

**ETAAC Advanced Technology Development
Draft Report
For Public Review**

September 18, 2009

Public Comments are Requested by October 9, 2009

**ETAAC ADVANCED TECHNOLOGY DEVELOPMENT
DRAFT REPORT
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This draft report is released for public review, and does not necessarily represent the position of any individual ETAAC member.

ETAAC Advanced Technology Development Report

Chapter One - Introduction

This report updates the original ETAAC February 2008 report with information on technology developments and policy developments such as the federal stimulus bill. It also focuses in on the challenges & opportunities for advanced technology development needed to meet California’s long-term GHG reduction goals, meet California’s air quality goals, and to compete in the marketplace. While the federal stimulus bill and other programs play an important role addressing some of the advanced technology development challenges identified by ETAAC, ETAAC finds that the State of California still holds a critical role for technological innovation. This report contains recommendations for California to continue its leadership role and promote technologies in the transportation, renewable energy, and energy efficiency sectors, while capturing economic opportunities. This introductory chapter will discuss the need for advanced technology development, advanced technology development challenges, and some examples of several existing programs intended to overcome those barriers.

The need for advanced technology development to meet GHG goals

Meeting climate change goals will require both the rapid deployment of existing technology as well as the commercialization and deployment of technologies that have not yet been commercialized or do not yet exist. For instance, CARB determined in 2004 that existing technology options could cost-effectively reduce passenger vehicle emissions by about one third by 2016 under Pavley GHG

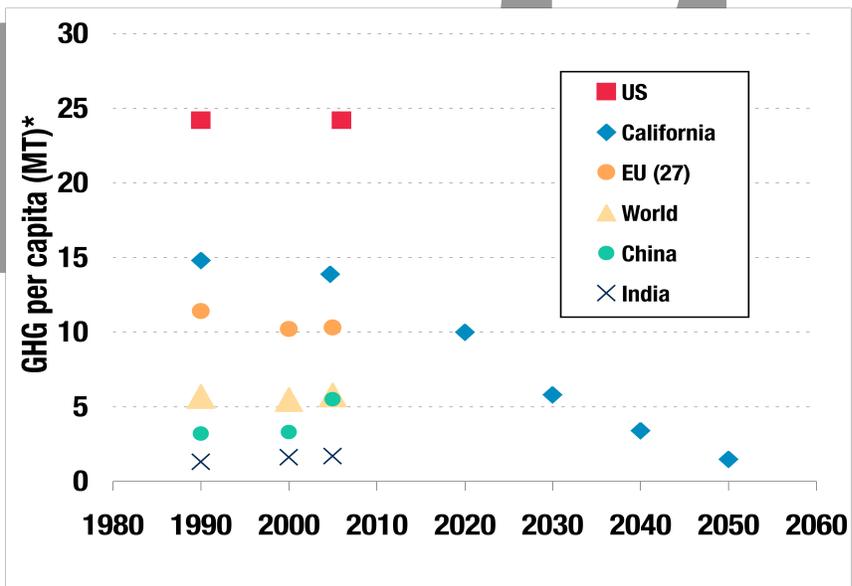


Figure 1-1 (Source: ICCT)

regulations (Pavley). Coupled with CARB’s upcoming “Pavley 2” regulation and related programs, applying existing technologies to passenger vehicles will make a major contribution to the emission reductions needed through 2020. On the other hand, achieving long-term GHG emission reduction goals out to 2050 shown in *Figure 1-1* will require a dramatic shift to zero and ultra-low GHG transportation technologies that do not yet exist at commercial scale. While transportation is the largest sector in terms of GHG emissions as seen below in

figure X, a comparable shift to zero and low-carbon technologies will be needed across all major sectors to meet long-term GHG reduction goals as well as 2020 goals.

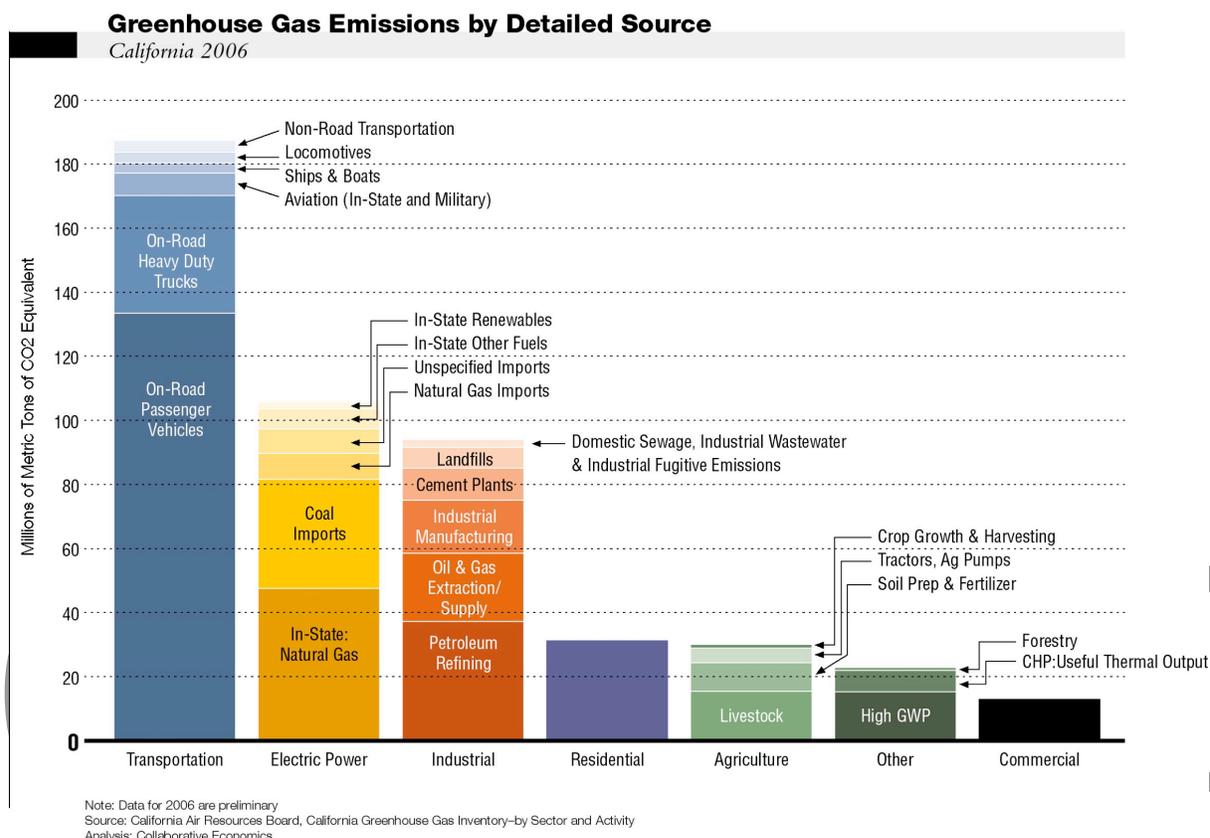
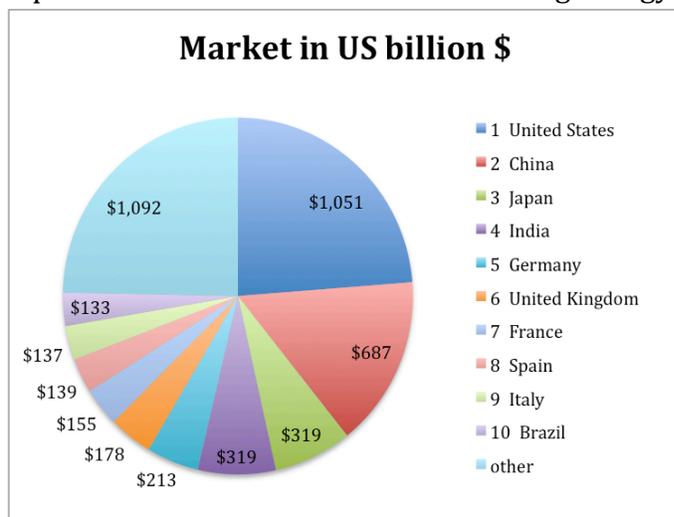


Figure 1-2 (Source: Next10)

While these technologies are needed to meet long-term goals, California must act to facilitate technology development pathways now. New technologies require a significant lead-time for development and commercialization. In the meanwhile, new fossil fuel fired power plants are likely to have a 30-50 year lifetime. Passenger vehicles have a 10-20 year lifespan, and it has taken a decade for hybrid passenger vehicle technology to reach a 5% market share in California. Infrastructure built to serve today's technologies may last a lifetime. Clearly, deploying the best technologies that are on the shelf today and then going about "business as usual" will not be sufficient to develop the advanced technologies needed to meet long-term GHG reduction goals and other environmental and economic goals.

In addition, "green jobs" are a leading growth industry in California. While these industries are not immune to the global recession, California environmental policies can continue to serve as a long-term driver for job creation. Renewable energy and other low and zero

greenhouse gas technologies are estimated to be a \$4 trillion market globally¹ as seen below in *Figure 1-3*. However, the global technology race in areas such as electric vehicles and renewable energy is dramatically escalating. In addition to providing zero and low-greenhouse gas products and services, California businesses will themselves need to implement innovative methods for cutting energy consumption and costs to remain



competitive. As noted by the United Kingdom's Stern Report, the cost of inaction would sharply escalate the inevitable economic costs of transitioning, even before considering the severe economic and environmental damage that would be inflicted by unmitigated climate change. Later sections of this report will provide a more detailed look at the economic development opportunities and challenges in general, and as they apply to the development of specific technologies.

Figure 1-3: Global "Green" Markets by Country (Source: UK BERR report)

Advanced technology development is also necessary to meet local air quality goals. For instance, air quality plans for the San Joaquin Valley and South Coast Air Quality Management Districts inhabited by about twenty million California residents rely on technology development to fill in a "black box" of unspecified emission reductions. Many of the advanced technologies needed to achieve GHG goals are likely to also reduce other air pollutants by increasing efficiency and shifting to non-polluting resources. For instance, reducing future in-state power generation emissions by 25% in 2020 through energy efficiency and renewable energy technologies would similar quantities of GHG reductions as well as avoid over 6,000 tons per year of emissions that cause ozone and fine particulates². Cutting on-road emissions by 5% through electric drive vehicles powered by zero emission renewable energy would avoid over 20,000 tons per year of these pollutants in 2020³.

¹ Low Carbon and Environmental Goods and Services: an industry analysis, Innovas, May 6, 2009, commissioned by the United Kingdom's Department for Business Enterprise & Regulatory Reform.

² Emissions reductions are ICCT calculations based on CARB's CEFS database available at <http://www.arb.ca.gov/app/emsinv/fcemssumcat2009.php>. The CARB scoping plan calls for a 26% reduction from "business as usual" electric sector emissions from renewable energy and electrical energy efficiency (not including combined heat & power).

³ Emissions reductions are ICCT calculations based on CARB's CEFS database available at <http://www.arb.ca.gov/app/emsinv/fcemssumcat2009.php>.

Advanced technology development that creates appealing low and zero carbon transportation and energy technologies is also critical to creating economic development trajectories that allow developing nations to address their own local and national air quality issues while avoiding the worst effects of climate change globally. As seen in figure 1-4, global energy demand in developing nations is forecast to increase by over 70% between 2006 and 2030.

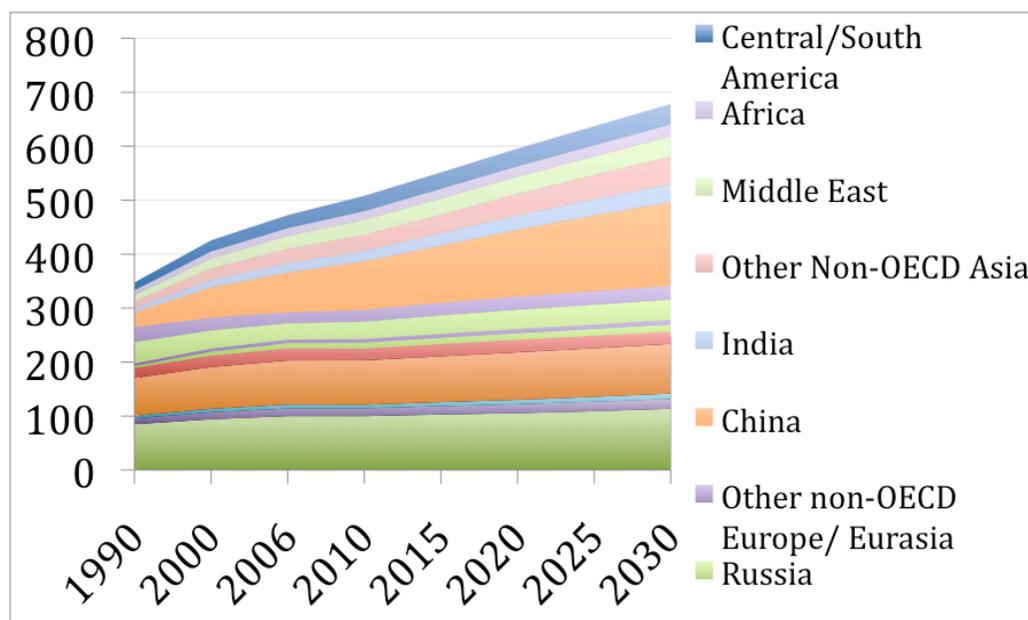


Figure 1-4 Global Energy Consumption in quadrillion BTUs (EIA, <http://www.eia.doe.gov/oiaf/ieo/ieorefcase.html>)

Technology Development & Commercialization Challenges

The focus of this report is on technologies that have developed to the point where their potential GHG reduction benefits can be assessed, but have not yet reached full commercialization. This may be a particularly important state role, bridging the traditional federal focus on basic scientific research with industry's focus on commercializing available

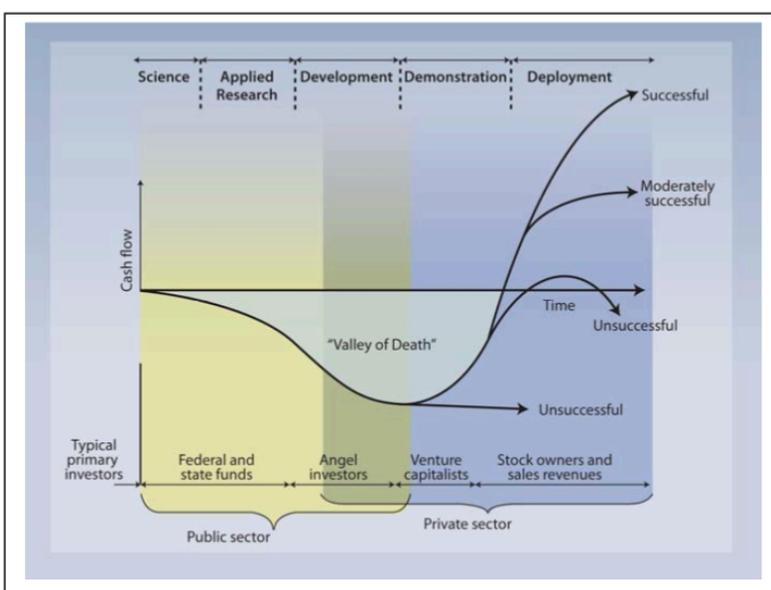


Figure 1-5 (source: "Carbon Lock-in, Barriers to Deploying Climate Change Mitigation Technologies")

technology and product development⁴. Later sections of this report focus on economic development opportunities & challenges, and technologies within the transportation, energy efficiency, and renewable energy sectors that will play an important role in meeting California's long-term GHG and environmental goals. (Please see the original February 2008 ETAAC report for a number of important recommendations in other sectors as well. *Appendix X* of this report contains a summary of ETAAC's February 2008 recommendations for overcoming barriers to promote R&D and technology development.)

Technology development & commercialization involves challenges that are described in the Oak Ridge National Laboratory's "Carbon Lock-in" report⁵.

"The commercialization and deployment process begins with "basic research" and "science," which provides the underlying foundation of knowledge that can lead to fundamental new discoveries. This part of the research continuum tends not to be problem-driven, but rather involves scientific study and experimentation to advance understanding. The next stage of "applied research" is problem-driven and is intended primarily to solve specific technical challenges impeding progress in technology development. This "strategic" research applies knowledge gained from more fundamental science research to the more practical problems associated with technology R&D.

The following stage of "development" includes applications engineering and possibly field testing. "Demonstrations" are then needed to evaluate the technology's performance in real-world operating systems. This may be followed by further production engineering to improve the fit between market conditions and technology characteristics. Finally, "deployment" activities are undertaken, including the development of distribution channels, targeted niche marketing and supply chain alignment, followed by cost reductions and broader market development to ultimately achieve widespread "market saturation." Time and effort spent in each stage along this path to market saturation varies by technology, and innovation does not occur without interaction with external forces."

In addition to technical challenges, there are also financial challenges throughout the R&D, demonstration, early commercialization, and mass market stages. New technologies must navigate most, if not all, of these stages and each stage presents different policy, technology and financial challenges. No technologies remain unchanged through this cycle; no entrepreneur has mastered the dynamics of each stage; and no financier is comfortable with the risks inherent in each category.⁶ The "Valley of Death" seen in figure 1-5 represents a formidable financial

⁴ Cal Economic Strategy Panel, *complete footnote*

⁵ "Carbon Lock-in: Barriers to Deploying Climate Change Mitigation Technologies", Oak Ridge National Laboratory, sponsored by US Climate Technologies program, revised January 2008, Marilyn Brown et. al.

⁶ CalCEF presentation to ETAAC April 29, 2009. Available at <http://www.arb.ca.gov/cc/etaac/meetings/042909pubmeet/mtgmaterials042909/Adler.pdf>.

challenge where the amount of capital needed is greater than typically available as equity. Technologies not yet proven at scale are unlikely to qualify for traditional commercial loans for demonstration projects, creating serious barriers as noted below.

Financial challenges continue through the initial deployment stage. For instance UK Carbon Trust analysis of several representative technologies found that deployment required 40 times the resources of projects at the R&D stage⁷.

ETAAC Perspective on Technology Development Challenges

ETAAC recognizes that public policy solutions are needed if new technologies are to overcome a daunting array of potential barriers identified at the national and international level. (See the “Carbon Lock-in, Barriers to Deploying Climate Change Mitigation Technologies” report for additional description of these and other potential barriers.)

As part of this ETAAC research effort, ETAAC examined barriers, from a California perspective, in four categories: Cost and Market Barriers; Information Barriers; Government Barriers; and Industry Structure and Infrastructure Barriers. The first question is how frequently a particular barrier is likely to occur in California. The second is how severe the barrier tends to be when it does occur. The results of this assessment, shown below in *Figure X*, provides useful background when confronting advanced technology development challenges. Later chapters on specific technologies will identify which are most specifically relevant to individual technologies, as which barriers are the most important to address can vary by technology.

ETAAC members have identified barriers within the cost and market category as the most frequent and severe market barriers. For instance, higher up-front costs are a universally frequent and severe concern, closely coupled with a lack of financial return for “externality” benefits such as lower emissions of GHG and other pollutants. For instance renewable energy, energy efficiency, and transportation technologies frequently have a higher up-front capital cost that is repaid from energy savings over time. Demonstration costs & risks are generally (although not universally) considered to be a frequent and severe barrier as well. Barriers to developing market demand for new technologies are medium to high frequency and severity, along with related information barriers to customer adoption of new technologies.

The industry structure & infrastructure category also contains a number of barriers that are both frequent and severe. Investment in long-term infrastructure, coupled with lack of investment in new infrastructure, is generally (although not universally) considered to be a both frequent and severe. Lack of fueling stations for alternative fuel vehicles is one clear example and transmission for new renewable electricity is another. Large incumbents industries with market power may have significant long-term investments in existing

⁷ “Focus for success: A new approach to commercializing low carbon technologies”. UK Carbon Trust, 2009, p. 10.

infrastructure and markets and are often, though not universally, seen as a significant barrier to technology development by committee members.

There appears to be a common view that government standards, fiscal policies, and approval processes are sometimes a barrier to development of new technologies. The severity of these barriers is usually considered moderate when they do occur with the exception of the approval process itself. Barriers related to the approval process and/or uncertainties about timing and outcomes sometimes occur and were most often though not always considered a serious barrier when they do occur. For instance, the original ETAAC report notes that citing new renewable energy technologies typically involves approval processes that do not apply to existing fossil-fuel power plants.

While the federal stimulus bill and other existing programs play an important role addressing some of these barriers as noted in *section X*, this report will address gaps where the state can play a key role. The following sections of this report will describe where barriers have been overcome or where gaps remain for manufacturing and examples of opportunities for advanced technology development in the transportation, renewable energy, and energy efficiency sectors.

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Potential Barriers to the Commercialization and Deployment of Low and Zero Greenhouse Gas Technologies

Cost and Market Barriers		
<i>External Benefits</i>	Frequency- high Severity- high , in some cases considered medium	External benefits of GHG-reducing technologies that are not available to the owners of the technologies, as well as other environmental benefits and employment & other spill-over economic benefits are examples.
<i>Up-Front Capital Costs</i>	Frequency – high Severity - high	Up-front capital costs are higher for the production and purchase of many zero and low-carbon technologies. While capital costs are often repaid over time, lack of access to capital and short term planning by industries, small businesses, and households can compound this barrier. Capital-intensive demonstrations may be particularly challenging.
<i>Demonstration Costs & Risks</i>	Frequency – high/med Severity- high/med	Technologies in the development & demonstration phase may have higher capital cost, higher labor/operating cost, increased downtime & lower reliability, lack of standardization, and/or lack of engineering, procurement and construction capacity. Private investments in reducing this costs & risks through demonstration projects may be disincentivized by benefits that can be shared by competitors.
<i>Market Demand</i>	Frequency – med/ high Severity- med/ high	Customers may be risk/change-adverse; “chicken and egg” dilemma of low demand for emerging technologies prior to full commercialization may inhibit production at scale necessary to achieve full commercialization.
<i>Misplaced Incentives</i>	Frequency- medium Severity- medium (in some cases considered low or high)	Misplaced incentives occur when the buyer/owner is not the consumer/user (e.g., landlords and tenants in the rental market and speculative construction in the buildings industry) – also known as the principal-agent problem.
Information Barriers		
<i>Incomplete and Imperfect Information</i>	Frequency- high/med Severity- med/ high	Lack of information about technology performance (especially trusted information), increased decision-making complexities, and cost of gathering and processing information about new technologies are potential barriers. This barrier may be compounded to the extent that shared benefits of customer education are a distinctive for private investments.
<i>Lack of Specialized Knowledge</i>	Frequency – med/ high Severity- in some cases considered low, med, and high	Inadequate workforce training/expertise, cost of developing a knowledge base for available workforce, and inadequate reference knowledge for decision makers are examples.
Categories developed from Oak Ridge National Laboratory Report “Carbon Lock-in, Barriers to Deploying Climate Change Mitigation Technologies”, Dr. Marilyn Brown et. al as revised January 2008; February 2008 ETAAC report; ETAAC April & June 2009 meetings		

**ETAAC Review of Potential Barriers to the Commercialization and Deployment of
Low and Zero Greenhouse Gas Technologies**

Government Barriers		
<i>Unfavorable Standards</i>	Frequency- med Severity- med (in some cases considered high)	Standards that “grandfather” existing infrastructure and facilities; programs that operate in “silos” rather than integrating relevant concerns such as air quality, climate change, and energy security; and rules granting access to water rights and other resources on a “first come first served” basis can create barriers.
<i>Uncertain Standards</i>	Frequency – med Severity- med	Examples of uncertainty about future regulations of greenhouse gases including emission levels, potential GHG emission subsidies through free GHG allowances allocations, and ownership/liability of underground sequestered carbon.
<i>Unfavorable Fiscal Policy</i>	Frequency – med Severity – med (in some cases considered low)	Fiscal policies that slow the pace of capital stock turnover; state and local variability in fiscal policies such as tax incentives and property tax policies; distortionary tax subsidies that favor conventional energy sources and high levels of energy consumption are potential barriers.
<i>Uncertain Fiscal Policy</i>	Frequency – med (in some cases considered high) Severity- med (in some cases considered high)	Short-duration tax & fiscal policies (such as production tax credits); uncertainty over future costs for GHG emissions; market-development oriented incentive programs with uncertain lifespan & funding levels are examples.
<i>Unfavorable Approval Processes</i>	Frequency – med Severity – high (in some cases considered med)	Approval processes may favor incumbents if agencies lack familiarity & established processes for new technologies such as carbon capture and sequestration and off-shore energy development. Permitting/approval procedures serving valuable public purposes that apply to new but not existing facilities & infrastructure may favor incumbents that are grandfathered, especially when approval processes are not coordinated.
<i>Uncertain Approval Processes</i>	Frequency – med Severity – med/ high	Uncertain timing and outcome of approval processes may be a potential barrier.

