tiffany | Carson Hydrogen Power |
| 4 | improved fuel/air mixing increases combustion efficiency | CO2, others | $199/gas engine | Mogford | John | Tadger Group International |
| 5 | pulse corona discharge to control soot from combustion | soot | na | Harris | Godfrey | Pulsatron Technology |
| 6 | more HOV lane stickers to incentivize high mpg vehicles | CO2 | na | Kutaka-Kennedy | Joy | citizen |
| 7 | fuel and oil additives for improving vehicle mpg | CO2, others | na | Phelps | Kyle | Advanced Lubrication Technology |
| 8 | H2 ICE and fuel cell transit buses | CO2 | na | na | na | na |
| 9 | on-board water to H2 generation for ICE intake air fumigation | CO, PM, HCs, others | $12,900 for large diesels | Gilchrist | Steve | Canadian Hydrogen Energy Company |
| 10 | fuel taxes to encourage high mpg vehicle development | CO2 | na | Fromm | Larry | Achates Power |
| 11 | high-albedo materials to reduce a/c cooling demands | 110-210kg CO2/year/100sq m treated roof | $0.0 - $0.20 /sq foot | Taha | Haider | Altostratus Inc. |
| 12 | SCR for ferry boats | NOx, THC, PM | 17 percent of vessel constructio n costs | Weaver | Chris | EF&EE |
| 13 | solar, wind, fuel cell ferry boats | CO2 | na | Culnane | Mary | San Francisco Bay Area Water Transit Authority |
| 14 | split cycle retrofit kit for existing engines | NOx, PM, 50k tpd CO2-eq for CA diesel fleet | $500/liter displaceme nt | Rutherfor d | Rob | Roted Design Ltd. |
| 15 | advanced mpg display in cars to inform/incentivize drivers | CO2 | na | Rhett | Norm | citizen |
| 16 | improve electricity generation efficiency by enhanced turbine H2 cooling system control | .64mmtpy CO2/yr from 32 plants | $140k-$260k per plant | Speranza | John | Distributed Energy Systems |

| | | | | | | |
|---|---|---|---|---|---|---|
| 17 | relocate power plants to oil fields for CO2 sequestration and oil recovery | na | na | Zozula | Kerby | Ventura County APCD |
| 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 | CO2, others | na | Hodge | Cal | For a 2nd Opinion Inc. |

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|---|---|---|---|---|---|---|
| | to subsidize high mpg cars | | | | | |
| 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/year | Simmons | Blake | Sandia National Laboratories |
| 51 | biodiesel from algae | CO2 | $.52/L | Simmons | Blake | Sandia National Laboratories |
| 52 | on-board ammonia for reducing NOx | CO2 | na | Jacobson | Wiliam | SY-Will Engineering |
| 53 | capture landfill gas for power generation | CO2, CH4 | na | Bennet | Russ | Redding Power |
| 54 | increase average vehicle ridership through ridesharing incentives | CO2 | na | Bishop | Josepth | Traffic Bulldog |
| 55 | Demand Side Management, reduced population growth | CO2, others | na | Bennett | Russ | Redding Power |
| 56 | proprietary substitute for blowing agent for polyurethane and polystyrene foams | F-gases, HFCs, 500k tonnes CO2-eq | na | Kalinowski | Tim | Foam Supplies Inc |
| 57 | tax rebates for residential solar water heaters | CO2 | $1500 rebate/unit | Del Chiaro | Bernadette | Environment California |
| 58 | decentralize worksites for large organizations to reduce commute emissions | CO2 | na | na | na | na |

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|---|---|---|---|---|---|---|
| 59 | convert diesel engines to natural gas | CO2 down 20 percent -25 percent | na | Funk | Werner | Omnitek Engineering |
| 60 | ice storage air conditioning to shift a/c loads to off peak hours | CO2 4-6 tpy CO2-eq/commercial building | up to $30k/installation | Kuhlman | Paul | Ice Energy Inc. |
| 61 | solar conversion of ambient CO2 to fuel | 450 tpd CO2 per 100k gallons MeOH produced | $5-$6/gallon gasoline equivalent produced | Stechel | Ellen | Sandia National Laboratories |
| 62 | truck APU | CO2, others | $1350 installed, $120/yr | Dennehy | John | Emerson Suphal |
| 63 | convert all CI & SI engines to run on plant-based fuels | CO2, others | equal or less than current fuels | Hotaling | Dick | Fleet Multi-Fuel Corp |
| 64 | use nuclear power, iron-seed oceans to increase algae | CO2 | $.10/kw-hr, trillion dollars | na | na | nrc.gov, planktos.com |
| 65 | fuel additive to improve fuel economy | CO2 | $03-$.12/fuel gallon treated | Taplin | Harry | BTU Consultants |
| 66 | continue incentives for CHP projects | CO2 50 percent reductions over central power plants | $1800-$3000/kw plus .5-2 cents/kw | Wong | Eric | California Clean DG Coalition |
| 67 | scrubber for removing VOCs without combustion | CO2, others | 10 percent -100 percent cost of conventional thermal oxidizer systems | McGinness | Mike | EcoShield |
| 68 | hybrid HVAC using evap cooling, heat exchangers and thermal storage | CO2, others | $15/sq ft | Lentz | Mark | Lentz Engineering Associates |
| 69 | install solar collectors as Salton Sea evaporates to reduce dust and generate power | CO2, dust | na | na | na | na |
| 70 | install flue gas condensers on boilers/heaters to recover latent heat | CO2, CH4, reduced by 10 percent -15 percent | na | Abma | Sid | Sidel Systems USA Inc |
| 71 | reactors to reduce ag waste for burial/sequestration and oil recovery | CO2 | $500/unit | Semerau | John | na |
| 72 | ban high consumption light bulbs, incentivize residential solar panels, etc. | CO2 | na | na | na | na |
| 73 | restore ecosystem | CO2 200 | na | Coleman | William | Planktos |

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| | productivity | tons/hectare | | | | |
| 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 | Truebloo d | 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 | CO2, 10ktpd for 500MW plant | na | Graham | Wendy | Air Products and Chemicals Inc. |

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| | costs | | | | | |
| 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 |

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| 111 | incentives for hybrids to replace older cars, ala Moyer program | CO2 | na | na | na | na |
| 112 | enhance phytoplankton fertility as offshoot of Ocean Thermal Energy Conversion facilities | CO2 | na | Barry | Chris | Ocean Renewable Energy |
| 113 | digestion and co-digestion of organic feedstocks to methane for CHP | CO2, CH4 | na | na | na | na |
| 114 | suction to remove CO2 from atmosphere | CO2, CH4 | na | Goodrich | John | na |
| 115 | alt fuels for Container Terminal Equipment | CO2 | na | na | na | na |
| 116 | replace older equipment with lean burn equipment | CO2 | na | Ayala | William | Jon's Marketplace |
| 117 | partial oxidation catalyst for vehicles | CH4, NOx 41 percent | $18-$30/vehicle | Bartley | Gordon | SwRI |
| 118 | permitting fast track for businesses using green technologies | CO2, CH4 | na | Ryan | Hank | Small Business California |
| 119 | focus on efficiency, incentives for performance | CO2 | na | na | na | na |
| 120 | instead of cap & trade, use tax refunds/feebates to incentive technology development and commercialization | na | na | Johnson | Ken | na |
| 121 | find substitute for Si in PVs, advance Ni-metal-hydride for H2 storage in cars | CO2 | na | Deniz | Gladys | na |
| 122 | better refrigerator insulation, lower appliance stand-by power demand, prioritize hiway lane access | CO2 | na | na | na | NA |
| 123 | CO2 capture via hydrogenation to methane | CO2 | na | na | na | ECO2 (Norway) |
| 124 | innovative HVAC system for improved indoor air quality at reduced energy consumption | CO2 | na | Mumma | Stanley | Penn State |
| 125 | wind power to generate H2 for vehicle use | CO2 | na | na | na | na |

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[12] Assuming an average emissions factor of 805 lbs. $CO_2E$/MWh.

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[29] Ibid.

[30] It has been estimated that there is the potential of storing over 1 billion tonnes of $CO_2$ 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.
[31] The volume of $CO_2$ that must be extracted from all power plant emissions streams is orders of magnitude greater than those used and sequestered in EOR processes. A single 800-MW coal-fired power plant will produce approximately 6.1 million tons of $CO_2$ annually, compared to the approximately 5 million tons of $CO_2$ used annually by the largest EOR projects.
[32] Myer, Larry, *$CO_2$ Sequestration Options for California*, ETAAC, California Energy Commission, May 10, 2007
[33] Hobbs, Ray, *Topical Report: Development of Hydrogasification Process for Co-Production of Substitute Natural Gas (SNG) and Electric Power from Western Coals*, NETL, May 31, 2007.
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[35] Rau, Greg, *The Essential Role of $CO_2$ Sequestration in Stabilizing Atmospheric $CO_2$*, U.C. Santa Cruz and Lawrence Livermore National Laboratory, ETAAC, May 10, 2007.
[36] A number of deep, leak-proof geologic formations have been identified as candidates for long-term $CO_2$ storage. These include depleted oil and gas reservoirs, deep saline formations, and unmineable coal seams. In most cases, $CO_2$ would be injected into such formations as a supercritical fluid to maximize the storage density. To ensure that injected $CO_2$ 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 $CO_2$ storage is the subject of much international research and many testing programs.
[37] IPCC Special Report, *Carbon Dioxide Capture and Storage, Summary for Policymakers.*
[38] 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.
[39]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.
[40] There are ICGG plants operating in Florida, Indiana, California, Delaware, Kansas, Italy, Spain, Japan and Singapore.
[41] There are currently two operating coal-based IGCC plants in the U. S. and two in Europe. The two U.S. projects were supported initially under the DOE's Clean Coal Technology demonstration program but are now operating commercially without DOE support.
[42] 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.
[43] Rau, Greg, *The Essential Role of $CO_2$ Sequestration in Stabilizing Atmospheric $CO_2$*, U.C. Santa Cruz and Lawrence Livermore National Laboratory, ETAAC, May 10, 2007.
[44] Reheis-Boyd, Catherine H., Letter to Alan Lloyd, Ph D. Chair, ETAAC, Western States Petroleum Association, June 13, 2007.
[45] MRW & Associates, *Nuclear Power in California: 2007 Status Report*, Prepared for the California Energy Commission, Sacramento, CA, June 2007.
[46] Nuclear Energy Institute, New Nuclear Plant Status as of August 2007.
[47] Since LLNL is managed by the UC, it provides several important linkages to the ten UC campuses. The Campus-Laboratory Collaborations (CLC) Program and the Campus-Laboratory Exchange (CLE) Program are efforts to foster and support collaborative research efforts between the campuses and LLNL. Research collaborations between LLNL and the UC campuses have produced many beneficial results in the carbon sequestration area. Three of the eight CCS projects conducted at UC campuses mentioned above were collaborations with LLNL.

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