ETAAC Review of Potential Barriers to the Commercialization and Deployment of Low and Zero Greenhouse Gas Technologies		
Industry Structure & Infrastructure Barriers		
<i>Existing Infrastructure "Lock-in"</i>	Frequency- med/ high (even split) Severity- med/ high (even split)	Existing large investments such as long-term power and transportation fuels production and distribution infrastructure can "lock-in" existing technologies.
<i>Lack of Needed Infrastructure for New Technology</i>	Frequency - high /med Severity- high	Renewable electricity transmission capacity, alternative transportation energy supply distribution, and other infrastructure needs are examples. Lack of manufacturing facilities and distribution/supply channels and other supply chain shortfalls can also be a barrier.
<i>Incumbent Industry Market Dominance</i>	Frequency- high , in some cases considered low and med Severity-mostly high , in some cases considered low	Natural monopolies or large incumbents with market power may disenable technological innovation to prevent disruption of existing profitable markets & investments.
<i>Industry Segmentation or Fragmentation</i>	Frequency- med Severity- med/low	Industry segmentation can inhibit change. For instance, manufacturing a single long-haul truck is often split among independent engine, chassis, and body manufacturers segments, with a variety of manufacturers within each segment. Small business owners may be harder to reach with information about new energy efficiency technologies, especially as their needs often vary based on business type.
<i>Intellectual Property</i>	Frequency-med Severity-low/med	High transaction costs for patent filing and enforcement, conflicting views of a patent's value, and techniques such as patent warehousing, suppression, and blocking can create barriers.

Table 1-1: Prioritizing Barriers

Example Programs to Overcome Barriers to Advanced Technology Development

1. UK Carbon Trust Report

The UK Carbon Trust recently issued a report “Focus for success: A new approach to commercializing low carbon technologies.”⁸ The report emphasizes the challenges of moving clean energy innovations from the laboratory to the marketplace, and suggests a range of focused strategies for UK policy makers to consider. ETAAC finds this work to be relevant to California’s efforts under AB32, in particular the discussion and proposals around demonstration finance that follow in the Innovative Financing chapter of this report and others. Similar to the UK Carbon Trust proposal, ETAAC believes that a concerted effort needs to be made to assist emerging technologies in crossing the “valley of death” between venture-backed, equity-supported innovations and debt-financed, large-scale proven technologies. We highlight some of the findings of the Carbon Trust here, to provide further context to the discussion that follows.

The Carbon Trust report outlines the evolution of technology development philosophy from a policy of picking specific hardware and companies, which resulted in expensive “white elephants” such as Concorde and specific nuclear technology. In response a “free market” technology neutral approach was adopted, such as general renewables obligation, but did not succeed in developing new technologies. As a result, the report recommends a “technology-focused” approach, of selecting promising sectors but not individual companies.

The technology-focused approach recommended by the UK Carbon Trust proceeds as follows:

- Identify priority low and zero GHG technologies for commercialization through systematic and transparent assessments – the demonstration stage allows a better assessment of prospects that during R&D, and there is also a need to differentiate at this stage because capital cost is 40 times higher than R&D for the technologies studied by the Carbon Trust for this report
- Designing a customized range of policy support for each of the prioritized technology families
- Recognizing the differences between earlier and later lifecycle stages & the different policies needed for each
- Create strong competition for support between companies within a technology family
- Carefully monitor against milestones to keep waste to a minimum.

The report also recommends a focus on “sunrise” instead of “sunset” industries. In the past, a policy focus on “sunset” industries – which are very visible due to the loss of existing jobs - was an expensive mistake that merely prolonged their demise. The ETAAC demonstration finance proposal in the Innovative Finance chapter accounts for these challenges by integrating a technology support program into existing energy procurement frameworks such as the Renewable Portfolio Standard program, where competition among emerging renewables can

⁸ “Focus for success: A new approach to commercializing low carbon technologies”, July 2009 <http://www.carbontrust.co.uk/default.ct>

provide a market-based screen that avoids unjustified support of low-priority technologies. Many of the other chapters also provide other examples.

2. Lessons Learned for Residential Solar Hot Water Heater Tax Credits

Residential solar hot water heaters have a long history in California. By 1897 a third of Pasadena homes had installed a solar water system, which provided savings on relatively expensive fuel supplies at the time. Large natural gas discoveries in the 1920's and 1930's in the L.A. Basin eliminated the California market at that time,⁹ though not the potential for residential solar hot water heating in California.

After the oil shocks of the 1970's, large federal and California tax credits totaling 80% of system costs were offered to home owners to overcome the initial higher capital costs of the systems. However, there were no certification or other quality assurance requirements and many companies jumped into a boom market based on these lucrative tax credits without the necessary experience. As a result, quality was inconsistent¹⁰ and the technologies' reputation for reliability suffered greatly. Quality issues, declining oil prices, and the abrupt end of tax credits in the mid-1980's led to a market bust and a lingering negative consumer perception. Quality assurance remains an equally or greater concern among consumers than cost-effectiveness¹¹ despite a technology that has matured with 46 million units installed globally.¹² Current sales in California are below 2,000 units annually¹³ – not much higher than the number of units in place at the beginning of the 20th century over a hundred years ago.

This experience provides several lessons for ensuring the successful long-term roll-out of technologies that reduce energy consumption along with air emissions and GHG. First, quality standards are needed to offset lack of information about technologies that are new to consumers (even if the technologies themselves are not new), and in some cases to overcome negative perceptions about past failures. For instance both the current California solar initiative for

⁹California Solar Center, at http://www.californiasolarcenter.org/history_solarthermal.html last accessed September 1, 2009. The leading system at the time was the "Climax".

¹⁰ Solar Water Heating: How California Can Reduce its Dependence on Natural Gas, Environment California, Bernadette Del Chiaro and Timothy Tellen-Lawton, April 2007. Accessed September 1, 2009 at http://www.environmentcalifornia.org/uploads/at/56/at563bKwmfrrtJI6fKI9U_w/Solar-Water-Heating.pdf

¹¹ *ibid*

¹² Solar Water Heating: How California Can Reduce its Dependence on Natural Gas, Environment California, Bernadette Del Chiaro and Timothy Tellen-Lawton, April 2007.

¹³ Andrew McAllister, California Center for Solar Energy, Solar America Cities Annual Meeting, April 1, 2009. http://www.solaramericacities.energy.gov/PDFs/2009_Annual_Meeting/Maximizing_Use_Solar_Water_Heating/Lessons_San_Diego_SWH_Pilot_Program.pdf, accessed September 1, 2009.

photovoltaics and the pilot solar water heating incentive set certification and QA standards and set incentives based on performance levels determined from installation-specific data.

Secondly, government incentives that create a “boom-bust” cycle can be counterproductive. Another examples of “boom-bust” cycles can also be seen from past expirations & renewals of federal production tax credits for renewable electricity as shown in *figure X* from the Gigaton Throw-Down report. The current California PV solar and the new solar hot water heating program (Solar Hot Water Heating and Efficiency Act of 2007, AB1470) phase-out incentives on a predictable schedule over a decade long-timeframe. In contrast, the federal stimulus bill is designed to pump resources into the economy as soon as possible. Federal one-time stimulus money is often focused on immediate up-front capital costs for manufacturing and purchasing but may not address other market barriers to long-term success. Later chapters on specific energy technologies will note where complimentary policies are needed to avoid “boom-bust” cycles after federal stimulus money ends.

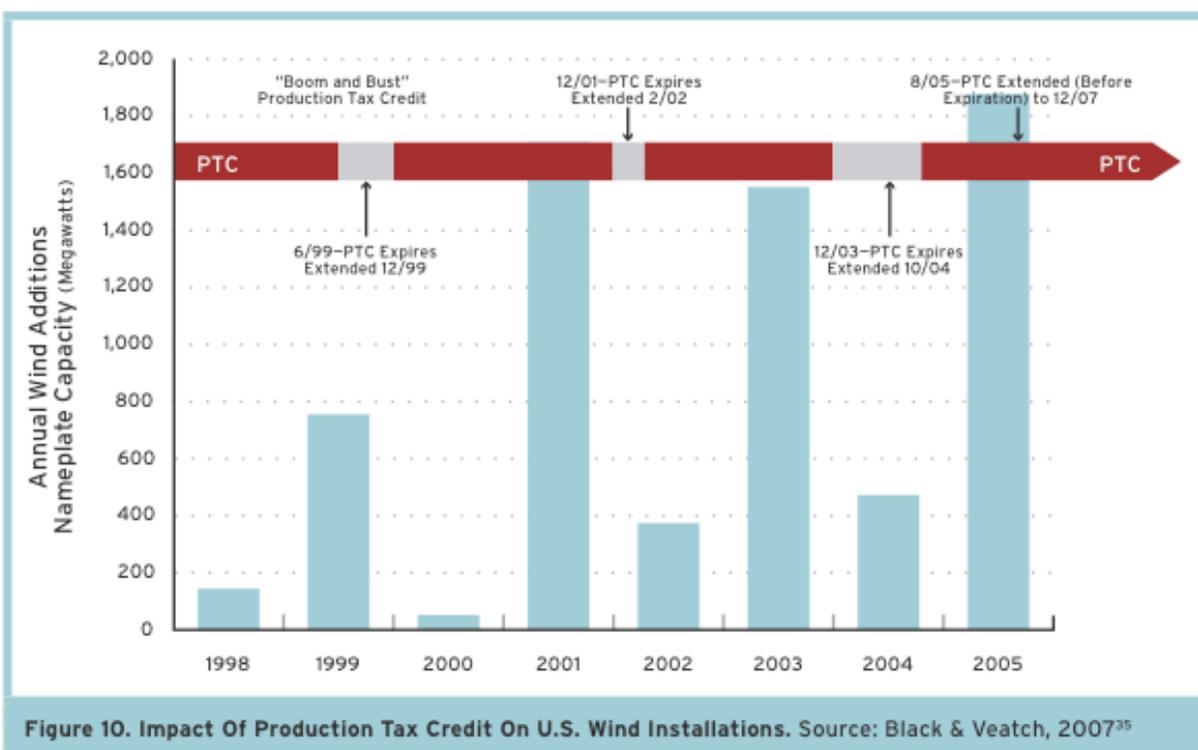


Figure 1-6 (source: Gigaton Throwdown)

3. The American Recovery and Reinvestment Act

The American Recovery and Reinvestment Act (ARRA) provides a major pulse of resources that can potentially overcome capital cost, demonstration, and other barriers to manufacturing and commercialization of many low and zero GHG advanced technologies (in addition to “shovel-ready” projects). The ARRA contains some elements that are similar to the “technology-focused” approach recommended by the Carbon Trust. For instance, a general incentive for renewable energy is also coupled with funding to develop and demonstrate several advanced

technology elements. It also includes call for significant investment in specific companies selected through a competitive process.

This section of the ETAAC Advanced Technology report provides an overview of resources related to advanced technology development from the ARRA. Technology-specific discussions later in this report will identify what barriers will likely be overcome by ARRA spending for specific technologies and what barriers will most likely require additional attention by California policy-makers at the state level or in cooperation with federal and/or other partners.

National Programs

The Department of Energy's Office of Energy Efficiency and Renewable Energy is administering \$16.8 billion in ARRA funding. While much of this funding (such as weatherization of low-income homes) focuses on "shovel-ready" projects it also contains a number of aspects that can also help advanced technology development. Technology development funding opportunities announced in June and July of 2009 include but are not limited to:

- Solid-state lighting (see ETAAC recommendation 5-B) and energy efficiency technology development for buildings
- Solar market development & high deployment rate (ETAAC chapter 5-H)
- Development of algal/advanced biofuels
- Wind turbine development (ETAAC chapter 5)
- Carbon capture and storage (ETAAC chapter 5)
- Smart grid technology (ETAAC chapter 5-C)
- Heavy duty truck technologies (ETAAC chapter 3)

The ARRA also provides \$2 billion for domestic battery manufacturing for vehicles to fund up to five facilities capable of delivering 20,000-100,000 batteries per year as well as drivetrains and components (US DOE EERA ARA plan p 6) and also contains workforce development that may help overcome some information barriers, with awards announced August 5th. This wave of funding and later "Clean Cities" awards are also expected to provide resources for infrastructure and demonstrations including market development by funding transitions to cleaner government fleets (recommended in ETAAC chapter 3). In addition to the ARRA, the "Advance Technology Vehicle Manufacturing Program" recently announced \$8 billion in awards for both advanced conventional vehicles (Ford) and plug-in vehicles (Ford, Nissan, and Tesla) and federal support of General Motors and Chrysler will likely be targeted to move them in that direction.

In addition, the ETAAC recommended (ETAAC report page 10-46) extension of tax credits for renewable energy projects through the end of 2013 worth \$16 billion (over 10 years) will help overcome capital-cost and externality barriers identified by ETAAC as frequent and serious. In addition to the scale-up of existing technologies like wind and PV solar, this financing will help develop technologies such as the thermal solar demonstration projects (see ETAAC report p. 10-40) that are in the pipeline in California (http://www.energy.ca.gov/sitingcases/all_projects.html).

The ARRA also provides manufacturing tax credits that will help address the capital cost of manufacturing low and zero GHG technologies. The ARRA provides \$2.3 billion in tax credits equal to 30% of the cost of manufacturing facilities for renewable energy; plug-in vehicles and batteries and fuel cells; carbon capture and sequestration renewable energy storage & transmission; renewable fuels refining; energy conservation technologies (including lighting); and other technologies that are certified to reduce greenhouse gases. A number of these technologies were identified as priorities in the 2008 ETAAC report and will contribute to meeting 2020 AB32 GHG goals as well as long-term GHG reduction objectives. The lower cost of manufacturing would presumably also trickle down to help consumers afford these technologies, as up-front costs to consumers have been identified as a prevalent and severe barrier to low and zero GHG advanced technology development.

The bill also contains \$6.9 billion for transit capital construction, \$4.5 billion for green buildings and over \$14 billion in other building renovations that can include energy efficiency improvements. While these projects will rely on off-the-shelf technologies, some of them could also incorporate demonstrations of energy efficiency & renewable energy advanced technologies.

State Programs and Government Awards

California was awarded \$90 million to provide a statewide energy efficiency retrofit program and cost effective clean energy systems for residential, commercial, and industrial buildings and facilities under the State Energy Program. The revenue savings from these efficiency measures will be recycled for additional efficiency measures, and this type of long-term broadening of efficiency markets can create “market-pull” for advanced technologies for energy efficiency over the long-term

California also plans to develop and implement a public education, marketing, and outreach effort to ensure the benefits and value of energy efficiency are well understood (Information barriers are sometimes a major barrier to low/zero carbon technology development in California). The California Energy Commission will expand its \$15 million investment in alternative fuel and advanced vehicle technology needs through its Green Jobs Training Program with \$20 million in ARRA funding to also include energy efficiency and clean energy sources, including wind and solar energy (ETAAC Cleantech Workforce Development recommendation 2-D). After successful implementation the state will receive more than \$113 million in additional funding, for a total of \$226 million for the entire program.

(<http://www.energy.ca.gov/recovery/sep.html>)

California is also expecting \$351.5 million in ARRA block grants via US DOE, with \$49 million received at the state level with the goals of 1) saving 61.2 million kWh of electricity; 2) save 207897 therms of natural gas; 3) reduce CO2 emissions by 22,541 tons; and 4) save local jurisdictions in excess of \$9.0 million per year

(<http://www.energy.ca.gov/recovery/blockgrant.html>). The purposes are very broad and can include developing programs (such as ETAAC on-bill financing recommendation 2-G) that encourage the adoption of low and zero carbon technology as well as potentially implementing projects for distributed generation (which could include distributed solar and digester-gas-to energy, ETAAC recommendations 4-D and 6-A). This money will be distributed by the

California Energy Commission to small cities and counties. The remaining \$301 million is distributed to large cities and counties for energy conservation. In addition, California has been issued \$74 million for weatherization with an additional \$92 million promised upon successful implementation.

Additional awards are likely to come through the \$300 million Clean Cities program for areas including alternative fueled vehicles infrastructure and vehicle demonstrations.

California facility funding

Several significant awards have been issued for California facilities. Two are related to ETAAC recommendations for low GHG new vehicles (chapter 3-E) and plug-in electric drive vehicles (chapter 5-F&G). Tesla Motors will receive a \$465 million loan to finance a manufacturing facility for the Tesla Model S sedan. Tesla intends to begin production of the Model S in 2011 and ramp up to 20,000 vehicles per year by the end of 2013, creating 1,000 jobs in Southern California. The loan will also support a facility to manufacture battery packs and electric drive trains to be used in Teslas and in vehicles built by other automakers, including the Smart For Two city car by Daimler. Early pilot battery pack production is expected to begin in 2011, reaching about 10,000 by 2012 and 30,000 packs in 2013 with 650 workers in Northern California. In addition, the Electric Transportation Engineering Corp. received a \$100 million grant to manufacture with partner Nissan 5,000 electric vehicles in Phoenix Arizona and Northern California for deployment along with charging station in California and five other states.

Another is related to the ETAAC carbon capture & storage recommendation (ETAAC 5-I). Hydrogen Energy International LLC, a joint venture owned by BP Alternative Energy and Rio Tinto, received \$308 million to design, construct, and operate an integrated gasification combined cycle power plant in Kern County. The plant would convert coal and petroleum coke into hydrogen burned for power and CO₂ separated out by the Rectisol process and injected into nearby oil reservoirs for storage and enhanced oil recovery. The project is intended to capture 90% of the CO₂ that would otherwise be emitted, or more than 2,000,000 tons per year of CO₂. The project developer expects to begin construction in 2012 and begin operation in 2015.

As noted in the following sections of this report, these investments will help overcome some of the barriers to Advanced Technology Development but not others, many of which are identified in later chapters of this report.

Please see Appendix X of this report for an updated summary of selected local, state, national, and international advanced technology development programs.

DRAFT TABLE
U.S. Department of Energy
[Energy.gov/Recovery Table](http://Energy.gov/Recovery)

Data is as of July 24, 2009

Program Office	Project	Authorized/ Appropriation (\$K)	Awarded/ Obligation (\$K)	Spent/ Outlay (\$K)
ARPA-E	Program Funding Level	400,000	0	0
	Advanced Research Projects Agency - Energy (ARPA-E)	0	23	0
	Program Direction - ARPA -E	0	72	39
ARPA-E Sum:		400,000	95	39
Energy Efficiency and Renewable Energy (EERE)	Program Funding Level	16,796,000	0	0
	Advanced Materials RD&D in Support of EERE Needs to Advance Clean Energy Technologies and Energy-Intensive Process R&D	0	900	0
	Battery Manufacturing	0	0	0
	Buildings and Appliance Market Transformation	0	2,899	0
	Commercial Vehicle Integration (SuperTruck) and Advanced Combustion Engine R&D	0	0	0
	Concentrating Solar Power	0	0	0
	EE Appliance Rebate Programs	0	0	0
	EE Conservation Block Grant Program	0	4,905	0
	EGS Technology R&D	0	0	0
	Enabling Fuel Cell Market Transformation	0	2,400	871
	Energy, Water & Emissions Reporting and Tracking System	0	0	0
	Enhance and Accelerate FEMP Service Functions to the Federal Government	0	0	0
	Fundamental Research in Key Program Areas	0	0	0
	Geothermal Demonstrations	0	0	0
	High-Penetration Solar Deployment	0	0	0
	Industrial Assessment Centers and Plant Best Practices	0	0	0
	Integrated Biorefinery Research Expansion	0	10,800	0
	Investigation of intermediate ethanol blends, optimization of E-85 engines, and development of transportation infrastructure	0	0	0
	Large Wind Turbine Blade Testing Facility	0	0	0
	Management and Oversight (EE Program Direction)	0	8,376	1,811

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	Modify Integrated Biorefinery Solicitation Program for Pilot and Demonstration Scale Biorefineries	0	0	0
	NWTC Upgrades	0	0	0
	National Geothermal Database, Resource Assessment and Classification System	0	0	0
	PV Systems Development	0	0	0
	Renewable Energy and Supporting Site Infrastructure	0	54,400	0
	State Energy Program	0	1,265,140	10,235
	Transportation Electrification	0	0	0
	Weatherization Assistance Program	0	2,121,595	49,310
	Wind Energy Technology R&D and Testing	0	0	0
EERE Sum:		16,796,000	3,471,415	62,227
Fossil Energy	Program Funding Level	3,400,000	0	0
	Expand and Extend Clean Coal Power Initiative Round III	0	0	0
	Geologic Sequestration Site Characterization	0	0	0
	Geologic Sequestration Training and Research Grant Program	0	0	0
	Industrial Carbon Capture and Storage Applications	0	0	0
	Program Direction - FE	0	631	281
Fossil Energy		3,400,000	631	281
Loans	Program Funding Level	5,970,000	0	0
	ATVM Administrative Fees Transfer	0	4,668	542
	Administrative Fees Section 1705	0	2,263	0
Loans Sum:		5,970,000	6,931	542
OE	Program Funding Level	4,496,000	0	0
	Enhancing State and Local Governments Energy Assurance	0	0	0
	Interconnection Transmission Planning and Analysis	0	0	0
	Interoperability Standards and Framework (EISA 1305)	0	10,000	10,000
	Program Direction - OE	0	355	103
	Smart Grid Investment Grant Program (EISA 1306)	0	1,150	0
	Smart Grid Regional and Energy Storage Demonstration Project (EISA 1304)	0	40,067	0
	State Assistance on Electricity Policies	0	0	0

Authorized/ Appropriation (\$K): Funds made available to DOE in the Recovery Act.

Awarded/ Obligation (\$K): Funding commitments from DOE that will likely result in payments.
Spent/ Outlay (\$K): Amount of awarded/obligated funds that have been paid.

Figure 1-7

draft

ETAAC Advanced Technology Development Report

Chapter Two – Overview of Economic Opportunities and Challenges

The economic development opportunities of advanced technology development have taken even greater importance with California’s severe economic downturn. The purpose of this chapter is to highlight the status of California’s economy regarding “green” jobs today, to identify economic opportunities for California regarding low and zero advanced technology develop, and to provide recommendations related to manufacturing advanced technologies generally. The global four trillion dollar market¹ for low and zero carbon technology contains many opportunities that are closely aligned with strategies in California Air Resources Board’s AB32 climate change plan and air quality goals.

Advanced technology development economic opportunities

“Green” jobs today are an increasingly important component of the workforce, exceeding 100,000 jobs as of 2007 (including zero and low-GHG jobs and other environmental jobs)² as seen in *figure 2-1*. While this sector is not yet large enough to offset the state’s severe economic downturn, it is important to continue growing jobs in this sector.

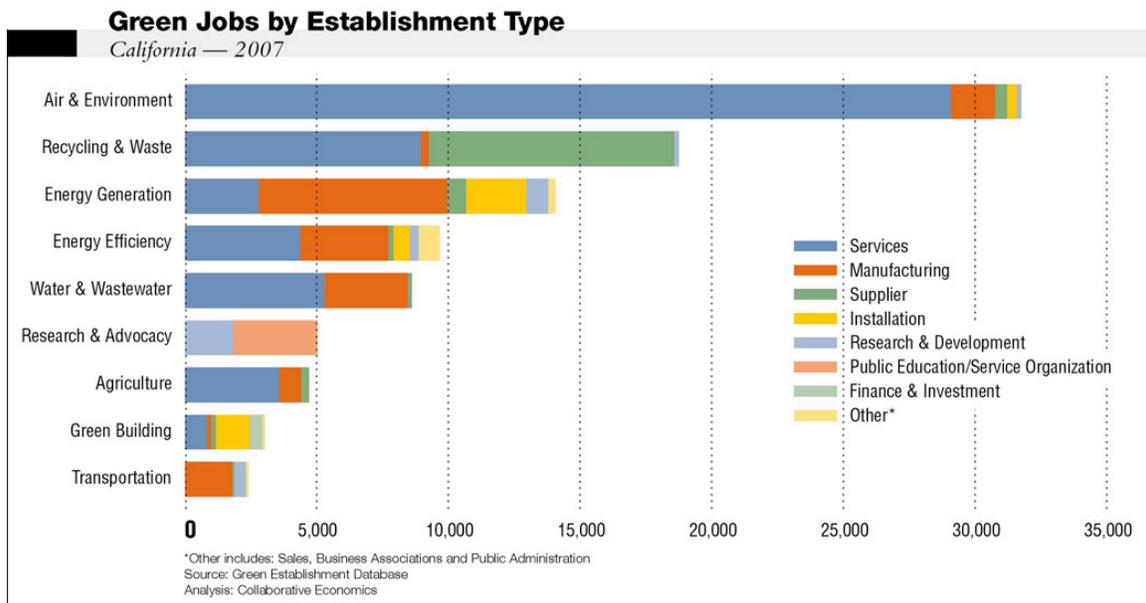


Figure 2-1 (source: Next 10)

¹ Low Carbon and Environmental Goods and Services: an industry analysis, Innovas, May 6, 2009, commissioned by the United Kingdom’s Department for Business Enterprise & Regulatory Reform. The accounting method for this data groups nuclear energy under “alternative fuel” in the BERR-sponsored report. A separate value for nuclear energy was not provided. Top categories are alternative fuels, alternatively fueled vehicles, renewable energy technologies and energy efficiency technologies as shown in figure 2-3.

² source: Next10 Green Innovations Index

In 2008 California venture capital firms received \$3.3 billion (over half of the US total VC capital), with about half of that ultimately spent in California⁴. While these levels dropped in the first quarter 2009 to \$334m/quarter⁶, that is still approximately equal to 2006 levels on a per quarter basis. In addition, global government 2009 investment in “cleantech” is likely to reach \$200 billion, exceeding the \$150 billion in private capital expenditure in 2008. US incentives include \$60 billion in direct spending and subsidies, \$7.6 billion in financing, and a variety of tax credits (E2/Cleantech – *add footnotes*). Every \$100 million in venture capital investment is estimated to create an average of 2,700 jobs (E2/Cleantech), highlighting the importance of policies that continue to attract venture capital. Leading California sectors are energy generation (especially solar), energy efficiency, transportation & related energy storage (CA Economic Strategy Panel).

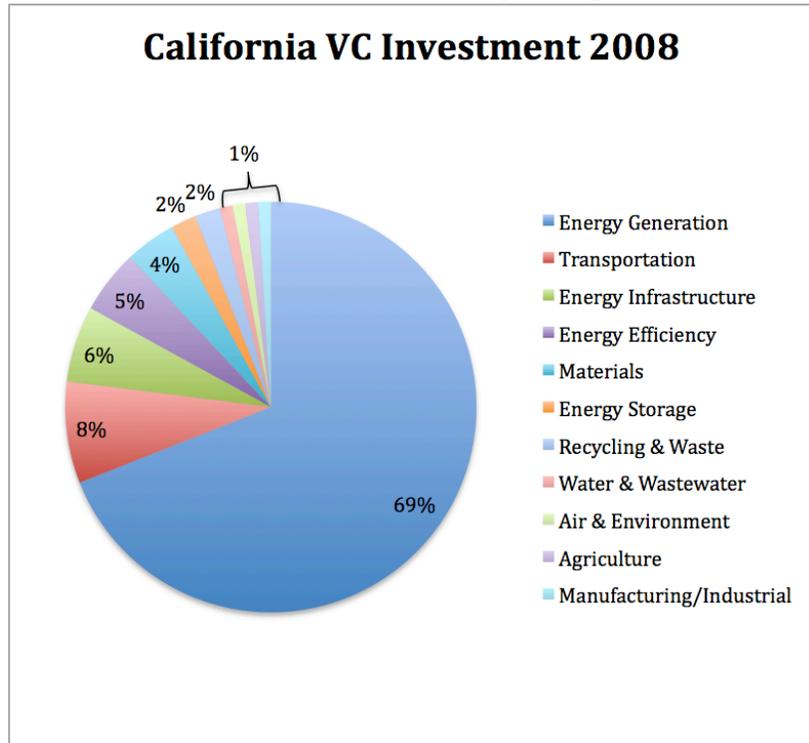


Figure 2-2: California VC Investments 2008 Distributed by cleantech segment, Source: Next10

⁴ Next10, Calstart, ABAG report, CalCEF

⁶ Venture capital declines have been due to (1) a general concern about investment risk, (2) the lack of capital from traditional investors such as university endowments and public pension funds, (3) the collapse of the market for new public offerings (4) the collapse in valuations from mergers and acquisitions, (5) more cash required by existing portfolio companies due to a shortfall in their revenues, and (6) decline in energy prices from cyclical highs in the first half of 2008.

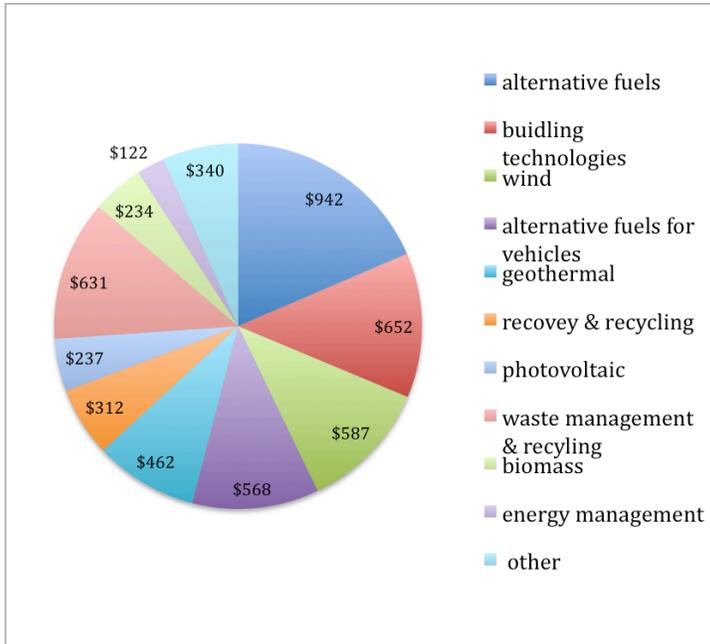


Figure 2-3: Global “Green” Markets by sector in 2009 US Billion Dollars (source: UK BERR report)

There are important opportunities for California to both encourage advanced technology development and receive economic returns. Examples of policies that create California markets (including suppliers) include AB32, the California Solar Initiative, and Proposition 118 transportation incentives. These policies together with investments and research in California, can help form clean technology “clusters” that facilitate further investment and economic development. This capability can help tilt the state toward energy efficiency & renewable energy technologies that displace imported energy supplies and create more in-state

jobs (UCB Roland-Holst report, CEC power plant licensing applications). There are also challenges, as explained for the manufacturing sector below and in the technology-specific chapters.

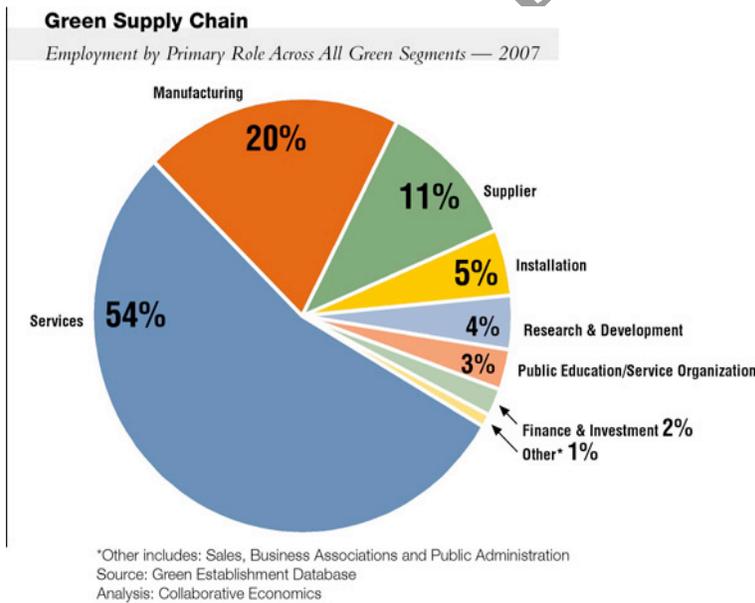


Figure 2-4 (Source: Next 10)

Service jobs are the most prominent category when environmental consulting is included, while manufacturing rises to approximately half the of total jobs for the low and zero carbon technology categories of transportation, energy efficiency, and renewable energy, which are covered in later chapters of this report. (CA Economic Strategy Panel)

Several categories of job creation resulting from policies to promote advanced technology development are very likely

to expand in-state jobs typically paying above-average wages (Bay Council/ABAG report, CA Economic Strategy Panel). Installation and supplier jobs need to be located close to in-state customers, along with the operation and maintenance portion of service jobs. Consulting and research jobs also have ties to in-state customers, although they are to some extent mobile. Perhaps the largest potential for job mobility into or out of California is in the manufacturing sector, as discussed below.

UK BERR report top growth areas:	
<i>Technologies</i>	<i>Countries</i>
Wind Turbines and Systems	China
Photovoltaics	India
Alternative Fuels for Vehicles	Pakistan
Energy Efficient Windows	South Korea
Other Alternate Fuels	Thailand

Figure 2-5: Background on California’s “CleanTech” Manufacturing

California’s manufacturing sector has shrunk about a fifth in the last decade, several percent more than the rest of the US manufacturing sector, yet still continues to play an important role in the state’s economy by providing a total of 1.5 million direct jobs (California Economic Strategy Panel) and important additional indirect benefits. Roughly half of California “Green” jobs for energy generation, energy efficiency, and transportation technologies are in manufacturing (including assembly) – approximately 13,000 overall⁷. Renewable energy (largely PV solar), lighting, environmental controls, and electric drive transportation are top sectors for the most “Green” manufacturing jobs (along with heating & other machinery) (Cal Economic Strategy Panel p.17, Telsa announcement, Next10). This shows that California has an existing platform to compete for advanced technology manufacturing jobs such as renewable energy, solid-state lighting, monitoring & controls for energy efficiency, and electric drive transportation covered in more detail in following chapters

California manufacturing enjoys competitive advantages and also suffers competitive disadvantages for capturing these jobs. An emphasis on “specialty” & flexible manufacturing may fit well the emergence of new advanced technologies (Bay Council/ABAG report). The proximity to financiers, markets, suppliers, and researchers is a potential advantage to California advanced technology manufacturers. On the other hand, these advantages may be offset or outweighed by California’s expensive and challenging business climate, including higher US labor rates compared to international competitors (CA varies when compared to other states) (Bay Council/ABAG), tax rates such as sales tax for manufacturing equipment (ETAAC p2-16), and higher real estate prices.

⁷ This number does not reflect recent job losses due to the recession nor job gains due to federal stimulus spending described in other chapters of this report.

Energy costs can be a serious disadvantage, in particular for energy-intensive industries. Energy rates are higher (such as cents per kilowatt hour) than US averages and many international competitors (Bay Council/ABAG). Energy efficiency programs can offset some of this premium for industrial sectors (ETAAC p4-1), and ETAAC has recommended a number of opportunities to increase these savings further in both our original February 2008 report and in Innovative Financing and Energy Efficiency Chapters of this report.

This landscape favors manufacturing advanced technologies with low input costs and healthy profit margins and disfavors those that are more labor and energy-intensive. While conditions may be better for manufacturers of advanced technology than other manufacturers, there are few assurances that even advanced technologies manufacturing will be located in-state.

Policy Recommendations on facilitating manufacturing's role in advanced technology development

Access to capital and the higher upfront capital costs for low and zero carbon technologies may be the most significant barrier limiting technology development and associated economic development. ETAAC believes that capital costs combined with other barriers identified in chapter one are the reason why technologies identified as cost-effective, such as in the McKinsey Report, are often not implemented. AB32 is likely to require significant capital investments both for manufacturers that become more efficient in response to GHG costs in their own supply chain as well as for companies responding to customer demand and market opportunities created by AB32. For instance, the capital cost of manufacturing facilities for plug-in hybrid battery packs may be \$3 million per 1,000 packs annual capacity or more (Gigaton Throw-down). Companies in California must also pay sales tax on manufacturing capital equipment, which is exempt in most other states⁸.

Potential solutions could be modeled on a successful program in the United Kingdom. The UK Climate Levy imposed since 2001 recycles revenues back to businesses to help them with the capital costs of making transitions to lower their carbon footprint. Companies can depreciate 100% of capital costs in the first year⁹, offsetting much of incremental up-front costs of transitioning to efficient low and zero carbon equipment. Small businesses can access zero interest loans, and companies that meet reduction targets receive a major discount on the levy. AB32 cap& trade allowances paid for by California businesses could be similarly be used in part to help California businesses transition to most efficient “best in class” operations through tax incentives or low/zero

⁸http://cpr.ca.gov/CPR_Report/Issues_and_Recommendations/Chapter_1_General_Government/Improving_Business_Climate/GG17.html

⁹ This program is considered effective though not universally known and does not always completely offset the increased capital costs (House of Commons Environmental Audit Committee, ICCT/Next10 summary) and a 80% discount for meeting climate targets is another significant incentive

cost loans while also helping create markets for advanced zero and low GHG technologies. Allowance value may be the best opportunity at the state level due to the difficulty of finding available state revenues - although there is a potential obstacle if federal legislation is adopted that constrains how the value of allowances are used. (AB32 scoping plan fees for high global warming potential gases could be used for a similar purpose.)

Another important step is making sure that small and medium sized businesses receive informational assistance accessing stimulus funding that supports advanced technology development. A UK study found that “small businesses generally have fewer resources with which to monitor government policy so are less aware of new announcements”¹⁰, which is also true in the United States. Prioritizing outreach in California, including efforts underway at some state agencies, is especially critical due to the combination of a major push to spend one-time stimulus money and severe state agency budget constraints. It is also important to make sure that workforce training dollars from the stimulus bill or other sources are spent on high-priority workplace needs and not just spent quickly on temporary jobs. The original ETAAC report recommended workforce training, (a major barrier identified in chapter one of this report) to address the following priorities:

- 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.

As noted in original ETAAC report¹¹, demonstration project funding & partnerships will also benefit advanced technology development & deployment in California by overcoming demonstration project barriers noted by ETAAC. These programs can also help California manufacturers improve their own efficiency and competitiveness.

These recommendations will facilitate the manufacturing of advanced technologies to meet environmental and economic goals, and can be best implemented as part of a comprehensive long-term economic strategy for the state.

¹⁰ HC 354, “Reducing Carbon Emissions from UK Business: The role the Climate Change Levy and Agreements”, p 13 and pp 29-30 with regard to UK Climate “Levy” and associated small business interest-free loans to reduce energy use

¹¹ See February 2008 ETAAC report p2-7, 2-11, 4-11, 4-12, 9-5.

ETAAC Advanced Technology Development Report

Chapter 3 – Innovative Financing Strategies –

This chapter addresses innovative financing strategies to promote advanced technology development. These strategies are needed to overcome the higher upfront cost of technologies that often repay themselves over time from lower energy costs. These strategies also promote market creation by lowering the cost to consumers of technologies and products. This chapter addresses a range of market segments from renewable energy technology demonstrations to residential mortgages. It also addresses other strategies including municipal assessments, on-bill financing, and other strategies that can benefit both California businesses and residents.

Financial Strategies to Support Emerging Clean Energy Technologies

I. Demonstration Finance Strategies

The challenge of financing unproven technologies at scale is a large and growing component of the clean energy transition. In brief, and as discussed in the ETAAC report adopted in February of 2008, the issue arises due to a structural weakness in the clean energy finance industry: risk equity, in the form of venture capital, finances technology development, while debt markets will support proven technologies in achieving infrastructure scale. The crucial intermediate step, the provision of funding for a maturing but not fully-proven technology to demonstrate its viability in real-world settings, is missing from the financial marketplace. As clean energy technologies mature, the absence of this financial support will only become more detrimental.

The existence of this problem is well known, and potential solutions are emerging (ETAAC report, E2 Carbon Trust report, pending CalCEF and CEG reports). California has the opportunity to combine a number of these potential solutions and integrate them with existing clean energy procurement mechanisms, in particular the well-developed policy tools used in the state's Renewable Portfolio Standard (RPS) program. What follows is a brief description of some of these potential solutions, presented in a form that attempts to locate each option along the spectrum of technology development from early-stage concept to proven, scalable resources.

Framing Issue – an Emerging Technologies Plan. California's RPS program does not presently include a structured plan for the consideration of interesting innovations that reasonably balance the public interest in clean energy deployment and the need for ratepayer protections against downside risk. Absent this plan, regulators and utilities must consider each emerging technology on a standalone basis, with little means for determining the potential programmatic benefits of sponsoring one technology project over another. Moreover, there is little if any opportunity to share the benefits of project success with the ratepayers that undertake a portion of the necessary financing risks. Formation of a statewide plan for the integration of emerging technologies with RPS procurement may encourage more strategic choices of demonstration opportunities. The

plan can also be paired with a shared earnings approach, such as that discussed below, to promote an equitable distribution of financial benefits.

Identification of Funding Source and Scale. The CEC PIER program provides one source of R&D funding for emerging technologies. Once a technology moves beyond lab or limited field testing and is ready for a large scale demonstration (e.g., first MW), technology developers typically rely on obtaining utility power purchase agreements (PPAs) to help them secure financing. Considering that some commercially available renewable technologies already carry a cost premium (e.g., solar PV) compared to conventional fossil fuel generation, the utilities and the CPUC may be reluctant to grant PPAs for emerging technologies that could have even higher costs or carry greater uncertainties. Given the generally higher cost of emerging renewable technologies, it may be reasonable to consider a “regulatory budget” to support a demonstration finance strategy in conjunction with the RPS program, which could take the following form:

- a. Integration with the CEC PIER program for the funding of emerging technologies. The two programmatic efforts of RPS and PIER have not been sufficiently integrated in the past, potentially wasting a useful collaboration opportunity between the two agencies.
- b. Taking a programmatic approach to fund the above-market portion of emerging technology PPAs. With or without the financial support of the CEC PIER program, there may be extra costs that ratepayers will absorb through such mechanisms as an above-market Power Purchase Agreement authorized to spur deployment of a new technology. A comprehensive program strategy should identify the funding source, scope, maximum amount and process for funding above-market emerging renewable projects, while considering the potential ratepayer impact to limit upward pressure on rates.

Physical Location of Demonstration Facilities. A core component of the demonstration challenge is the inability of new technologies to be sited and tested in real-world operating conditions. Performance under these conditions, including the inevitable failures and the attendant systems repair and learning that occur, must be closely monitored over extended periods in order to provide project lenders sufficient data against which to lend. It is unlikely, however, that a single demonstration facility will be optimal for the range of potential renewable technologies; a potential solution might be to set aside a dedicated portion of existing or planned resource areas for specific technology types – e.g., a wind sub-park in the Tehachapi or solar thermal park in the Mojave, taking advantage of existing resource assessments, transmission interconnections, and other high-cost logistical issues that demonstration-stage companies are unlikely to be able to address.

Streamlining Integration of Demonstration Technologies in the RPS Program. The establishment of dedicated demonstration facilities helps to address a major integration issue for small projects. Further streamlining initiatives could include:

- a. A separate track for procurement of specified emerging renewables within the RPS– for example, a demonstration-specific track drawing in the technologies that will populate the reserved areas at technology-specific locations on the grid.

- There could also be a separate procurement track for specified emerging technology categories (e.g., biomethane) that cannot be demonstrated at a specific location.
- b. Ensuring that land use and permitting issues are addressed at the demonstration facility level, as opposed to being placed on the technology provider solely, creating a true “plug and play” environment for emerging technologies. This potentially mirrors the larger scale strategy under development for proven technologies within the RETI process.
 - c. Collecting the necessary performance monitoring data at the demonstration facility, to assess technology viability in preparation for scale-up.
 - d. If appropriate, establishing a milestone-driven process where an emerging technology can “graduate” to participating in the regular utility RPS RFO process, where the technology would be evaluated on equal footing with other renewable technologies.

Dedicating Energy Program Staff to Coordinating Engagement with Federal Funding Opportunities. Multiple federal programs exist that can aid in the progression of developing technologies, principally including direct grants, direct loans, and indirect loan guarantees. To best avail California of these resources, reduce the financial burden on ratepayers supporting emerging technology, and aid technology developers in efficiently accessing these funds, the state could consider the following:

- a. Dedicate staff to coordinating with federal agencies (DOE and Treasury) with purview over the relevant funding programs, to educate federal agencies about California’s demonstration program and potentially streamline the awarding of funds to worthy demonstration technologies. For example, a loan guarantee award to a technology maturing through the demonstration program could be made contingent upon the same set of milestones as described above.

Sharing Financial Benefits with Utility Ratepayers. While it can be bounded via the planning and funding process described above, ratepayer exposure to financial risk is potentially considerable under a demonstration finance program. The framework of such a shared-benefit structure is understood, and could potentially include creating a royalty payment mechanism for demonstration projects funded under the emerging technologies track described above to recover a portion of the ratepayer-funded, above-market PPA costs. The royalties can be paid into a utility balancing account when projects are developed and operational, where the funds could then be credited to ratepayers to reduce rate burdens, recycled into future iterations of the demonstration finance program, or both.

Conclusion. The potential solutions outlined above only begin to describe the range of options available to California in addressing this important problem. It is intended to spur discussion involving ETAAC and interested stakeholders as the State engages solutions to the problems identified in ETAAC’s previous undertakings.

II. Mortgage and Home-Equity Financing

Mortgage and other home-equity products can also play an important role in broadening the market for deployment of energy efficiency, renewable energy, and potentially also advanced transportation technologies by lowering up-front costs and increasing customer demand.

Energy Star mortgages are available for both home buyers, and for energy-efficiency retrofits by current homeowner. Energy Star mortgage pilots in Colorado and Maine provide homeowners with significant discounts on loans costs. For instance, the Colorado Governor's Office⁴ has taken a leadership role in their pilot for 2009. If successful, California should take a leadership role to also offer them in California and tie them into existing energy efficiency strategies. These mortgages can compliment on-bill financing and municipal assessments described above since some homeowners may prefer a more traditional bank financing approach, or may not have access to these other alternatives.

Currently, energy efficient mortgages are available to reflect the higher value of energy efficient loans and increased ability of homeowners to pay for them due to lower energy costs⁵. The increased use of home energy efficiency ratings can further enhance the use of these loans. The initial home-purchase loan can also be used to finance improvements to the efficiency of a home after purchase. While the housing market has taken a significant downturn in California, the opportunity for energy efficiency savings is still very important.

Transportation-efficient loans are also available in areas where transportation costs are lower due to transit service and compact development. Alternate-fueled vehicles which have significantly lower operating costs (such as electricity vs. petroleum) may also increase ability to repay mortgage costs, although not all of the same cost-savings would occur compared to avoiding a car altogether. To the extent that CARB can certify operating cost savings, this may facilitate the incremental expansion of location-efficient mortgages to transportation-efficient mortgages.

An emerging type of financial tool is Shared Equity notes. A number of entrepreneurial financial intermediaries are offering Shared Equity notes for the bulk purchase of lender-owned or REO (real estate owned) homes and the restructuring of existing pre-foreclosure and troubled mortgage obligations. Shared Equity-financed REO homes can be refurbished and made energy efficient to add value to the property, the community, and the environment. Unlike a traditional mortgage lender, a Shared Equity investor participates in the future growth of a home's value. With these notes, there is no lender but rather an investor who is entitled to a fixed percentage of the value of the home when the note matures, generally upon sale or refinancing of the home. There are no monthly

⁴ <http://www.nocoenergystarhomes.org/mortgages/index.html>, viewed 9-17-09

⁵ http://www.energystar.gov/index.cfm?c=bldrs_lenders_raters.energy_efficient_mortgage, viewed 9-17-09

payments, and accordingly, no risk to the owner of losing their home to the investor for failing to make such payments.

Market participants believe that cities which are likely to have 1) a high number of REO or near-foreclosure properties, 2) high energy costs, 3) less efficient buildings, and 4) communities already showing interest in sustainability would be the best places to enter the market. Providing customers with the ability to learn about and compare financing to other options could accelerate market adoption, and entities seeking to invest in energy efficiency could consider a portfolio of shared equity loans.

III. Financial Aggregation Strategies to Support Energy Efficiency⁶

This section explores the need for **financial aggregation** to unlock the development and implementation of advanced technology by grouping multiple projects in order to lower transaction costs and investor returns. Despite the broad array of market participants in the California energy efficiency and renewable energy marketplace, their activities have been largely confined to a relatively narrow band of services that are tailored to the needs of public sector, tax exempt, municipal customers. While it is true that local utilities and state agencies offer programs that serve industrial and large commercial customers, large portions of the market remain underserved. Limited financial products and business solutions are available to meet the needs of key small commercial and residential customers, groups that represent a significant portion of the energy savings potential in California. Although this disconnect between market segments with the largest energy reduction potential and the foci of major market participants is a hurdle in and of itself, numerous sector-specific barriers also limit the widespread adoption of energy efficiency.

What follows is an overview of the selected financing products and approaches, a summary of existing barriers to their implementation, and a review of strategies and actions that can lead to their widespread utilization.

Financial and Geographic Aggregation: Contractual Assessments – Residential & Small Commercial

Overview: Passed in July 2008, California Assembly Bill (AB) 811 allows efficiency improvements to be financed from contractual assessments on existing properties (i.e., property taxes). Specifically, local cities and municipalities can finance projects by issuing a bond (or raising funds through other means) to pay for initial installation costs with repayment made through tax rolls. Despite its recent enactment, several cities are already incorporating AB 811 contractual assessments into their energy efficiency and renewable energy initiatives, such as Palm Desert, Sonoma County and Berkeley or, like Chula Vista and Santa Monica, are considering doing so.

Under AB 811, a local agency within a city or county can form an assessment district that has the authority to levy property to finance energy efficiency or renewable energy-

⁶ This section is drawn from the white paper “New Business Models for Energy Efficiency,” produced by CalCEF *Innovations* in 2009 (www.calcef.org/innovations)

related improvements. Loans under AB 811 are secured by a property tax that remains with a property until paid off, regardless of changes in ownership. A key element of AB 811 is that it can be utilized only for existing properties.

Barriers to Contractual Assessments: Although AB 811 can help remove first cost hurdles to energy efficiency and renewable investments, it does not address the challenges that a local entity faces in raising capital to fund projects and cover administrative costs. Recent recommendations made by officials in Sonoma County to take a phased approach to implementing an AB 811 initiative highlight the uncertainties surrounding the availability of county-based sources of funding. Further, public bonds which are utilized for AB 811-type activities would not be tax exempt.

Expansion Strategies and Areas of Support: City and municipal agencies, in cooperation with local utilities, should work to **formally integrate property tax-based and other contractual assessments as a financing option** under any public, private, and utility energy efficiency and renewable energy program. To the extent possible, any best practices that emerge from the Palm Desert and City of Berkeley programs, and other ongoing AB 811 motivated initiatives, should be replicated statewide. The California Energy Commission has allocated a portion of the State Energy Program funds to assist cities, counties and groups of cities and counties in implementing or continuing their own municipal financing programs.

Use alternative sources of funds to finance projects. Federal stimulus funds for energy efficiency would be an ideal source of capital for programs to create **revolving loan funds**, as they would achieve shared federal and state objectives, would be quickly deployed, and would return to the local agencies for use in subsequent rounds of energy efficiency financing.

Under ARRA, the CEC has expanded the amount of loans available under the existing Energy Conservation Assistance Account Program (ECAA). The Energy Commission is providing loans with a low interest rate of 1 percent that can help local public jurisdictions invest in energy efficiency, save money, reduce greenhouse gas emissions, and build new jobs and industries for their communities. The current ECAA Loan Program is still offering a low interest rate of 3 percent for energy efficiency projects that do not qualify for ARRA funding.

Financial Aggregation: Utility On-Bill Financing (OBF) – Residential & Small Commercial

Overview: Utilities' OBF programs have proven successful for residential and small business facilities in New England, California, and some Midwestern markets. The majority of existing programs allow customers to finance efficiency projects through payments on their monthly utility bill and typically include the following elements:

- No capital outlay to purchase and install equipment and implement energy efficiency measures through the receipt of an interest-free, or low-interest loan;

- Customer repayments are based on estimated energy savings and are set to at a “cash flow neutral” level compared to their previous energy bills; and
- Ability to receive a cash rebate or incentive that can be utilized to lower the required loan amount.

A variation of OBF known as a tariffed installation program (TIP) uses a utility’s bill collection system to collect a charge that has been attached to the meter as a special tariff. TIPs may offer a mechanism for rented premises where the split incentives between landlords and tenants chronically lead to under-investment in energy efficiency.

With a TIP, the obligation is borne by the meter customer, not necessarily the building owner, and current residents can feel comfortable that they will only have to pay for improvements from which they directly benefit. Likewise, TIPs provide a mechanism for building owners to install measures in their property that may outlast the tenure of any particular tenant. Because the payment is tied to the meter, not the homeowner, TIPs allow for the current occupant to move, with the next occupant responsible for repayment. As a tariff, TIPs require the support of implementing utilities and approval from the utility regulators. In some states, legislation may be required to make TIPs enforceable.

On-bill financing is gaining ground in California. As the CPUC recently stated, “Financing was assumed to be the domain of banks, credit card companies, or special purpose government loan programs, the latter intended to make energy capital loans to state and local government facilities with presumed excellent repayment prospects. Actual experience has shown that in many customer markets the lack of access to capital for energy improvements on attractive terms may be holding back substantial levels of potential efficiency investments.” It has remained under the radar as a potential funding mechanism for energy efficiency improvements, but has gained some attention since 2005 when Sempra began its first OBF program. On Bill Financing (OBF), can address some areas and property assessment based AB811 type financing can move many other projects forward where longer loan timeframes are needed. Not all OBF programs are in place yet and the same applies to AB811 type financing

OBF initiatives have typically been funded through a combination of sources including internal utility funds, incentive monies from system benefits charges, or state-funded programs. Funding for the improvements can also come from the issuance of bonds, public funds, or private sources of capital. In the future, there may be additional funding pools such as using IOU’s ratepayer funds. The total cost of EE installations implemented through OBF programs in the U.S. ranges from an average of \$5,000 up to a total allowed project size of \$250,000. The current average loan amount for Sempra’s OBF program is \$28,000. Program requirements vary according to available collateral or recourse to customers. For example, SDG&E and SoCalGas offer unsecured loans, while others, such as First Electric Cooperative, require an equipment or property mortgage lien. These utilities and PG&E have proposed including OBF as part of their 2009-2011 program portfolio for business but not residential customers.

The CPUC has issued a proposed decision for 2010-2012 that would direct all California Investor Owned Utilities to use ratepayer funds for OBF, which would broaden the funding pool using a resource which carries minimal costs. The proposed decision would allow utilities to raise the maximum institutional loan amount to one million dollars. (ETAAC will update this section if additional information is available prior to our final report)

Some examples of other OBF programs that we can draw lessons learned from include:

- SCE, SoCalGas, and SDG&E offered OBF as part of their 2006-2008 programs to small businesses, and local governments.
- SDG&E and SoCalGas also offer OBF for non-owner occupied multi-family common areas.
- SMUD offers loans that operate much like on-bill finance for residential and business customer energy efficiency, as well as PV solar.

Barriers to OBF: Utilities are generally reluctant to perform what are considered traditional banking functions for their customers, which can force compliance with state consumer lending laws, and see a risk in making loan to customers using their own capital or ratepayer funds. Utilities that offer on-bill financing limit their risk by requiring short repayment periods, typically five years or less—too short for most residential projects, which have typical payback periods of ten years or more. OBF programs in the residential sector also face the added challenge of having to comply with CPUC cost-effectiveness tests.

Expansion Strategies and Areas of Support: Areas of adaptation and expansion to the plans currently being developed by the IOUs, or future iterations of on-bill financing, include:

- **Develop Customized energy efficiency Utility Programs Integrated With OBF** designed to provide residential and small commercial customers with the turnkey solutions (financial and technical) that are often required to implement efficiency measures. Existing on-bill financing initiatives in California are typically treated in isolation from the range of energy efficiency measures available to consumers, supporting only a small subset of possible regimens and technologies. Developing a specialized program that offers OBF as a centerpiece alongside a suite of technical assistance would streamline the project development process for customers and could potentially be managed by private firms that are active in small commercial market segments.
- **Establish partnerships between local utilities and ESPs** that can deliver engineering and technical services to small commercial customers. Partnering with a group of pre-screened firms would provide utilities with multiple channels to access new program participants. Private services providers would benefit from being able to offer customers an OBF option, and local utilities would benefit from having the sales and business development teams of partner firms identify and bring customers into utility programs.

- **Limit Downside Risk:** utilize system benefit monies to create a **loan guarantee program** that can attract private lenders as a source of funds for on-bill financing programs for small commercial and residential customers.
- **Adjust cost-effectiveness requirements** for residential energy efficiency programs that include OBF, so that repayment periods offered to customers are consistent with the time horizons required by the full range of customer classes that might benefit from the service.
- **Partner With Consumer Finance Institutions:** One of the barriers to OBF is that utilities are not in the business of loaning money to their customers, nor do they want to be. Therefore, one option is for utilities to partner with banks that are in the business of making loans and can manage the consumer credit evaluation and lending portions of OBF. With such an arrangement, banks maintain the loans and liabilities on their balance sheets and utilities arrange the payment mechanism, project evaluation, and marketing.

Financial and Technological Aggregation: Efficiency Services Agreement (ESA) – Large Commercial & Industrial

Following the recent trend of the increased utilization of power purchase agreements (PPAs) as a vehicle to finance renewable energy projects, efficiency services agreements (ESAs) are starting to emerge as an attractive structure to provide comprehensive financing solutions that enable end-users to avoid the capital outlay associated with the implementation of energy efficiency measures. Via an ESA, customers can receive 100% financing for engineering, design, construction, equipment, installation, maintenance and ongoing monitoring of energy efficiency projects. Project financing is structured as a services agreement whereby customer repayment is based on an agreed-upon cost of avoided energy (e.g., \$/avoided kWh of electricity) or share of energy savings. The ESA provider finances and develops projects via contractual agreements with a customer and an ESCO or ESP.

Under this model, an ESA provider serves as financier and owner of energy efficiency assets and partners with service providers to carry out required project installation and maintenance activities. Customers make regular payments (e.g., semi-annually) that are based on the energy and operating savings realized by a project. ESA payments are structured to be less than the customer's baseline utility costs and escalate at a fixed rate. While the characteristics of individual deals vary, the fundamental framework of the ESA is consistently applied across all projects to help minimize transaction costs. Key elements of projects financed using an ESA include:

- *Ownership of Project Assets:* The ESA provider holds title to project-related assets during the contract period. At contract end date, customers have an option to purchase a project's assets at fair market value.

- *Pricing*: Set as a services charge based on a cost per unit of avoided energy or share of energy savings. An escalation schedule, based on a constant percentage rate, is defined in the ESA.
- *Contract Length*: ESA contract periods can vary but typically range from five to 12 years.
- *Measurement & Verification*: An M&V plan is set forth in each ESA contract with customers and is typically prepared semi-annually or quarterly.
- *Performance Guarantees*: To mitigate project performance risks, the ESA provider typically obtains a performance guarantee from an ESCO or ESP. The ESA product is well suited for end-users in the commercial, industrial, manufacturing, private higher education and health care sectors. Typical project sizes for ESAs exceed \$1M and include a variety of commercially proven energy efficiency technologies: heating, ventilation, and air conditioning (HVAC), building and equipment controls, motors, pumps, process equipment, and lighting.

Barriers to Expansion of Energy Services Agreements: The ESA is a relatively new product and requires significant front-end customer and ESCO and ESP education. The attractiveness of the ESA is constrained by the poor depreciation treatment of energy efficiency assets in commercial facilities, which are typically classified as “general building” items by the IRS that are depreciated on a straight line 39-year property basis. In addition, third-party owners of energy efficiency assets are not allowed to claim the EPACT28 tax deduction for energy efficiency equipment in commercial buildings per §179D of the Internal Revenue Code.

Expansion Strategies and Areas of Support:

- **Integrate the ESA offering into third-party-run utility programs** that would provide large commercial and industrial end-users with a comprehensive set of technical assistance and financial services.
- **Allow investors that hold title to energy efficiency equipment installed at 501(c)(3) or state / municipal facilities under an ESA to be exempt from paying state income tax on energy efficiency property.** Third-party owners of solar PV are exempt from any property tax payments on such equipment. However, even though energy efficiency is a higher loading order priority in California, currently, even if energy efficiency property is being installed at a tax exempt facility under an ESA, state property taxes are still levied since an outside investor owns the energy efficiency assets. This tax burden adds an average annual expense that is equivalent to one to two percent of the total project cost and limits the applicability of the ESA in tax exempt and municipal markets.
- **Foster federal action to allow energy efficiency assets to receive the same depreciation treatment and tax deduction allowances as solar and other sources of renewable energy.** Specifically, in order to encourage installation of energy efficient

technologies in commercial buildings: Section 168 of the Internal Revenue Code should be amended to designate energy efficiency property installed in or on a commercial building as 5-year depreciation property; and Section 179D of the Internal Revenue Code should be amended to extend the allowance of the energy efficiency commercial building property deduction to owners of energy efficiency commercial building property who are not owners or lessees of entire buildings.

- **Conduct marketing and outreach** activities to California industry groups and business associations to promote the ESA structure as an alternative source of financing efficiency improvements.

draft

DRAFT ETAAC Advanced Technology Development Report

Chapter Four: Renewable Energy

California's 33% Renewable energy target will play a key role in meeting both CARB's 2020 GHG reduction goals¹ and in putting the state on a trajectory for longer-term GHG reductions. Technological development is also critical for meeting AB32's goal of serving as a model for other countries to implement economic development along a low and zero carbon pathway. Advanced technology renewable resources also have an important role to play in meeting California's air quality challenges – especially in regions where identified air pollution control technologies fall short of air quality goals.

Developing renewable energy in California also offers important economic opportunities. Over two-thirds of venture capital invested in California in 2008 was in renewable energy, primarily solar, stimulating important job-creation. Locally developed renewable energy can replace fossil fuel imports with in-state natural resources, and a number of reports have found that it provides significantly more jobs per megawatt than fossil fuel technologies². In addition, renewable energy is already a large international market – for instance the global market for solar and geothermal technologies is estimated at nearly \$700 billion annually and renewables are a leading sector for high market growth potential (UK BERR report)³.

This chapter addresses the challenges and opportunities for the development of renewable technologies in two parts. The first part addresses issues that are faced by a number of different technologies, including the proper distribution of renewable energy to load and demonstration finance. The second part recognizes that individual technologies also face technology-specific issues while addresses issues for solar, geothermal, biomass, and wind energy.

I. Technology-Agnostic Issues

a. Grid Expansion: Transmission Efforts are Key to Renewable Energy Production Goals

There is broad recognition today that the nation's interstate transmission infrastructure needs to be expanded to accommodate existing and new sources of renewable energy, which tend to be located at considerable distance from population centers. Simply put, without a more robust bulk transmission grid, the economic, environmental and energy security benefits that would come from the country's immense renewable energy potential will not be captured, jeopardizing our ability to successfully meet the country's

¹ The ARB's Scoping Plan shows that a 33% RPS could contribute up to 21.3 MMT out of 176 MMT of CO₂e reduction.

² for instance, Deloitte report for US DOE, http://www.energy.gov/publications/reports/Geothermal_Energy_and_Jobs_Issue_Brief.pdf

³ footnote reference needed

mounting energy and environmental challenges. For more details, please see chapter 5 of the original ETAAC report.

Current transmission lines are insufficient for the nation's growing renewable energy needs. Expanding renewable energy production, particularly on the scale envisioned under proposed climate change and renewable electricity standard legislation, hinges on a renewed and significant investment in our country's bulk electric transmission infrastructure. A key to accomplishing this vision is updating the standard policy framework governing interstate transmission financing and cost recovery leading to a regulatory environment for transmission and related enabling technology investments that enhances development and utilization of location-constrained renewable resources. In addition, federal stimulus legislation under the American Recovery and Reinvestment Act will provide additional funding to support innovative transmission efforts.

This transmission challenge is particularly acute for prospective project sponsors looking to build so-called green interstate transmission superhighways in wholesale bilateral markets not served by regional transmission organizations, an area that includes the entire interior West. These projects have the ability to be designed and built specifically to maximize access to cost effective out of state renewable energy resources more economically, while at the same time minimizing land use and wildlife impacts.

Active California and regional transmission planning processes reflect these priorities. For instance, thousands of megawatts of undeveloped geothermal reserves have been identified that can help California and Nevada meet their ambitious renewable portfolio standard goals, with additional grid reliability benefits attributable to these baseload resources.

Many renewable technologies are site-specific, often distant from load centers and lacking sufficient transmission to get energy to market. Nationally, lack of adequate transmission is a major obstacle for developing some of the more favorable renewable resource areas. In California, transmission planning, siting and construction is underway which will allow the development on new resource zones.

Southern California Edison is currently constructing the first segment of the Tehachapi Transmission line. When fully operational, these new transmission facilities will access up to 4000 MWs of new wind generation.

San Diego Gas and Electric has approval to construct the "Sunrise Transmission Line" connecting San Diego to resources to the east. There are significant opportunities for wind other resources in southern San Diego County and Northern Baja California in Mexico.

California has developed a stakeholder process known as the "Renewable Energy Transmission Initiative (RETI)" designed to identify new transmission needs and to create Competitive Renewable Energy Zones. This process has produced two reports with specific mapping that is useful in identifying key areas for renewable energy

development and related transmission. (Foot note). This process is consistent with the recommendations contained in the ETAAC Report.

Transmission planning is a dynamic process where location of new generation and patterns of load growth affect the need to add new transmission facilities. This will continue to be a process that will significantly affect the renewables industry as it grows into new geographical areas more remote from load centers.

The key barriers associated with transmission are environmental siting concerns raised as specific projects are proposed. Conflicting land use and environmental goals are issues that policy makers need to address.

b. Distribution System Upgrades

Renewable distributed generation offers benefits to the electrical system and is a high-priority resource in the state's Loading Order. Growth of these resources, if properly managed, can continue to play a major role in achieving the goals of AB32. However, there are technical issues associated with the expansion of DG which must be addressed as DG resources continue to scale up and play an increasingly meaningful role in the state's energy system.

Most utility-scale renewables are generally built in remote areas and thus require long distance transmission to transport the power to load centers. In contrast, distributed renewable generation such as solar PV provides a local generation resource that can usually be accessed much more quickly and without some concerns such as those associated with building utility scale power plants in ecologically sensitive areas. At sufficiently high levels of penetration, distributed generation can potentially help alleviate transmission congestion and/or avoid the need to build new long distance transmission, provided there is sufficient back-up generation, energy storage and/or demand response capability to offset the load when intermittent DG resources drop off. Balancing the amount of utility scale versus distributed generation would involve a complex set of variables and trade-offs among resource quality, technology efficiency, economies of scale, transmission and distribution system upgrade costs/savings, environmental factors, equipment and installation costs, among others. This section specifically examines the impact of distributed generation on the local grid and how those impacts may be mitigated.

The existing electric distribution system uses a top-down, one-way hierarchy, with interruption devices placed throughout the feeder. Any energy that is generated must be used up by other loads on the same feeder. The injection of large amounts of distributed generation such as photovoltaic solar onto the distribution feeders raises a number of issues. Specifically;

- Voltage regulation: The feeders are not designed to accommodate injection of on-off energy sources. A high concentration of distributed generation from intermittent resources could cause voltage sags if the generation drops off suddenly (e.g. from cloud cover over PV systems). Conversely, the lines could

- become over-energized if the amount of generation is much greater than available load on the system. The voltage distortions created by PVs as they come on line and off during operation could cause the line voltage to exceed acceptable limits.
- Protection coordination: The interrupting devices installed on distribution feeders are designed to isolate affected areas during an event. As PV units are added to the distribution system, the adequacy of the protection devices in the circuit must be reviewed and/or modified as needed (e.g. increasing fuse size). While the number of distributed PV installations is low now, the California Solar Initiative calls for the installation of 3000 MW of PV by 2016. As the penetration of PV increases, the amount of protection coordination will also increase, which could add considerable burden to distribution planning in terms of both time and cost.
 - Anti-islanding: Distributed generation units on the feeders are equipped with anti-islanding devices. This means that during fault events when power is shut off to a feeder circuit, any generating equipment on the feeder must also disconnect to prevent power flow to the line. For large generators, direct transfer trips are installed. In the case of PV, contacts in the inverter are designed to automatically open when “bumps” in line frequency –such as those that occur when the breaker on the feeder line trips–are detected, and reclose after a timed delay (generally 5 minutes) if there is no actual power outage. This also means that PV systems could and indeed do trip offline at other times when frequency fluctuations occur on the line for other reasons. A large amount of distributed generation coming on and off the grid could cause PVs in the same or nearby circuits to constantly trip off.

Advanced Technology Solutions: Smart Grid and Smart Inverters

Various Smart Grid-related technology research and developments are underway within the State and nationally. Among these, smart inverters may have the potential to enable higher penetration of PVs and provide a number of services to optimize grid operation such as:

- Enabling installed PVs to act as a grid resource to provide ancillary service.
- Communicating with the grid to integrate distributed generation and storage facilities – for example, sending the power generated to energy storage devices or charging plug-in EVs at specified times.
- Allowing PV generation to remain connected during some grid disturbances, while meeting safety operation requirements.
- Providing voltage regulation by injecting into or absorbing reactive power from the grid. This can help prevent voltage disturbances that in benign cases cause dimming of lights or in worse cases, computer crashes or damage to equipment.

However, current interconnection standards were developed for current capabilities and penetration levels, and therefore prohibit inverters from providing reactive power or anything that impacts line voltage. As technological capabilities improve and penetration levels increase, standards will need to change at the national level in order for the grid to use smart inverters for voltage support (IEEE 1547 and UL inverter standards). In addition, there is no communication capability in inverters sold today, although they can be manufactured to include communication capability. California will be the first market to reach the PV penetration level that would make smart inverters useful. This will

provide the potential to transform the market, but the policy framework to enable technology development and commercialization must be developed.

DOE's Solar Energy Grid Integration Systems (SEGIS) program is studying and supporting the development of smart inverters. However, the technology development is at R&D phase. Additional support will be needed at each technology development phase, from lab testing to field demonstration, to eventual commercialization.

These advanced technologies solutions are less well understood (than Home Area Network or HAN, for example, described in the Energy Efficiency section) in terms of how they should be applied and what value they create. At this early stage in the technology lifecycle, state and federal governments need to fund/support efforts that seek to demonstrate the applicability and value of these technologies to a broad set of industry stakeholders (e.g., utilities, vendors). Furthermore, similar to the situation with HAN, every effort must be made to support the development of standards that will enable interoperability and an efficient market for these technologies. By taking this approach, CA not only benefits from the deployment of advanced technology solutions but positions itself as a fertile ground for smart grid innovation and advancement.

c. Energy Storage to Facilitate Renewable Expansion and Integration

Storage was identified in the ETAAC Report as an important game changing enabling technology which has significant impacts on the wind industry. Storage, utilizing batteries, compressed air, or pumped storage (hydro-electric), uses excess generation to charge batteries, compress air or pump water which can then be used by the grid operator at a later time. The need for storage to meet California's aggressive renewables goals is being more widely understood. The federal government has also recognized this need. The Department of Energy recently issued a Funding Opportunity Announcement under the American Recovery and Reinvestment Act (ARRA) to solicit proposals for advanced energy storage. DOE noted that "Electric grid operators can utilize electricity storage devices to manage the amount of power required to supply customers at times when the need is greatest (during peak load). Electricity storage devices can also help make renewable energy resources, whose power output cannot be controlled by grid operators, more manageable. They can also balance microgrids to achieve a good match between generation and load. Storage devices can provide frequency regulation to maintain the balance between the network's load and power generated, increase asset utilization of both renewables and electric systems, defer T&D investments, and achieve a more reliable power supply for high tech industrial facilities."

DOE's proposed funding of up to \$200 million in energy storage demonstration projects is an important first step in getting more storage on the utility grid to allow the integration of more low-carbon resources. However, there are non-technology challenges that will still need to be overcome.

The original ETAAC report noted the importance of energy storage to meet GHG reduction goals by helping integrate larger quantities of renewable energy from technologies that are not dispatchable, e.g. cannot be turned on & off to match demand.

The report also identified the potential for synergies between electric vehicles as a potential energy storage solutions, as vehicles can accept off-peak renewables if the timing for charging is right. Energy storage can also provide many different beneficial services, including some combination of: 1) interruption avoidance, 2) outage avoidance, 3) congestion relief, 4) transmission upgrade deferral, 5) distribution upgrade deferral, 6) generation deferral, 7) time-of-day price arbitrage, 8) peak demand reduction, 9) renewables firming, and 10) several forms of ancillary generation service. This wealth of opportunities presents two challenges: “How do you optimize between the benefits (e.g., how much ancillary services support can be provided while providing other services)?” and “How should the cost of those services be recovered?”

The latter challenge results because there may be four different recipients of value: the transmission ratepayer class (FERC recovery), the distribution ratepayer class (CPUC recovery), the generation market (CAISO recovery or energy market recovery), and/or individual customers (services market recovery). Allocating costs between some combinations of the four possible “markets” is not an easy or common task.

PG&E recently requested federal funding under the ARRA program for a storage project in Kern County designed to store wind energy generated in the Tehachapi Wind Resource Area. The Compressed Air Energy Storage (CAES) project would have a 300 MW capacity with 10 hours of storage. PG&E proposes to use saline porous rock formation as storage media. Saline aquifers are abundant in California. If approved, this demonstration project may be an important advancement in energy storage. Southern California Edison made a proposal under ARRA to use lithium ion batteries to store 32 MWh of wind energy in the Tehachapi area. AES, has recently added several new battery installations in Southern California and is looking for additional opportunities. Ultimately, the advent of hybrid and electric cars will provide a meaningful opportunity for utilizing renewable energy generation, in the form of wind, for transportation. This will require additional investments in new infrastructure integrating wind resources with individual vehicles.

These new storage technologies will present new planning, rate recovery and rate-making issues for the CPUC and publicly owned utilities in developing these resources. Similarly, these new technology may raise local land use and CEQA related issues. California will need to be proactive in ensuring that storage technologies are an integral part of the RPS.

Regulators can shape policies to better define how costs should be allocated among different jurisdictions. The State should also examine how short duration energy storage can participate in the ancillary services market. Projects such as pumped storage and compressed air storage have to go through the same, streamlining siting and permitting review process as other renewable developments and thus face the same challenges. For example, a pumped hydro storage project could take as long as 10 years to receive approval. The State should identify ways to coordinate siting and permitting reviews by various agencies and enable utilities to more quickly leverage these solutions to integrate renewables. Finally, the American Recovery and Reinvestment Act (ARRA) can

potentially provide funding support for utility energy storage project. An expedited CPUC rulemaking process the deployment of storage projects will be needed to help access these federal matching funds.

Initial storage applications may not all be justified on pure economics, so regulatory support will also be needed to recover above-market costs.

II. *Technology-specific Issues*⁴

a. **Photovoltaics**— role of costs, technology improvements in feasibility of 33% target
The CPUC 33% RPS Report models PV penetration that ranged from 3000 MW in the 33% RPS Reference Case (current procurement practice) to 15,000 MW in the High DG Case. According to the report, the former would require increasing worldwide installed solar PV by about 15% relative to 2008 levels, and the latter would require a doubling of global solar PV capacity in California over the next 10 years in



Installation of solar photovoltaic panels (Source: AC Transit)

addition to strong solar PV demand in other countries. The risks associated with relying on technologies untested at this scale may include, at best, project delays, or at worst, the possibility that some of the new technologies never reach commercialization. On the positive side, technology breakthroughs could occur, though they would need to occur almost immediately to meet the 2020 timeline. California has major strengths in PV solar technology development, such as leadership in venture capital investment, public and

⁴ Categorized based on CPUC 33% RPS Report categories

private research, and interconnections with the semi-conductor industry – providing opportunities for economic development as well. The State needs to make a coordinated and concerted effort to remove barriers to project development and implementation and support commercialization of emerging technologies.

Photovoltaic technology has made progress on several fronts since the ETAAC report was written. New ways of making thin film PV materials have moved from prototypes to production lines, increasing competition for industry-leading silicon. The current thin film leader announced that it had broken the \$1/Watt cell cost barrier at the end of 2008 only to have a competitor using the same material open a new factory a few months later with a claimed ability to achieve even lower costs.

The cost progress with the greatest impact occurred within the silicon market. Four factors contributed to the lowest silicon cell cost in history. Silicon shortages in the last few years created the market signal to build new silicon production factories, which went into operation recently. The global recession has had some effect on demand for PV. The third factor affecting silicon cell costs was due to a policy change in Spain. The Spanish government reviewed the last few years' activity in and costs of its feed-in tariff and decided to put in place a cap that severely reduced activity in 2009 while lowering FiT prices in an attempt to reduce the "tariff deficit" that had forced utilities to sell electricity under cost, at an estimated loss of €4.85 billion in 2008. As the industry had planned on the continuation of a 1-2 GW market, the cap effectively created an instant excess of 1-2 GW of PV modules. The fourth factor in the silicon PV market is the growth of the Chinese solar industry. The Chinese solar industry has grown quickly. In 2008, 5 of the top 10 PV suppliers in the world were from China or Taiwan. China now has a 40% share of the world's PV manufacturing capability.

These cell cost improvements have not produced significantly lower installed system prices, except in a few large-scale applications. One factor affecting how little system installation costs have changed is that labor and other non-module costs are a major part of system costs and they have not seen substantial cost reductions. Other economic factors may also be involved – for example, one study of PV cost trends in California suggests that heavy subsidies can dampen the motivation of installers to provide, and or customers to seek, lower installed costs.⁵

IC Insights, a researcher specializing in the semiconductor sector, issued a report in July 2009 that summarized the net effect of the above events. The report says that global PV production capacity in 2009 will grow 32% while installations worldwide will decline 22% on a MW basis. As a result, panel and module costs will be reduced by 28%. However, installed system prices will only fall by 9%.

California is providing substantial financial support to promote PV. The State authorized a 10-year, \$3.3 billion⁶ ratepayer funded program (Go Solar California) in 2007 which aims to install 3,000 MW of new grid-connected solar and encompasses the California

⁵ The Gigaton Throwdown report, (http://www.gigatonthrowdown.org/files/Gigaton_EntireReport.pdf)

⁶ CSI: \$2.167 billion, 1940 MW; NSHP: \$400 million, 360 MW; POU programs: \$784 million, 700 MW.

Solar Initiative (CSI), the New Solar Homes Partnership (NSHP), and programs offered through publicly-owned utilities (POUs). The California grid now has nearly 50,000 sites with distributed solar PV with nameplate capacity of more than 515 MW about 44% of which were installed under the CSI and the rest installed primarily under prior programs. To further improve solar PV's competitiveness, the State can support technology developments in areas such as more efficient inverters, solar concentrators, and tracking devices, as well as mounting systems that are more labor efficient to install.

In addition, the State could continue to support policies that enable greater PV penetration such as feed-in tariffs and net metering. The State is in the process of expanding feed-in tariffs and net metering caps for solar PV installations. Feed-in tariffs offer price certainty over the long run (10-20 years) and help improve project economics. The existing California feed-in tariffs are available to solar projects sized at 1.5 MW or below and are based on a market price referent set by the CPUC, up to a combined total of 500 MW statewide. The California legislature passed legislation that, if signed, would expand the eligibility to projects up to 3 MW and a total statewide target of 750 MW, and the CPUC is also considering raising the eligibility cap – potentially up to 10 MW. *[Note: At the time of this draft report the Governor's action on this bill was still pending – we will update status of SB32 before finalizing report]*

As for net energy metering (NEM), each utility has a cap of 2.5% of the utility's aggregate customer peak demand. This cap is likely to be reached way before the CSI goals are reached – according to the CPUC, the current weighted average NEM penetration is just about 1 percent, but will be 4.5 percent if the CSI Program achieves its goal of installing 1,940 MW statewide. The CPUC is conducting a study on the cost and benefits of NEM to participating and non-participating customers; in the mean time, the State legislature is considering raising the cap to keep the CSI program going while the study is being completed.

The legislature also passed a bill which would modify the definition of low income and expand the eligibility pool for the Single Family Affordable Solar Homes (SASH) Program under CSI. *[Note: At the time of this draft report the Governor's action on this bill was still pending – we will update status of AB1551 before finalizing report.]*

Finally, it should be noted that the State's RPS rules currently do not allow the inclusion of renewable energy credits (RECs) such as those generated from PV installations at customer sites. The CPUC is currently addressing the issue of tradeable RECs.

b. Solar Thermal

Progress on the concentrating solar thermal front has occurred, for instance there are a number of solar thermal projects that have applied for a license from the California Energy Commission (CEC), but it has not been as obvious nor as widely, systematically, and transparently tracked as PV progress. Individual companies have publicized their technology developments, but most cost information is still proprietary. Applications to the CEC confirm other studies showing that solar thermal electric generation provides at least twice the in-state jobs of fossil thermal generation.

The challenges that apply more universally to concentrating solar thermal technologies have been more apparent and widely discussed. Three challenges, beyond individual technologies, slow the deployment of concentrating solar thermal power projects. Of the two solar technologies, only concentrating solar thermal must address the need for cooling the working fluid run through a turbine to produce electricity. Many projects have addressed the issue by designing dry-cooled or minimal-water cooled plants. This is a particularly difficult issue in the desert where there is a lack of cooling water but the high ambient temperatures make dry cooling inefficient and costly. The other two issues slowing concentrating solar thermal are equally applicable to utility-scale PV projects. The best solar resources and the amount of land needed to site a project (5-10 acres per MW) both imply the need to locate away from population centers, necessitating major transmission expansions. Both of those issues also imply another challenge – the substantial footprint requirement and the need for transmission both create environmental impacts. There needs to be a mechanism to mitigate environmental impacts while still allowing a level of development.

Solar thermal also has industrial-scale applications, as exemplified by two recent announcements from solar thermal developers who have teamed with industrial customers. One application uses solar thermal troughs to make steam for a snack food plant. Another application uses a solar thermal power tower to make steam for enhanced oil recovery. Both are good examples of ways to harvest the sun's energy to reduce the use of fossil fuels and greenhouse gas emissions. However, neither contributes to RPS goals.

c. Biomass –

1. Biomethanation

The siting and permitting of biomass power plants are becoming increasingly difficult due to air quality regulation. Converting biomass and biogas to pipeline quality natural gas (biomethanation) allows the biomethane to be transported to and burned in highly efficient natural gas combined cycled power plants with state of the art emissions control technologies. This turns the biomass feedstock into a flexible resource that can be stored and dispatched as needed. Biomethane is also an effective way to increase renewable generation by displacing natural gas at existing plants. There are two technology options for biomethanation: biologic conversion through anaerobic digestion and chemical processes such as pyrolysis and gasification.

Anaerobic Digestion: While anaerobic digestion technology is not new, regulatory and permitting hurdles limit the economic and project feasibility of biomethane projects. Research is on-going to improve digester efficiency as well as the upgrading process. Technologies to increase methane yield or reduce residence time include co-digestion of various feedstock, e.g. food waste, and the selection of optimal mix of bacteria, as well as improvements in digester design and controls. These technology improvements need in-field demonstration and technology validation before they can be scaled up. More importantly, the State needs to streamline and expedite the permitting process.

Gasification: Anaerobic digestion is suitable for wet feedstock such as animal and food waste and sewage sludge. Gasification, on the hand, applies to dry, lignin-rich biomass such as forest residues, straw and orchard prunings, and major portions of the MSW stream. Gasification is a thermochemical process that converts biomass into a hydrogen and carbon monoxide rich gas, which can then be converted to methane (bio-synthetic natural gas or Bio-SNG) through the use of a catalyst. While biomass gasification for power production has been under development for some time, it has yet to reach commercial success. There are small scale biomass gasifier-generators being deployed for power production; however, the same air regulation and other onsite generation constraints exist. Biomass gasification combined with biomethanation is an emerging field, and as such, many of the same barriers to entry apply – in particular, high capital cost and the need for demonstration financing.

Pyrolysis: Pyrolysis refers to the thermal decomposition of biomass in the absence of oxygen to produce syngas or bio-oils that can be used for heat and power production or conversion to liquid fuels or industrial chemicals. As with gasification, the pyrolysis process is suitable for agricultural or forestry residue; however, pyrolysis operates at a lower temperature than gasification and produces lower bioenergy output. However, pyrolysis produces biochar as a residue. Research has shown that biochar has value as a soil amendment to increase soil productivity. By adding biochar to the soil, it can also effectively sequester carbon in the soil for hundreds of years. Additional research, validation, and protocol development is needed in this area.

2. Torrefaction/Pelletization

One technology solution to address the biomass transport and storage issue is to pelletize woody biomass – drying, shredding and compressing the biomass into small cylinders or pellets which can then be transported to biomass power plants and burned as fuel. Wood pellets can be made from sawdust or soft wood grown in industrial plantations. This practice is generally used in Europe and the eastern US.

A newer technology solution involves torrefaction – a process of heating woody biomass in an oxygen-free environment to a mild temperature (200-300C) and then compressing the “roasted” product into pellet form. The torrefaction process increases the energy density of the biomass to that similar to coal and also makes it brittle. This means that the torrefied pellets – also called bio pellets or biocoal – are ideal for co-firing in coal plants. Depending on the amount used, co-firing of biocoal has the potential to bring the GHG emissions of coal plants down significantly.

3. Microbial Fuel Cells

Microbial fuel cells are biologic fuel cells that generate electricity by harvesting the electrons produced by bacteria during the digestion of organic feedstock such as wastewater or sludge. They serve the dual benefit of clean power production and wastewater treatment. As the injection of biogas from wastewater treatment plants and landfill gas into utility gas pipelines is either expensive due to clean up requirements or prohibited (in the case of landfill gas), microbial fuel cells provide an ideal solution

where onsite generation is not feasible, e.g. due to air emissions regulations. The development of microbial fuel cells is at an early stage and will require demonstration support as the technology further advances.

4. Dedicated Energy Crops

Dedicated energy crops provide one solution to dispersed and inconsistent biomass supply. Some crops can be purposely selected to have certain properties such as the ability to grow on marginal land, withstand drought, and produce high yield. Such crops help improve project economics by requiring less land and lowering costs associated with harvesting and transporting the feedstock, thus making dedicated energy crops a viable source for biopower.

Additionally, biomass crops can be used for remediation of degraded or impaired land. For example, biomass crops can be selected to absorb selenium and grown in areas where excess selenium is an issue. Finally, some crops may provide carbon sequestration through their below-ground root mass. For example, switchgrass has deep root systems extending as deep as three meters as well as the ability to replace dying roots with new, live roots. At least one study has shown some increase in soil organic carbon in soils where switchgrass has been grown as a dedicated energy crop after 5 years⁷, although the results across sites are inconsistent and additional field-based assessment are needed to determine the net carbon sequestration effects.

d. Wind

Wind energy is an integral part of California's renewable resources. California was an early leader in incorporating wind resources as a part of the energy mix, with contracts, tax policies and other incentives to encourage wind development. California was the primary wind market for many years. The California Public Utilities Commission estimates that between 7500 MWs and 9500 MWs of new wind will be need to meet California's 33% RPS goals.

Today, California's wind capacity ranks third behind Texas and Iowa. While there is continued interest in building new wind generation, as well as, repowering existing sites with newer technology, wind faces several infrastructure and environmental challenges. These include:

- Technology Development
- Integration of intermittent wind into the grid
- Avian impacts
- Transmission to wind resource areas (as addressed above)

The CARB Scoping Plan calls for a 33% Renewable Portfolio Standard. Wind energy resources will be an important component in meeting this RPS policy. Therefore, it is essential that these challenges be expeditiously addressed.

⁷ M.A.Liebig, M.R. Schmer, K.P.Vogel, R.B. Mitchell, "Soil Carbon Storage by Switchgrass Grown for Bioenergy", 2008

1. Technology Development

Wind technology development has played an important role in bringing wind energy costs down dramatically. While the technology is fairly mature, there are also further technological developments that can play an important role in expanding wind energy further.

The Wind Energy Research and Development Act of 2009 was passed by the US House of Representatives in September 2009. The bill directs the Secretary of Energy to carry out a research and development program focus on research and development of specified areas, including: (1) new materials and designs to make larger, lighter, less expensive, and more reliable rotor blades; (2) technologies to improve gearbox performance and reliability; (3) automation, materials, and assembly of large-scale components to reduce manufacturing costs; (4) advanced generators; (5) wind technology for offshore applications; (6) methods to assess and mitigate the effects of wind energy systems on radar and electromagnetic fields; and (7) wind turbines with a maximum electric power production capacity of 100 kilowatts or less.

Improving the reliability and capacity of wind while reducing costs through this research program and associated demonstration financing would help make wind even more competitive with fossil energy in California and other areas.

2 Grid Integration:

Wind energy is an intermittent resource that is dependent upon whether the wind is blowing. This is related to meteorological conditions which can change seasonally or even over the course of the day. Therefore, integrating wind generation into the grid is important issue necessary to fully develop potential wind energy resources.

The grid operators, also known as “balancing authorities” are responsible for keeping the transmission grid balanced in real time at 60 hertz cycle. This is a very dynamic process as load fluctuates throughout a day with generation dispatched to follow it. The “integration” challenge for wind is matching its availability to demand. There are several strategies for addressing this issue.

Operationally, wind availability is not a random event. Wind resource areas have been well studied as to wind patterns so that wind availability is generally understood. Sophisticated software predicting wind is available to grid operators for dispatch decision.

The larger the operating area of the grid operator the less significant the integration issue may be, because the wind resources will be geographically dispersed. Wind may not be available in one area, but is blowing hard in another. Managing intermittent resources over a larger geographical area with multiple grid operators may be an effective integration strategy.

Back-up generation is also available. The CAISO will dispatch fossil fuel plants and peakers, to meet the ramping needs of wind resources. The wind resources displace this fossil generation in other times of the day. However, it is important that electricity products in the form of ancillary services, are available to meet this growing need.



(source: Wagner Christian)

3. Avian Issues

A California wind developer will generally spend three to six years to obtain a permit to build a wind project, and spend on the order of \$1 - \$3 million to conduct the required environmental studies and navigate the permitting process. Substantial research (at least \$5 million over three years) is needed to improve the efficiency and efficacy of the environmental study and permitting process.

In 2007, the Energy Commission and California Department of Fish and Game released *California Guidelines for Reducing Impacts to Birds and Bats from Wind Energy Development (Guidelines)* to provide recommended protocols for assessing and minimizing impacts from wind energy development to birds and bats. The *Guidelines* also recommended mitigation measures. In October 2008, the CEC released a *Roadmap for PIER Research on Methods to Assess and Mitigate Impacts of Wind Energy Development on Birds and Bats in California (Roadmap)*. The *Roadmap* discusses the lack of scientific bases for many, if not most, of the recommendations that were made in

the *Guidelines* and identified several short- and long-term research needs to determine the methods that are most effective in predicting fatalities at sites of various types.

Absent this research, wind energy developers must comply with voluminous recommendations in the *Guidelines* while also conducting the studies that are necessary and appropriate for a particular site. The result is an inefficient, unduly expensive, and time-consuming process. Further, the *Guidelines* lack any structure for determining which studies should be conducted, to what extent, at any particular site. Such a framework should involve asking and answering questions like: What are we trying to determine with the data we are collecting? How much data is needed of what quality to be confident in the predicted mortality? Which sites need less study and which sites more? Developing such a framework should be rigorously tested with real data.

The wind industry believes that a relatively modest research effort, aimed at ensuring the effectiveness and efficiency of study techniques in accurately predicting and mitigating avian/bat impacts, could significantly reduce both the time and expense of the permitting process, while improving environmental outcomes.

Wind has significant potential in meeting a portion of the electrical needs in California and the west. Interstate transmission planning, storage and new technology will create further opportunities for wind development.

e. **Geothermal Power** – Update on Development and Barriers

1. Background

Geothermal power continues to be a growing and important part of the energy supply mix in the Western United States, as grid-connected geothermal power plants provide, baseload power today in California, Nevada, Utah, and Idaho with reliability of 90% or greater⁸. Geothermal energy produced 4.5% of California's electricity in 2007, producing 24 hours a day (although energy storage could also benefit this technology to the extent that it allows shifting off-peak electricity to peak periods of demand). Moreover, a recent study by researchers at Stern School of Business at New York University concludes that geothermal energy is on the verge of becoming a better investment than fossil fuel.⁹

In September 2008, the U.S. Geological Survey estimated that geothermal reservoirs in 13 states could produce upwards of 9,000 megawatts of electricity—as much as nine nuclear reactors. The actual potential of geothermal power may be much greater, thought, because scientists have never fully assessed the moderate-to-high-temperature resources that are available. The U.S. Geological Survey report suggests that it may be possible to generate an additional 30,000 megawatts of power from moderate-to-hot geothermal resources that have yet to be discovered. The Western Governor's Association found that adding new geothermal power capacity of 5,600 MW by 2015 could add nearly 10,000

⁸ <http://www.westgov.org/wga/initiatives/cdeac/Geothermal-text.pdf>

⁹ See Melissa A. Schilling and Melissa Esmundo, "Technology S-curves in Renewable Energy Alternatives: Analysis and Implications for Industry and Government," in *Energy Policy* 37 (2009) pp. 1767–1781.

jobs, and also generate about 36,000 person-years of construction and manufacturing business¹⁰.

2. Geothermal Development

Despite the lagging economy, interest in new geothermal power projects remains strong. The Geothermal Energy Association's (GEA) most recent industry update in March 2009 showed a 25% increase in new geothermal projects since August 2008 and a 35% increase in overall power production potential of new geothermal projects. The GEA report identified 126 geothermal projects under development with the potential to put 5,500 megawatts of new capacity on line. Nevada has the most production under development, with 60 projects totaling potential capacity of 1,765-3,300 megawatts, with California second with 28 projects and potential capacity of 1,050-1,350 megawatts. Many Native American tribes in California and elsewhere are also now considering geothermal power for their energy needs. In 2008, the Northwestern Band of the Shoshone Nation announced a 100-megawatt geothermal project in Northern Utah projects under development include California's Fort Bidwell Indian community, which has received Department of Energy funding.

3. Impact of the American Recovery and Reinvestment Act¹¹

The recently enacted federal stimulus package (the American Recovery and Reinvestment Act of 2009) is a direct and positive driver for increased geothermal energy development, through tax incentives, loan guarantees, and research and development funding. One of the keys to recent growth in the geothermal power market has been the extension of the federal production tax credit (PTC) to include new geothermal power projects in the Energy Policy Act of 2005. The PTC was first enacted in 1992 for wind projects and has demonstrated its effectiveness in providing an incentive for that industry. The PTC provides a tax credit of approximately 2.0 cents per kilowatt hour to new qualifying projects for every kilowatt hour produced in the first ten years of production.

Beginning in 2005, Congress extended the PTC for wind, geothermal, and other qualifying renewable technologies. The American Recovery and Reinvestment Act addresses this and other incentives for the geothermal power industry, including the following:

- A three-year extension of the PTC, making geothermal power facilities placed in service by December 31, 2013 eligible for the full credit.
- Extension of the 30% investment tax credit (ITC) to new geothermal energy projects, in some cases allowing developers to apply for a cash grant in lieu of the ITC.
- A new 30% credit for companies manufacturing renewable/geothermal power equipment.

¹⁰ <http://www.westgov.org/wga/initiatives/cdeac/Geothermal-text.pdf>

¹¹ For more information about some of these projects, go to http://www.eere.energy.gov/tribalenergy/projects_technology.cfm.

- \$1.6 billion in new bonding authority for Clean Renewable Energy Bonds, used to finance new renewable power projects by public power, municipal, and government entities.
- Up to \$6 billion in loan guarantees for new renewable/geothermal power projects, explicitly for commercial technologies

In addition to the tax and loan incentives, the stimulus legislation provided \$400 million in new funding for the U.S. Department of Energy's (DOE) Geothermal Technologies Program to implement a wide range of research, development, demonstration, and deployment activities that will fund important and unique opportunities for the geothermal industry. This DOE program will spur new jobs in the industry, the development and deployment of new technology, and growth in new applications for the geothermal marketplace.

The DOE has announced a series of specific funding solicitations targeting key areas for near-term and long-term industry and technology advancement, including the following:

- Geothermal demonstration projects (\$140 million) – Funding will support demonstrations of cutting-edge technologies to advance geothermal energy in new geographic areas, as well as geothermal energy production from oil and natural gas fields, geo-pressured fields, and low- to moderate-temperature geothermal resources.
- Enhanced geothermal systems technology research and development (\$80 million) – Funding will support research of enhanced geothermal systems (EGS) technology to allow geothermal power generation across the country. Conventional geothermal energy systems must be located near easily accessible geothermal water resources, limiting its nationwide use. EGS makes use of available heat resources by technologically engineering reservoirs so they are capable of producing electricity in otherwise untappable areas. While the long-term goal of EGS is to generate cost-competitive clean electricity, enabling research and development is needed to demonstrate the technology's readiness in the near term.
- Innovative exploration techniques (\$100 million) – Funding will support projects that include exploration, siting, drilling, and characterization of a series of exploration wells utilizing innovative exploration techniques. Funding the exploration of geothermal energy resources can carry a high upfront risk. By investing in and validating innovative exploration technologies and methods, the Department of Energy can help reduce the level of upfront risk for the private sector, allowing for increased investment and discovery of new geothermal resources.

In total, geothermal funding to the DOE under the American Recovery and Reinvestment Act is expected to support up to 90 new projects. The DOE will select up to 20 demonstration projects to bring 20 megawatts in new applications on-line, such as oil and gas coproduction. The DOE expects to select 30 new research and demonstration projects and will support exploration at 40 projects anticipated to involve up to 400 megawatts of new capacity. All of these projects are in addition to the 126 new industry projects identified above. The DOE hopes to complete an expedited review of the numerous applications it has received under these solicitations and expects to announce decisions by late summer or early fall 2009.

4. Geothermal Leasing Improvements Facilitate Growth

A strong market, financial incentives, and technology and deployment support are all important measures. But with roughly half of the geothermal power production taking place on public lands, federal agency leasing and permitting activities are also important for the industry's future. There are currently 39 geothermal power plants operating on 354 federal geothermal leases.

The BLM has been moving forward with a strong program intended to support geothermal production on appropriate public lands following the enactment of changes in the federal geothermal leasing laws in the Energy Policy Act of 2005. The BLM held a competitive geothermal lease sale for 255,354 acres in California, Nevada, and Utah in Reno, Nevada earlier this year. The BLM has also completed and published a programmatic environmental impact statement (PEIS) for geothermal leasing on public lands. The plan allocates approximately 111 million acres of BLM lands and 79 million acres of National Forest System lands open for leasing. In addition, the plan allows pre-existing studies on specific lands to be used along with best management practices. The change should help reduce the processing time of future geothermal power development. Up until recently, the experience of geothermal leasing on federal lands has been difficult. Before the issuance of the PEIS, most leases were processed in 2-3 years. BLM hopes the PEIS will reduce the process to 6 months..¹²

Emerging Geothermal Technologies

As geothermal technology progresses, resources that were once non-commercial are now being actively examined as feasible possibilities. The following are some of the more commonly discussed areas of future development.

- Enhanced geothermal systems (EGS) – Often categorized under the term “hot dry rock,” EGS refers to any resource that requires artificial stimulation. This includes resources that have to be fully engineered or ones that produce sub-commercial hydrothermal fluid. One technique involves drilling down at least three miles, pumping water to the hot rock there to capture the heat, and then forcing the hot water back to the surface to run electric turbines. Although EGS technology is still young and many aspects remain unproven, several projects are currently underway. If EGS technology proves commercially successful, it will

¹² More information on the BLM's plan is located at http://www.blm.gov/wo/st/en/info/newsroom/2008/december/NR_12_18_2008.html

significantly increase the output from existing geothermal fields, as well as result in the development of geothermal energy in previously unproductive locations. In 2008, the DOE selected 21 recipients for the research, development and demonstration of EGS including a Nevada project that could lead to the first EGS plant, producing 5 MW. Subject to annual appropriations, the DOE will provide up to \$43.1 million over a four year period to the 21 awardees, some of which include universities, which should help promote innovation. With cost-share by the recipients, the public-private investments will be up to \$78 million.

Barriers to the Development and Expansion of Geothermal Resources

Geothermal investment may continue to be a challenging investment option for conventional energy industry investors due to the high cost of development and exploratory risk with long cost recovery time frames. Geothermal exploration and development is similar to the high risk profile in oil and gas exploration, but without high return potential, as geothermal profits are usually subject to more regulated electricity markets. The high upfront risk, coupled with the moderate return on investment, has detracted investment from the conventional energy industry over the years, but new policies and technology possibilities are increasing interest in geothermal once again.

One of the greatest near-term barriers to geothermal development is the scale of its power plants compared to the feasibility of development. The large resources at The Geysers, for example, have been largely developed, so geothermal power plants are becoming smaller – using technology breakthroughs to generate electricity from lower temperature resources. The small-scale plant itself is profitable and cost feasible from a per project scope, which has also made it possible for these projects to be built in time to meet the frequently-expiring federal production tax credit. However, transmission access and infrastructure build-out requirements as noted earlier pose problems regarding feasibility of scale for a long-term geothermal strategy.

EGS is expected to be the new generation of geothermal is receiving significant government funding. The current challenges of EGS regard reservoir management, connectivity and feasibility of drilling at extended depths and low permeability. As these technical challenges are being addressed, EGS will open new possibilities while at the same time magnify current constraints. EGS will attempt to improve returns by expanding the location and scalability currently limited by resource requirements. Exploration risks, however, will be magnified as EGS continues to expand the boundaries of the current terrain by potentially drilling deeper wells, engineering subsurface reservoirs or expanding current reservoirs.

Despite increased focus and investment, the following market penetration challenges persist:

- Access to capital – High risk capital requirements in the early stages of project development are a barrier for geothermal exploration.
- Drilling – Rising drilling costs and competition with the oil and gas industry for similar talent and capital reduce the attractiveness of geothermal investment.

- Leasing and permitting – Land lease and permit processing may not be able to keep up with demand.
- Skilled labor – Scientists and engineers are aging and in decline while the industry demands more skilled labor than other renewable resources.
- Working fluid and water supply – Working fluid prices are continuing to increase as creating possible long term feasibility issues for binary systems. EGS areas of the Western United States with potential geothermal development are susceptible to water supply shortages and constraints.

At a July 2009 meeting of geothermal developers, operators, suppliers and consultants sponsored by the Geothermal Energy Association, participants listed the following factors as impediments to the development and expansion of geothermal resources (from most significant to least significant):

- Lack of financing
- High total project costs
- High risk of development
- Inadequate transmission
- Permitting delays
- Need for better resource information
- Federal/state policy changes
- Drilling risks
- Inadequate government support
- Environmental restrictions, and
- Other.

5. Areas for Further Research and Development

At the July 2009 geothermal meeting, participants listed the following as the most critical areas for further research support (from most critical to least):

- Resource identification
- More successful drilling
- Lower cost drilling
- Finding hidden resources
- New exploration technology
- Reservoir engineering techniques
- Higher efficiency cooling systems
- Lower temperature power production
- Enhanced geothermal systems, and
- Higher efficiency power systems.

6. Geothermal Energy and Induced Seismicity

One controversial issue associated with EGS is the impact of induced seismicity, which has been the cause of delays and cancellation threats of at least two EGS projects

worldwide. The oil, gas, mining, hydropower, and other extractive industries have long histories and substantial experience with seismicity due to hydrofracturing and other surface and subsurface activities. Earthquake activity, or seismicity, can be induced by human activity, including development of geothermal fields, which can result in low magnitude events known as “microearthquakes” which have Richter magnitudes below 2 or 3 and which are generally not felt by humans.

A recent *New York Times* article (June 24, 2009) on a microearthquake set off by EGS drilling in Basel, Switzerland has raised some concerns in California about the possibility of a similar event at The Geysers as a start-up company intends to begin drilling using the same techniques to fracture hard rock more than two miles deep to extract its heat. Residents of the region, which straddles Lake and Sonoma Counties, have already protested smaller earthquakes set off by a less geologically invasive set of energy projects there. Some seismologists believe that breaking rock that far down carries more serious risk. Because geothermal operations usually take place in areas that are also tectonically active, it is often difficult to distinguish between geothermal-induced and naturally occurring events and many regions where geothermal development has occurred or has been planned are already known as areas with high levels of fault activity. A seismic monitoring committee has been established at The Geysers to provide an open forum for concerned individuals. The environmental impact report prepared in connection with the project to bring in supplemental water from Lake County for injection at The Geysers determined that a geothermal facility would induce less than significant increases in seismic activity.

The Australian government has published a report on the risks associated with hydrofracturing¹³. Its findings are consistent with the findings of a Lawrence Berkeley Laboratory study published in 2006, which concluded that “EGS-induced seismicity need not pose a threat to the development of geothermal energy resources if site selection is carried out properly, community issues are properly handled and operators understand the underlying mechanisms causing the events.”¹⁴ The Geothermal Energy Association’s website has five new issue briefs on this topic and others¹⁵.

¹³ “Induced Seismicity and Geothermal Power Development in Australia”, at: www.ga.gov.au/minerals/research/national/geothermal/

¹⁴ See “Induced Seismicity Associated with Enhanced Geothermal Systems,” Ernest L. Majer, Lawrence Berkeley National Laboratory, 2006, LBNL-LBNL-61681, at <http://repositories.cdlib.org/lbnl/LBNL-61681/>.

¹⁵ available at <http://www.geo-energy.org/publications/reports.asp>

ETAAC Advanced Technology Development Report Chapter 5 - Energy Efficiency

Energy Efficiency: A Critical Path to GHG Reductions

California has long supported programs, technologies, and policies that promote energy efficiency as a cost-savings means of achieving critical air quality, energy use reduction, and greenhouse gas (GHG) mitigation goals. The success of existing programs have played a major part in California's ability to keep per-capita electricity demand flat rather than following the national trend of increasing per-capita demand for electricity. While California will continue to enjoy the cost-savings and environmental benefits of electricity consumption a third less than other areas of the country, meeting California's GHG goals will require accelerating that trend with development of advanced technologies for both electricity and natural gas efficiency. These technologies will also play a role in meeting air quality goals and helping keep California's businesses competitive while promoting the development of new markets that can help California's economy.

This document updates the February 2008 ETAAC report by providing a brief overview of critical advanced technologies along with policy recommendations to facilitate the development of these advanced technologies for California homes, industries, and businesses.

I. Existing Policy Framework

The following brief overview of relevant California activities underscores the State's commitment to this policy tool. In 2003, the California Energy Action Plan—a joint publication of the California Public Utilities Commission (CPUC) and the California Energy Commission (CEC)—established energy efficiency as California's top-priority resource for meeting energy demand. A 2005 update to the Plan reiterated this policy, noting, "Energy efficiency is the least cost, most reliable, and most environmentally-sensitive resource, and minimizes our contribution to climate change." (California Energy Action Plan II, page 3).

The CPUC's Long-Term Energy Efficiency Strategic Plan, published in 2008, focuses on technologies and actions that will significantly optimize California's energy use—and dramatically decrease GHG—over the next 10 years. Other state activities, including legislation and the Governor's Green Building Executive Order, further highlight California's reliance on advanced energy efficiency technologies to achieve significant GHG reductions.

California's investor-owned utilities (IOUs) and publicly-owned utilities (POUs) have implemented increasingly strategic approaches to energy efficiency for the past 30 years. The most recently proposed three-year program for California's IOUs, could save some 95,000 gigawatt-hours of electricity and 2,500 million therms of gas, leading to a

reduction of roughly 69 million life-cycle tons of carbon dioxide (CO₂) (IOU-proposed Energy Efficiency Portfolio, July 2, 2009, mandatory scenario) over the lives of measures installed through the 2009-11 program cycle as proposed. Similar programs run by the State's publicly owned utilities (POUs), as required by AB2021, will also yield GHG reductions. According to a March 2009 report from POUs to the California Energy Commission, the 15 largest POUs account for nearly 97 percent of energy efficiency savings in the public power community. In addition, POU energy efficiency expenditures for FY08/09 are expected to increase to over \$150 million, resulting in 128 megawatts of savings during the summer peak, 625 million kilowatt-hours during the entire year, and 2.3 million tons CO₂ equivalent over the lifetime of the installed measures.¹

Building on this momentum, the Climate Change Scoping Plan, published in 2008 by the California Air Resources Board (CARB), envisions applying energy efficiency to reduce electricity demand by 32,000 gigawatt-hours and gas use by 800 million therms, thereby cutting GHG emissions by more than 26 million metric tons, by 2020 (Scoping Plan, Tables 7 and 8, page 44). However, the Plan cautions, "Achieving the energy efficiency target will require redoubled efforts to target industrial, agricultural, commercial, and residential end-user sectors, comprised of both new initiatives ... and improvements to California's traditional approaches of improved building standards and utility programs. (Scoping Plan, page 42).

Finally, California's long-term planning process, embodied in the Integrated Energy Policy Report and the long-term procurement plan, provides a basis for both assessing GHG potential as well as the mechanisms—described above—that lead to the promised GHG reductions.

II. Promising New Technologies for Enhanced Energy Use and GHG Reductions

Among the new initiatives called for in the Scoping Plan are advanced technologies that can help California retain its lead in energy use and GHG reductions. Described below are the key new technologies either on the horizon or recently introduced that could, with additional support, join the State's arsenal of energy efficiency measures and lead to significant GHG reductions. Table 1 below provides a brief summary of these technologies including GHG savings, potential economic benefits, potential barriers & policies to address those barriers.

Industrial and Commercial Solar Thermal Hot Water and Steam Systems

Many are looking to solar thermal systems—which convert the sun's radiation into usable heat—as a means of sharply reducing natural gas consumption. Typical solar thermal systems employ lenses, a concentrating mirror, or any of an array of emerging technologies to concentrate sun's radiation. This concentrated heat in turn heats a fluid (often water/glycol mixtures or mineral oils) to almost 400°F or higher. The hot fluid is

¹ <http://www.ncpa.com/images/stories/LegReg/2009SB1037ReportFINAL031609.pdf>

then fed into a boiler to generate steam or hot water for process needs instead of on-site natural gas combustion or to generate electricity.

These solar thermal steam generators eliminate the need for much of the natural gas now consumed by most of the boilers and heaters used in the process industry and commercial buildings in California—a reduction that directly decreases GHG emissions.

Commercial and industrial users can currently expect a payback of five to ten years. That payback period will likely shrink as costs are assigned to GHG emissions, lowering a primary barrier to implementation. An interesting opportunity may occur if new electricity generation cross-fertilizes with other sectors with significant thermal and electrical needs. Many of the current cost reducing innovations (new materials, modular installation) taking place are specific to smaller scale hot water and steam systems. The RPS standards driving the solar thermal electricity generation sector is resulting in some spill-over in that the companies drawn to that market-place are also expanding into systems for commercial/industrial customers. It is a reasonable expectation that future specific technology developments for the electric generation sector can spill-over into customer scales steam, hot water, and even electric generation from solar.

Benefits to California companies include cost-savings and improved competitiveness for companies that adopt this technology, potential for increased job density in California when imported fuels are displaced, and installer and other potential jobs. Lastly, the ETAAC is currently evaluating whether additional measures are necessary to support this technology.

Wastewater Treatment

Technologies now coming to market can decrease the energy consumed in wastewater treatment and open the door to interrelated approaches that reduce the GHG—primarily methane—released from wastewater treatment processes.

Wastewater treatment falls primarily into two categories:

- **Municipal systems:** Taking the form of either a plant or a large lagoon (where land is available), municipal systems are operated by a city or county and receive waste from the municipal sewer system, which generally mixes wastes from many residential, commercial and industrial sources.
- **Industrial systems:** Typically smaller lagoons, industrial systems are operated on-site at an industrial or food processing facility. These systems treat waste generated only by that facility prior to discharge to land, water, or sewer.

Both municipal and industrial systems depend on two principal methods for treating wastewater: aerobic and anaerobic. The aerobic process treats waste in the presence of oxygen (supplied by electrically powered aerators); anaerobic digestion treats waste in the absence of oxygen. GHG emissions result from both the electricity required to power the treatment processes and from the treatment process itself, which can generate “fugitive” GHG emissions. Aerobic treatment generates CO₂, and anaerobic treatment generates methane (CH₄), a much more potent GHG than CO₂. The methane produced in

the anaerobic treatment process can be flared or used for onsite generation, where the combustion process turns the methane into less potent CO₂.

Solar-powered water circulators and other new technologies aim to reduce the electricity needed in lagoon processes. However, technologies that capture fugitive emissions—especially methane—and enable its re-use to generate heat or fuel processes could yield far greater GHG reductions. Strict GHG regulations are needed to drive research and development of, and market shifts toward, technologies that improve methane capture at a variety of points, from sludge handling and treatment through anaerobic digestion. Such technologies include cogeneration systems, gas purification technologies, and anaerobic digestion systems. Also needed is additional research to address the challenging problem of quantifying GHG savings from reductions in fugitive emissions.

Increased use of anaerobic digestion can increase the supply of electricity and can result in wastewater solids or process waste (food scraps) having economic value. Technologies to reduce the energy use of aerobic treatment can reduce operating cost for wastewater treatment processing, and create jobs and business opportunities for the companies supplying those solutions.

Solid-State Lighting

Because lighting accounts for so much of overall energy use, expectations are high for the next generation of lighting technologies. By saving energy, such technologies will also lead to decreased GHG. Solid-state lighting—comprising light-emitting diode (LED) and organic light-emitting diode (OLED) technologies—is the exclusive focus of Department of Energy (DOE) lighting research. Similarly, private companies based the majority of new products displayed at Lightfair 2009—the lighting industry’s premier event—on solid-state technologies.

However, reliable, low-cost, high-performing products for many consumer applications may still be years away. And as LED technology advances, conventional technologies will also improve, narrowing the comparable benefits of solid-state options – although there is less room for improvement on existing technologies. Perhaps even more significant, the price of LED fixtures is not likely to compete with that of fluorescents in the near term except in applications where superior longevity yields other cost savings.

California's high tech infrastructure and entrepreneurial culture has fostered numerous solid-state start ups and as noted in chapter two lighting is one of the main sectors for “green” jobs in California. The California presence tends to focus on R&D and product development, as well as serving as a beach-head for U.S. sales and marketing. The major international LED chip manufacturers are Nichia, Seoul Semiconductor, Osram Sylvania, Phillips, GE, and CREE; the major U.S. fixture manufacturers (LED integrators) are Hubbell, Acuity, Cooper Industries, and Phillips Lighting. Developing the California market may help pull this technology to full commercialization and set a leadership example for others to follow.

Home Area Networks²

Sometime in the not-too-distant future, both residential and business premises across the U.S. may be equipped with smart networks—called home area networks or HAN—that give consumers near real-time information and control of their electricity usage. Studies have shown that real-time usage information not only heightens awareness, but can often trigger behavior changes that result in lower energy use, and thus, GHG reductions. These changes can be in the simple form of turning off devices and/or unplugging them, to more complex methods, such as using an energy management system to turn appliances off/on in response to pricing and other signals provided by the energy provider. Furthermore, consumers can obtain device level consumption information for specific appliances to identify “energy hogs”, which can lead to energy efficiency measures such as replacing equipment with newer more energy efficient equipment.

Small and medium businesses and commercial and industrial customers also benefit from the ability to increase their market competitiveness by helping them identify and reduce wasted energy and improve process management. While California does not have a large manufacturing base for related technologies such as smart meters and programmable thermostats, Silicon Valley is home to many start-ups and venture capital firms focusing on HAN solutions in utility and consumer markets. The HAN ecosystem encompasses many device and energy management solution providers, developing innovative and low-cost ways to provide energy management tools.

DOE has identified ZigBee+HomePlug SE 2.0 as Smart Grid communication standard within consumer premises. Still under development, this standard may be available in consumer devices as early as 2011. Smart meter infrastructure, now available and being installed in many areas, is a key requirement for HAN deployment.

In addition, while many of the component technologies required to implement HAN are available and reasonably well-understood, the full set of standards required to enable integration and broad-based interoperability are still not yet mature. That said, countless standards bodies with broad industry participation (e.g., OpenHAN) are actively working to develop and refine these standards. The state and federal governments can support these efforts by endorsing HAN-related initiatives that are consistent with the emerging standards. Furthermore, funding of additional resources to support work on standards will also likely accelerate the development timeline.

Zero-Net Energy Homes and Commercial Buildings

Two of the big bold strategies advanced in the CPUC’s Strategic Plan focus on zero-net energy (ZNE) buildings. Specifically, the Plan envisioned that all new homes would be ZNE by 2020 and all new commercial construction would be ZNE by 2030. The CPUC defines ZNE as “. . . a combination of building energy efficiency design features and on-site clean distributed generation that result in no net purchases from the electricity or gas grid, at the level of a single ‘project’ seeking development entitlements and building code

² Pertains to both business and residential, but is referred to in this document by its common nomenclature.

permits.”³ Because ZNE buildings would use far less energy than conventional buildings, their GHG footprint would be considerably smaller.

This broad definition enables utility programs charged with making ZNE construction a reality to analyze and implement a wide range of energy efficiency and renewable options. At the most basic level, these programs aim to design buildings with very low energy demand and distributed renewable generation technologies to generate enough energy to net out those loads, usually on an annual basis.

Reducing building loads will require advances in construction materials, systems, and technologies, as well as in design processes and strategies for integrating these elements. For example, advanced building envelope design and construction methods lower the overall need for heating, cooling, and lighting; advanced lighting and HVAC systems can meet the lower demand more efficiently and appropriately than today’s systems; and integration of all can weave together individual systems to enhance the energy performance of the structure as a whole. Also needed is optimum integration with the renewable generation technology—at either the project site or a remote location—selected to net out the low building loads. Thus achieving ZNE will require maintaining a consistent vision of design and performance goals throughout the entire design and construction process.

There are a few instances where split incentives could come up in the context of ZNE, generally involving rental properties where a tenant pays the utilities but is not able to modify the building systems without owner consent and participation. This would likely only come up in a retrofit situation. For new development, owners/developers are generally pursuing ZNE either because they will directly benefit from a lower utility bill (and the bragging rights of having a ZNE building), or because they believe that the ZNE property will be worth more to prospective tenants or owners, and they will therefore directly benefit from higher rent, an increased sales price, faster sales, etc.

Building energy use is a large percentage of national energy consumption; significant reductions in the loads of zero net energy projects will result in corresponding greenhouse gas reductions. Ultimately, as advanced building systems, technologies, and design strategies evolve and transform the market, they will become part of standard design practice, pushing the built environment towards the big bold CPUC goals.

Advanced Residential & Commercial Air Conditioning Residential Hot Dry Air Conditioner

California’s peak electric demand dominates the need for additional power plants, transmission infrastructure and related environmental issues. California and other states with hot dry climates need air conditioners that maximize indoor temperature reductions for the expended energy. This is particularly true at high outdoor temperatures. Commercially available air conditioners are designed to meet national performance

³ Interim Opinion on Issues Relating to Future Savings Goals and Program Planning for 2009-2011 Energy Efficiency and Beyond, Decision 07-10-032, October 18, 2007, page 38.

standards that are roughly based on “average” cooling season weather conditions across the United States.

The goal of Hot Dry Air Conditioner Project is to build peak reducing split and package system air conditioners for hot/dry climates and to subsequently produce and promote a performance standard for air conditioners with superior performance in these climates.

The primary methods of producing an air conditioner particularly suited to hot dry climates are: higher efficiency evaporator coils, higher efficiency condenser coils, lower watt draw evaporator fan motors, smaller compressors, and evaporator fan motor controls that utilize the moisture on the evaporator coil to provide additional sensible cooling after the compressor cycle ends. Methods of improving the sensible performance of air conditioners at high temperatures include the above items as well as evaporatively cooled condensers and improved condenser coil airflow.

The studies show that the top tier HDACs can provide savings of 44% at peak and 33% annual energy savings over the SEER 13 baseline. Aggressive adoption of HDAC standards could provide tremendous energy savings.

Advanced Commercial Rooftop Units

Central packaged rooftop units (RTU) are the most commonly used air-conditioning systems in commercial buildings. RTUs consume about a half of all the energy used to cool the commercial buildings. Surveys indicate that most RTUs have some degrees of undetected malfunctions, particularly in air-side economizers.

California Energy Commission initiated the advanced packaged rooftop unit (ARTU) project under the Public Interest Energy Research program (PIER). New features have been specified into ARTU, which include: improved outdoor air control, improved economizer reliability, on-board self-diagnostics and troubleshooting capability, and fault-tolerant design. The Consortium for Energy Efficiency, as an association of utilities and efficiency advocates will adopt new features for an advanced HVAC tier, and thus encouraging the manufacturers to build them.

With these new features, the rooftop units will be more reliable and have less performance degradation over time. ARTUs will have improved long-term energy performance and will ensure the equipment meets the current efficiency benchmarks at the desired levels throughout its lifetime.

Industrial and Commercial Refrigeration

Replacing today’s refrigerants with new fluids specifically fabricated for low global warming potential (GWP) appears a straightforward approach to reducing GHG. However, some caution is merited. Currently, the performance of these new GWP refrigerants is not well understood, and most commercial and industrial refrigeration systems are custom engineered. Systems based on the new refrigerants are therefore

likely to be more expensive and time-consuming to design and install than are conventional systems—and may not perform to targeted levels.

Further, changing the refrigerant may lead to either a small increase or decrease in refrigeration system energy use. The challenge—and opportunity—lies in influencing customers to engineer systems that simultaneously reduce energy use and GHG emissions. These benefits can come from coordinating GHG regulations limiting high-GWP with energy-efficient equipment redesigns.

The potential GHG reductions promise to be significant. For example, replacing 1 pound of conventional refrigerant (such as R-744) with one pound of low GWP refrigerant can reduce GHG by 3,784 tons. Incentives are available in California for emerging and existing refrigeration technologies that save energy in existing or new facilities. In addition, Title 24 Codes will apply to new build refrigerated warehouses beginning in January 2010. IOU incentives and demonstrations are available for new low GHG refrigerants, but only when they save energy.

Draft

Table 1. Promising Advanced Energy Efficiency Technologies

Technology	Market Introduction/ Penetration Timeline	GHG Reduction Potential	Implementation Strategy	Barriers/Risks to Implementation
Solar thermal (steam)	1 year to introduction and ~1-5 years penetration	600 MM therms/yr x 0.0053 MT CO ₂ /therm = 3.19 MMT CO ₂ /yr (derived from CARB Scoping Plan 2009)	CA energy efficiency Programs, CA Solar Initiative	<p>First cost, lack of experience with technology</p> <p>Split incentives present a risk if there is a threshold below which facilities of a smaller size or a rental property are not directly responsible for paying for GHG emissions. The customer that might invest in the low GHG technology does not see the full benefit from doing that because they only indirectly pay for GHG emissions.</p>
Solid State Lighting	2007-2020	Technical potential of 189 TWh for U.S. (DOE/ Navigant 2008)	Partnership with DOE Consortium	<p>Relative size of near term market potential (lack of qualified product & high initial cost).</p> <p>Split incentives present a risk if there is a threshold below which facilities of a smaller size or a rental property are not directly responsible for paying for</p>

				GHG emissions. The customer that might invest in the low GHG technology does not see the full benefit from doing that because they only indirectly pay for GHG emissions.
Efficient Aerobic Treatment for Wastewater Lagoons	Currently in the market	1,000 GWh/yr x 0.00044 MT CO ₂ /kWh = 0.44 MMT CO ₂ /yr (derived from CARB Scoping Plan 2009)	CA energy efficiency programs	<p>First cost, lack of experience with technology</p> <p>Split incentives present a risk if there is a threshold below which facilities of a smaller size or a rental property are not directly responsible for paying for GHG emissions. The customer that might invest in the low GHG technology does not see the full benefit from doing that because they only indirectly pay for GHG emissions.</p>
Low GWP Refrigerant	1 year to introduction and ~1-5 years penetration	1 lb low GWP refrigerant can reduce GHG by 3,784 tons compared to 1 lb of a typical CO ₂ refrigerant, such as R-744; Note: <i>use of R-744 is in "its</i>	GHG regulations	<p>Limited understanding of new refrigerant performance characteristics</p> <p>Split incentives present a risk if there is a threshold below which facilities of a smaller size or a rental property are not directly responsible for paying for GHG emissions. The</p>

		<i>infancy". As of early 2008, 9 systems were using R-744 for in use in the entire US.</i>		customer that might invest in the low GHG technology does not see the full benefit from doing that because they only indirectly pay for GHG emissions.
Home Area Network	1 year to introduction and ~1-5 years penetration	May lead to a 5% - 8% reduction in energy use	CA IOU proof of concept demonstrations expected in 2010; potential for broader deployment in 2011 and beyond	Standards still in development. Enabling technology, HAN gateway, which can be located in the smart meter, is required. Split incentives present a risk if there is a threshold below which facilities of a smaller size or a rental property are not directly responsible for paying for GHG emissions. The customer that might invest in the low GHG technology does not see the full benefit from doing that because they only indirectly pay for GHG emissions.
Hot Dry Air Conditioner	1 year to introduction and ~1-5 years penetration	May lead to 17 MW demand reduction, 9 GWh energy savings, and 2139 Metric Tons CO ₂ /yr reduction.	CA energy efficiency Programs	First cost, lack of experience with technology Split incentives present a risk if there is a threshold below which facilities of a smaller size or a rental property are not directly

<p>Hot Dry Air Conditioner</p>	<p>1 year to introduction and ~1-5 years penetration</p>	<p>May lead to 17 MW demand reduction, 9 GWh energy savings, and 2139 Metric Tons CO₂/yr reduction.</p>	<p>CA energy efficiency Programs</p>	<p>First cost, lack of experience with technology</p> <p>Split incentives present a risk if there is a threshold below which facilities of a smaller size or a rental property are not directly responsible for paying for GHG emissions. The customer that might invest in the low GHG technology does not see the full benefit from doing that because they only indirectly pay for GHG emissions.</p>
<p>Advanced Rooftop Units</p>	<p>1 year to introduction and ~1-5 years penetration</p>	<p>May lead to 20% reduction in energy use.</p>	<p>CA energy efficiency Programs</p>	<p>First cost, lack of experience with technology</p> <p>Split incentives present a risk if there is a threshold below which facilities of a smaller size or a rental</p>

III. Lessons Learned and Policy Recommendations

Decades of ground-breaking work in energy efficiency and emissions reductions have provided California a rich lexicon of lessons learned. The current push for GHG mitigation can draw on this body of knowledge to speed and optimize efforts. This section briefly touches on a partial list of lessons and recommendations that might be incorporated into action or policy. The introductory section of this chapter touched on some of the lessons from the California experience. Energy efficiency deserves special attention because it can lead to significantly lower energy bills. Significant monetary savings associated with energy efficiency may be lost absent targeted policy initiatives due to myopic choices, the so-called behavioral gap familiar to energy experts.⁴ For a state like California that has been a leader in energy efficiency, it is to recognize that efficiency is not a finite, static resource. Rather, innovation constantly renews the possibilities for energy savings from new efficiency measures. As a concrete example of this, efficiency performance standards for refrigerators have been ratcheted down twice by the California Energy Commission and twice by the U.S. Department of Energy and since California first introduced this standard in the 1978.⁵ Even as the size of refrigerators increased and their cost declined, their energy efficiency improved at a rate of about 4% per year from 1974 to 2001.

Energy efficiency, especially when coupled with incentives and additional financing mechanisms such as the Federal stimulus bill, can be especially helpful in overcoming several of the barriers identified in the Introductory chapter of this report. Lack of market acceptance and knowledge, lack of demand, and higher upfront costs are particular challenges for advanced technologies. However, California's strict codes and standards, robust energy efficiency incentives, and progressive legislation make it an ideal model for pursuing and remaining a leader in development advanced and emerging technologies.

Increased Collaboration

First, collaboration will be critical to achieving GHG goals efficiently and rapidly. As noted in the Scoping Plan, "Successful implementation of many of the proposed programs and measures described in this plan will require strong leadership and a shared understanding of the need to reach viable and lasting solutions quickly. This challenge will also require establishing a wide range of partnerships, both within California and beyond our borders." (Scoping Plan, page 113) As noted earlier the path to successful developing a new technology can be short-circuited by a lack of coordination at a number of points. ETAAC can work with existing organizations⁶ to flag coordination issues.

⁴ For an authoritative recent discussion, see page 50 of the report *America's Energy Future: Technology and Transformation: Summary Edition* from the National Research Council, Committee on America's Energy Future. 2009. National Academies Press: Washington, DC.

⁵ S. Nadel, ACEEE, in ECEEE 2003 Summer Study, www.eceee.org

⁶ For example, the Investor-Owned Utilities in California coordinate through a standing committee.

A first step to building these partnerships would be to increase communication and collaboration among the multiple agencies and organizations described in the first section of this chapter. Helping these organizations effectively integrate GHG reduction goals into their efforts would help ensure the success of this GHG mitigation effort.

The ETAAC is evaluating specific recommendations for how various agencies should coordinate and collaborate.

Guidance on AB 32 Implementation

As implementers of energy efficiency programs, the IOUs and POU's would greatly benefit from clear guidance from the CPUC, CEC, and CARB on AB 32, particularly on the effects of AB 32 implementation on eligibility for incentives. As discussed in the previous report, this effort might draw on the precedents established for other statewide efforts, such as the Governor's Green Building initiative. The bottom line is that all stakeholders need to be accountable for achieving energy savings targets and GHG reductions. The stakeholders, CPUC, CEC, ARB, POU's and IOUs should collaborate to reach agreement on attribution so that parties can claim savings from projects that are also mandated to achieve GHG reductions, but paid through incentive programs.

Leverage of Federal Stimulus Funding

The American Recover and Reinvestment Act (ARRA) is making \$38.6 billion available for energy efficiency nationally. Of this, California expects to receive \$ 798 million, to be distributed through numerous agencies, including DOE, CEC, Housing and Urban Development, Department of Agriculture, and General Services Administration. Part of the funding coming to California includes \$3.2 billion from DOE slated for block grants to local governments. This money can help pay for energy efficiency retrofits using advanced technologies. By leveraging stimulus dollars with utility funded-incentives (as long as the utility is offering an incentive on the technology), government, residential, and commercial customers can cover most, or perhaps even all, all of the incremental costs of an energy efficient project - a barrier that ETAAC has recognized as both prevalent and significant. Incentive programs can also help overcome information barriers, which can be especially effective when combined with incentives. Given the inflow of these funds, no time is better than the present to begin to realize GHG reductions from energy efficiency projects funded by stimulus funds and push forward the development of promising energy efficiency advanced technologies such as those identified earlier. ARRA is discussed in more detail in the Introduction of this report.

Incorporating Pending Federal Legislation

As part of ongoing efforts to revamp federal energy legislation and create federal climate policy, the House of Representatives has passed HR 2454: The American Clean Energy and Security Act of 2009, and the Senate is debating a similar bill. The final legislation, when enacted, will undoubtedly affect California's energy efficiency and GHG mitigation efforts, and managing these impacts may present challenges. In all likelihood this legislation will explicitly or implicitly promote emerging technologies in specific areas.

As an example of these challenges, the following summary examines HR 2454 measures related to lighting, appliance and building technologies:

Lighting and Appliances:

- More stringent HR 2454 appliance standards, and associated policies and procedures, could increase energy efficiency savings for the state, for measures where federal standards currently preempt the State from advancing its own standards.
- California Title 20 appliance standards are same as federal standards, except where:
 - No federal standard exists, in which case California can develop a state standard
 - California has a specific exemption from federal preemption, allowing the State to implement a more aggressive standard.
- HR 2454 exempts California from federal preemption on several new appliances, allowing California to pursue more stringent standards for these appliances.

Building Technologies:

- California would need to implement several measures proposed in HR 2454, such as a program to retrofit entire buildings and a building energy performance labeling program. The labeling program would require significant state effort to achieve the desired 90% compliance. Efforts could include hiring inspectors, creating manuals, providing training, etc. Failure to comply could result in loss of funding and carbon credits.
- Local building code offices may be eligible to receive proposed HUD grants for local code enforcement agencies.
- Due to differences between proposed federal and California existing building code timetables, California would not be compliant with national commercial building standards until year 2 of the federal timetable. However, California would be compliant with national residential building standards in year 1.

Advanced Technology Development Report

CHAPTER 6- TRANSPORTATION

Background

The transportation sector in California is the largest in-state source of GHG, and transportation will play an extremely important role in meeting California's long-term GHG reduction goals. Transportation also constitutes nearly half of air pollutants contributing to ozone and fine particulate pollution in areas such as the South Coast Air Quality Management District. California has long been a leader in clean transportation technology, and successes in California's efforts to reduce greenhouse gases will be followed closely by decision-makers both in the United States and internationally.

In addition, responding effectively to market opportunities and federal spending on advanced vehicle technology development offers important opportunities to expand the state's "Green" jobs. California has significant innovation capital and capacity, a culture of "early adopters" such as with hybrid passenger cars, and the capability to manufacture clean transportation technologies. CALSTART has identified over 200 California companies and organizations supporting California's clean transportation industry.¹ In addition, transitioning to more efficient transportation will also reduce a significant cost for businesses in the state.

The refinement of conventional vehicle technologies is unlikely to lead to the same level of California job creation as technology capable of dramatic GHG reductions due to lesser market growth opportunities and California business' focus on newer generations of technology. In addition to job creation in the vehicle arena, the next generation of technologies involving plug-in hybrid electric vehicles, factory electric vehicles and fuel-cell electric vehicles will all require substantial infrastructure improvements and developments. This in turn will also lead to significant additional opportunities for creation of high quality jobs and dollars retained within the California economy instead of exported to purchase imported energy supplies. Creation of advanced biofuels may also create further opportunities.

The purpose of this chapter is to help update the original ETAAC report in these areas, both in terms of policies as well as economic developments including federal stimulus money. This chapter discusses light duty vehicles, and medium and heavy duty vehicle technologies for both near and long term. This chapter also discusses the potential for advanced technology biofuels.

I. Vehicles

A. Light Duty Vehicles

Near-Term Strategies

The US EPA has announced that it will establish GHG standards (working with the US Department of Transportation, which is responsible for fuel-economy standards) through

¹ CALSTART, Clean Transportation Technology in California, 2009

2016 that are as strict as those set by CARB. We are currently evaluating the details of this proposal for its implication for California and advanced technology development for the final report.

Financial incentives deployed in the near-term help technology development if they are structured properly. The results of the “cash for clunkers” incentive are mixed. Low fuel economy vehicles were retired early (average 15.8 mpg), but replaced with vehicles much less efficient (24.9 mpg) than will occur under federal fuel economy standards beginning in 2012. Thus, this program is most likely to remove older vehicles from the road without promoting technology innovation. A better alternative for advanced technology development would be “feebates” that create an incentive for cleaner vehicles while assessing a charge on less-efficient vehicles. Long-term “feebates” would encourage risk-averse manufacturers to invest in R&D and offer more fuel-efficient vehicles, with a stable price signal for efficiency even after manufacturers meet minimum standards (*placeholder: an ICCT report on feebates is in development*). The level of the incentive would increase for the most efficient vehicles, creating a technology-neutral market “pull” for advanced technology development to complement technology-specific efforts listed below.

California has offered a package of incentives to keep the NUMMI plant in Fremont operating after the departure of GM from the former GM-Toyota partnership. The plant has a capacity to produce several hundred thousand vehicles per year, and while future plans are uncertain it would provide potential for shifting to large-scale manufacturing for large-scale advanced technology vehicles in the future.

Long-Term Strategies for GHG Reductions

California has a variety of regulatory programs to address both greenhouse gases and conventional air pollutants. Currently CARB staff are developing a strategy to integrate the greenhouse gas and zero emission vehicle programs. According to CARB’s Tom Cackette, (Endicott House, August 2009) his staff is working on a multi-phased approach to reach the 80% reduction in greenhouse gases by 2050, which also requires a 28% reduction from 1990 levels in 2020. The specific actions required are:

- increase in fuel efficiency by a factor of three.
- transition from petroleum to ultralow carbon fuels.
- this transition to ultralow carbon fuels will require the transition to electric drive
- reduction in the vehicle miles traveled by about 20%

The implementation of these strategies should consider opportunities for technological growth, leadership and job creation in California. The existing programs to build upon and further develop existing technologies while leading to significant reduction in greenhouse gases are necessary for further job creation. In the transportation sector, the introduction of electric drive and decarbonization of fuels, particularly focusing on use of electricity and hydrogen, offer the potential for substantial job creation in California as noted earlier. Therefore, it is critical that the transportation program in California see a

continuing and consistent strategy, coupled with adequate funding, to ensure industry can respond in a way that can guarantee some certainty about implementation. For example, as discussed below, in addition to strong regulations, which are typically implemented over a period of years, market mechanisms such as those incorporated in a "feebate" system can provide immediate fiscal incentives.

Such a system will provide the industry with correct market signals for investment in these advanced technologies and a return on their investments in successful technology development. This will continue California's history of leadership over past decades on criteria pollutant technology development, as well as more recently on standards to promote GHG reduction technology.

Electric-drive technologies overview

The requirement for an 80% reduction in greenhouse gases by 2050 will drive the introduction of advanced technologies into the light duty fleet in California. According to the California Air Resources Board, by 2050 over two thirds of on-road vehicles with full range capacity will be powered by electricity or hydrogen. In the near term, it is anticipated that conventional hybrid electric vehicles will continue to be the dominant form of electric-drive vehicle in the fleet. As we move to greater electrification, such as Plug-in Electric Vehicles (PHEV), Battery Electric Vehicles (BEV), and Fuel Cell Electric Vehicles (FCEV), there will be an increasing need for the development of infrastructure to provide for the electricity to recharge vehicles and to supply hydrogen. The implications of this strategy are discussed below.

It is recognized that there will be additional costs per vehicle for the introduction of these advanced technologies. Figure 1 (*to be added*) shows an estimate comparing the cost of different electric drive vehicles, showing that the incremental costs of BEVs, PHEVs, FCEV². The differential costs are assumed to be those in mass production. Already there are incentives in place to offset the cost differential of these vehicles which will facilitate their entry into the marketplace as discussed below.

A substantial investment in battery technology being provided both by the federal government and other governments noted below will accelerate the introduction of electric drive transportation in California in addition to the regulations that will promote increased use of electric drive vehicles to meet stringent greenhouse gas goals. Such a change in the motor vehicle fleet is likely to lead to significant opportunities for job creation in California. In addition to the increasing investment in research into electric drive components and manufacturing of these components in California, companies such as Tesla and Electric Transportation Engineering company are developing electric vehicle production facilities in California with major federal funding. The required change in infrastructure as a result of the increasing numbers of electric and fuel cell vehicles, will provide significant additional job growth opportunities throughout California.

The increasing use of electric drive will also be seen in parts of a heavy-duty sector,

² figure 1 is from MIT

particularly for buses. This change is already happening in California with hybrids, pure electric and fuel cell vehicles.

The global electric passenger vehicle technology race

Competition to develop and manufacture electric passenger vehicles is a global technology race with well over \$12 billion in investments identified to develop battery electric (including plug-ins) vehicles committed globally since the original ETAAC report.

The United States is providing a massive surge of funding. The federal government and states such as Michigan and Kentucky (and to a smaller degree California) combined will spend \$7.2 billion on manufacturing, federal tax credits up to \$7,500 per vehicles, and demonstrations of electric vehicles and charging infrastructure. Matching private dollars for grants and pending “Clean Cities” awards for transportation electrification will boost that total close to if not over \$10 billion - not including the portion of public loans keeping GM and Chrysler afloat that are also used for this purpose. The federal climate bill passed by the House of representative could provide billions of dollars in additional funding beginning as soon as 2011.

The first round of \$2 billion in federal grants through the Advanced Technology Vehicle Manufacturing Program and private matching dollars (announced in June 2009³) is intended to result in the production of 170,000 electric vehicles (most of which will be electric vehicles with a 100-mile range) and an additional 10,000 battery packs. In August, DOE announced an additional \$2.4 billion in grants under the ARRA. The grants will provide \$1.5 billion for US manufacturing of batteries, components, and recycling, and \$500 million for electric drive components. An additional \$400 million will be provided for electrification, primarily demonstration of vehicles and infrastructure such as a South Coast demonstration project for Class 2-5 vehicles across 50 different utility fleets.

While ETAAC has not independently researched capital costs, these loans, grants, and matching funds should provide sufficient capital investment for at least several hundred thousand PHEV-40 battery packs and perhaps a million or more PHEV-15 battery packs annually. Thus, remaining challenges on the vehicle side will likely remain on bringing down technology costs – with \$500/KW-hr a key target set by the Department of Energy - and increasing performance through additional research and successful manufacturing at scale.

European and Asian governments in countries with significant auto manufacturing are also investing billions into electric drive vehicle manufacturing (as noted in the Appendix) and will compete with manufacturers in California and the United States. Japanese companies have a strong lead in advanced battery manufacturing for other applications, but are under pressure on the automotive side. China is hoping to

³ <http://www.atvmloan.energy.gov/public/pr-062309.pdf>, accessed September 10, 2009.

“leapfrog” existing conventional automotive technology where it is less competitive, into electric-drive vehicles and battery manufacturing through purchase subsidies and other incentives. South Korea is forming its own consortium, and LG Chem has announced separately that it will invest a total of Won 1tr (US\$799m) in manufacturing EV batteries for GM in the US by 2013. Germany, France, and the United Kingdom are also each investing upwards of half a billion dollars to develop electric vehicle technology.

Looking longer term, Congress has re-established funding for hydrogen fuel cell technology that DOE reports has made important steps towards commercialization. While EVs are a potential competing technology with fuel cells, expanding commercialization for EVs and PHEVs will likely facilitate fuel cells by driving down the costs of shared components. CARB predicts that these three technologies will together make up a third of the vehicle fleet by 2030⁴.

Policy Recommendations for California Regarding Electric-Drive Technology

California will play an important role in the deployment of vehicles supported by these large global investments in manufacturing (including R&D). Infrastructure and EV charging policies are necessary to complement California’s mandates to deploy electric-drive EVs/PHEVs. California is a leader in the introduction of new technologies such as hybrid vehicles and can play a similar role for other advanced technologies as they become available for deployment but will need to have the proper infrastructure. Pavley II and ZEV rule development can provide a long-term market and incentive to demonstrate technologies in California. In addition, California should receive preference in federal funding because its low-carbon grid will maximize GHG reductions compared to states with more coal and less renewables. (State-level encouragement of manufacturing is likely to be an economic development strategy rather than playing a critical role in addressing capital availability for technology development given the scale of existing global investments in manufacturing.)

For example, charging stations will be funded with \$22 million in Proposition 118 funding. The South Coast AQMD has received an award to demonstrate this technology in California and nationally for several hundred medium-duty vehicles. While this is a positive start, additional effort will be needed for broad coverage of charging infrastructure.

While some on-peak charging is probably inevitable, the right policies and infrastructure will promote off-peak charging (insert Calstart table of refueling stations in California) and help integrate intermittent renewable resources like wind into California’s electric grid (see Renewable Energy Chapter of this report). As full battery electric vehicles are commercialized, demand for “fast charging” that exceeds typical household load (in KW/hr) will increase. This is both an opportunity – to the extent that charging occurs at optimal times – as well as challenges, in cases where it does not. The California Public

⁴ CARB scoping plan page 119 (version posted on-line as of 9-9-09 at http://www.arb.ca.gov/cc/scopingplan/document/adopted_scoping_plan.pdf)

Utilities Commission is currently investigating a number of important questions such as these about EV charging infrastructure, pricing, and related topics.

The above discussion highlights the fact that AB 32 will require a dramatic reduction in greenhouse gases and a change in the technology and the marketplace. However it also assumes that the public will accept this new technology and buy the vehicles being provided. Based on past experience this is by no means a given. A key part of the overall program is to educate the public on options and needs for such a transformation. Therefore ETAAC, as it did in its earlier report, strongly endorses a comprehensive outreach program so the California public is fully aware all of the challenges posed by climate change and the actions required to mitigate or adapt to those changes. In addition, it is critical that California recognizes the importance of providing strong and consistent regulatory standards and market signals so that the industry can plan its investments over a longer period of time without being subject to changes every few years.

B. Medium and Heavy Duty Vehicles

Immediate Opportunities to Reduce Black Carbon, Other Criteria Pollutants and Greenhouse Gases

Particulate matter (PM) from the exhaust of diesel engines is well recognized as a significant health hazard and has been identified in California as a toxic air contaminant. The California Air Resources Board has extensive documentation on the role of fine particles (typically referred to as PM_{2.5}) in causing well over ten thousand excess deaths in California every year⁵. Diesel particulates from transportation in California are an important contributor to these PM_{2.5} health impacts.

Black carbon is the solid fraction of PM 2.5 that strongly absorbs light and converts that energy to heat when emitted into the atmosphere (and further impacts occur when deposits on ice or snow result in additional warming) Black carbon contributes to global temperature change, changes to geographic landmass of snow and ice and changing precipitation patterns. According to the International Panel on Climate Change, black carbon is the third-largest contributor to positive radiative forcing on climate change. The International Council on Clean Transportation has recently prepared a report (provided in the Appendix) that addresses the role of black carbon in climate change and lays out the basis for actions to reduce black carbon emissions.

The transportation sector, especially the heavy-duty vehicle sector, is an important source of emissions and reductions in emissions of these gases with significant impact in reducing GHG. While black carbon has not been officially recognized within the pollutants defined in AB 32, there is growing evidence that it should be recognized as such.

⁵ <http://www.arb.ca.gov/research/health/pm-mort/pm-mort.htm>

California recently instituted a mandatory heavy-duty vehicle retrofit program aimed at reducing oxides of nitrogen (NOx) and PM. The additional impetus given by recognizing the role of black carbon as a GHG should lead to the acceleration of programs for heavy-duty vehicles and off-road sources in California. It is well recognized that this could lead to continuing significant job creation and that these jobs would be generated in California.⁶

California should also integrate efforts to reduce emissions of GHG and more traditional pollutants with incentive programs, as recommended in the original ETAAC report (chapter 3). An example of legislation authorizing this type of coordination is AB 1527, which was passed by the Legislature and sent to the governor September 8, 2009. The bill would allow co-funding of projects from GHG/petroleum reduction programs (such as AB 118) and criteria pollutant funding (such as Prop1B /Carl Moyer) if incremental benefits are achieved and cost-effectiveness levels are met. For instance, truck owners could choose between an incentive for a cleaner diesel truck, or higher incentive levels for achieving both black carbon and GHG reductions with a hybrid diesel truck or an LNG truck. Incentive programs are one way to overcome the up-front capital costs of advanced technologies that are often a barrier to deployment as noted in Chapter One. *[note: this section on AB1527 is a placeholder pending the governor's decision on whether to sign this legislation. This bill was passed unanimously in both the House and Senate]*

Importance of California Technology Development Funding

The stimulus bill does not provide major new resources for development of medium-duty truck technology such as non-plug in hybrids. ARB has announced that it will provide between \$20 and \$25 million for medium-duty vehicle hybrids from AB 118 funding, demonstrating the importance of maintaining a state-level capacity to promote technologies that are important to California. These demonstrations are likely to be an important step towards achieving the emission reductions from this technology that are called for in the AB32 scoping plan, and helping businesses become more efficient.

For larger heavy-duty Class 8 trucks, the US DOE has announced \$90 million - \$160 million in "Super Truck" federal research, development and demonstration funding over the next three to five years. Cost-sharing by recipients would likely double the total research effort. California has a successful track record of helping commercialize clean technologies through programs such as Carl Moyer and now AB118 funding to develop GHG reduction technology. Future program development for incentive programs such as AB 118 should track these new Class 8 technologies for opportunities to demonstrate and commercialize new technologies that cut GHG and costs and help meet AB32 goods movement GHG reductions. This is another potential example of how a long-term technology development program such as AB118 (authorized through 2014) can benefit California

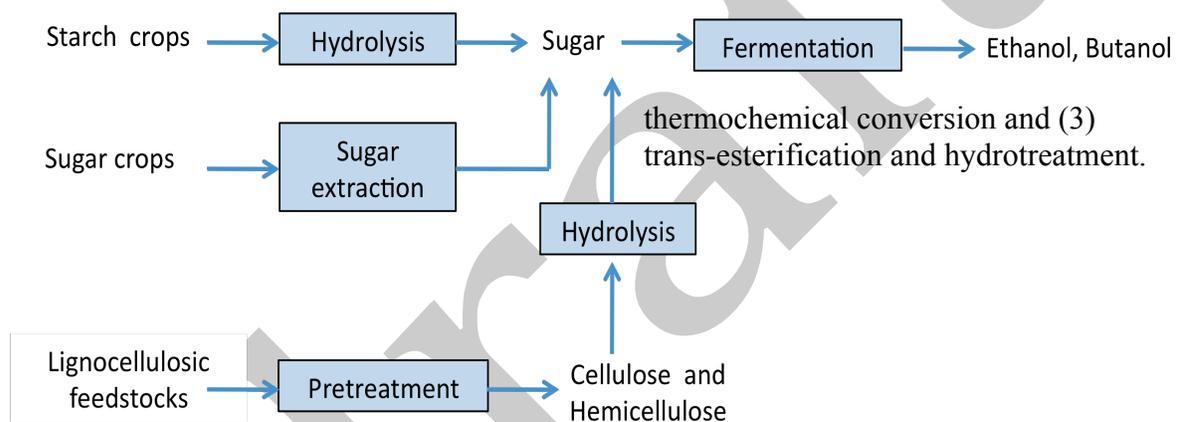
⁶ MECA, 2008, full footnote to be added

II Advanced Biofuels

A. Current Biofuel Pathways –

NOTE: The ETAC Advanced Technology Group has not yet reviewed the following submissions from subject matter experts and is reviewing them concurrently with the public review process

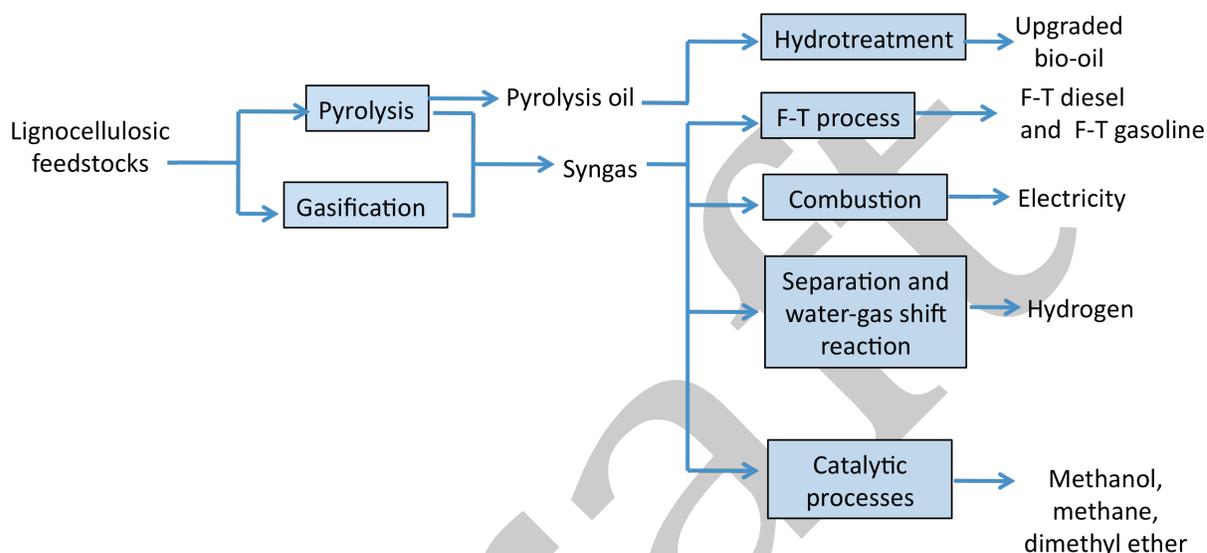
Biofuels have become a major focus in achieving compliance with the Low Carbon Fuel Standard of California. Provided that direct and indirect GHG emissions from growing, harvesting and processing biomass are low, biofuels provide an attractive option for reducing GHG emissions since CO₂ emissions from biofuel combustion are counter-balanced by carbon sequestered during the biomass growth. There are a wide array of biomass types that can be utilized for biofuel production such as sugar/starch crops, oil seeds, dedicated energy crops, agriculture residues, municipal solid waste, waste grease and fat, and algae. Depending on the conversion technologies utilized, biofuels with different characteristics, carbon intensity and final use can be obtained. Broadly speaking, there are three biofuel pathways (1) hydrolysis and fermentation (2)



Biofuels Fig. 1 Butanol and ethanol production via hydrolysis and fermentation

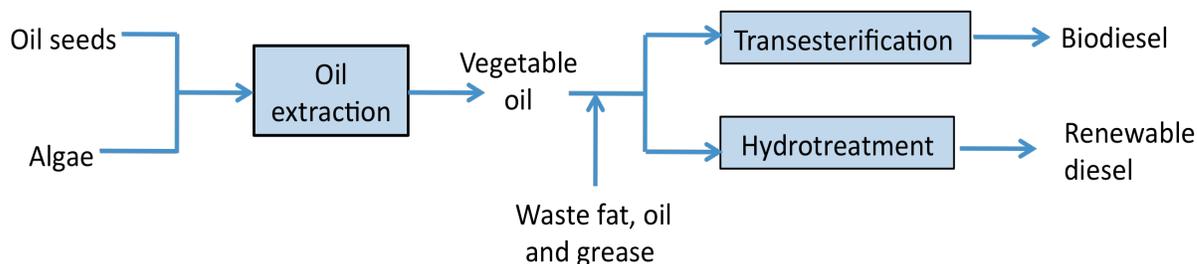
Hydrolysis and fermentation technologies can be used to produce ethanol and butanol from a number of sources such as lignocellulosic feedstocks that include dedicated energy crops, agricultural residues, forest thinnings, and municipal solid waste, starch crops and sugar crops (Fig. 1). Sugar crops including sugarcane are easy to handle since sugar is readily fermented into ethanol by yeast (*Saccharomyces cerevisiae*). Fermenting sugars by *Clostridium species* leads to butanol which has a higher energy content and lower vapor pressure than ethanol. Starch crops require an additional step before fermentation to hydrolyze starch into sugars using enzymes. Due to mature starch hydrolysis and fermentation technologies, sugar and starch crops have become the initial target in biofuel production and currently supply the bulk of biofuels produced worldwide. With growing concerns about GHG emissions from land use changes, direct and indirect, and potential food-fuel conflicts, the attention has now been shifted to producing ethanol and butanol from lignocellulosic feedstocks (Note: Because butanol is a new type of fuel additive it would be required by regulation to undergo a multimedia

assessment in order to thoroughly evaluate its chemical behavior before it could be considered for approval when used in California fuel.). Due to the recalcitrant nature of lignocellulose, it is difficult convert cellulose into sugars. Therefore, pretreatments are required to separate lignin from cellulose and hemicellulose and make these carbohydrates amenable to hydrolysis (Fig. 1). Successful commercialization of cellulosic ethanol and butanol hinges on significantly improving the pretreatment and hydrolysis steps. It is projected that the lignocellulosic technology can produce 115 gallons of cellulosic ethanol per dry ton of biomass (West et al., 2009).



Biofuels Fig. 2 Biofuel production via thermochemical conversions

Thermochemical conversion technologies are attractive because they can provide an interesting suite of fuels that include hydrogen, electricity, diesel, gasoline, methanol, and bio-oils (Fig. 2). Thermochemical conversions are more suitable for lignocellulosic feedstocks and start with either pyrolysis or gasification. Gasification results in syngas whereas pyrolysis results in both oils and syngas. Syngas is primarily a mixture of carbon monoxide, carbon dioxide, and hydrogen. The amounts of pyrolysis oils and syngas produced depend on how pyrolysis is done. For example, flash pyrolysis produces more oils than syngas. Pyrolysis oils can be upgraded using hydrotreatment to produce gasoline and diesel like fuels. Syngas, on the other hand, can be directly combusted to produce electricity, or it can be subjected to water-gas shift reaction and hydrogen separation to obtain improved yield of hydrogen. Another option is to produce F-T diesel and F-T gasoline by using the Fischer-Tropsch process from syngas. The Fischer-Tropsch process was originally used to produce diesel from coal and later on from natural gas. Alternatively, by using catalytic processes, syngas can be converted to methanol, methane, and dimethyl ether. Although thermochemical conversions are more versatile, their applications to lignocellulosic feedstocks for biofuel production are still in the research and development phase.



Biofuels Fig. 3. Bio-based diesel production via transesterification and hydrotreatment

Biomass that contains significant amounts of lipids such as algae, oil seeds, and animal fat; and waste grease and oils derived from them can be used to produce biodiesel and renewable diesel (Fig. 3). Biodiesel is typically produced via trans-esterification of oils and fats and comprises of mono alkyl esters. Renewable diesel is chemically similar to fossil diesel and is produced by hydrotreatment of oils and fats. Soybean is the main feedstock used in biodiesel production in the US whereas the rapeseed/canola is the major feedstock for biodiesel production in Europe.

Recently, there has been growing interest in algae as a potential feedstock for the production of both renewable and bio-diesel. The main reason behind this interest is the higher growth rates and oil contents of some naturally and genetically engineered algae. An NREL study (Sheehan et al., 1998) reported oil contents as high as 59%. It is to be noted that soybean, the current major source of biodiesel, has only 20% oil content. Genetically engineered algae can have oil contents of up to 80%. The per acre oil production from algae can be 100-300 times more than that from soybeans. Since, depending on the species, algae can be grown either heterotrophically in fermenters; or phototrophically in salty water, ponds⁷ in desert, and marginal lands not suitable for crops; it avoids the issues of land allocation and food-fuel conflicts. In a heterotrophic process algae feed on nutrients and carbon substrates whereas in an autotrophic process algae utilizes photosynthesis for growth and deriving energy. In addition, indirect land use change would be minimal if algae are used for biofuel production.

Production of diesel range fuels from algae is still in research and development phase. Several new startups and established companies such as Exxon Mobil and DOW Chemical have stated they will invest significant amounts of money in related research. Exxon Mobil expects that it would be able to commercially produce renewable diesel from algae within 5-10 years. Despite the abovementioned benefits, several challenges remain. Diesel from algae is not yet cost competitive with conventional diesel due to high processing costs. For example, Solix Biofuel, a California based start-up is capable of producing biodiesel at \$33/gal which is significantly higher than the current diesel

⁷ Eg. See: Sigeo, D., 2005. *Freshwater Microbiology: Biodiversity and Dynamic Interactions of Microorganisms in the Aquatic Environment*. John Wiley & Sons, 544pp., Also See: Richmond, A., (Editor), 2004. *Handbook of Microalgal Culture: Biotechnology and Applied Phycology*. Blackwell, 584 pp.

price (Greentech Media, 2009). Opportunities do exist for reducing the cost of production to \$3.50/gallon in the near future.

Besides the issues of scale and economics, there are technological hurdles that need to be overcome for commercialization of biodiesel from algae. The most prominent among them are algae cultivation, harvest, oil extraction and maintaining the controlled environment for algae cultures to achieve the maximum yields (CARB, 2009).⁸

B. Effect of California's Low Carbon Fuel Standard on Advanced Biofuels

NOTE: The ETAC Advanced Technology Group has not yet reviewed the following submissions from subject matter experts and is reviewing them concurrently with the public review process

Transition from petroleum to low carbon fuels

As stated earlier, to meet the 80% reduction by 2050 target requires transitioning from petroleum to ultra low carbon fuels, including advanced biofuels, electricity, low carbon natural gas, and hydrogen. Due to the long timeframes involved in changing fuel infrastructure, it is critical for California to begin this transition now in order to put the fuel sector on the necessary trajectory to meet the 2050 target. In recognition of this challenge, the California Air Resources Board recently adopted the nation's first Low Carbon Fuel Standard (LCFS).⁹ The LCFS is a performance-based, fuel-neutral approach to reducing the carbon intensity of gasoline and diesel fuel pools over time.

The LCFS requires oil refineries and importers to steadily reduce the carbon-intensity of their fuels starting in 2011 and by 2020, to achieve a 10 percent reduction in the carbon-intensity of their fuels. The standard provides fuel providers the flexibility to either supply a mix of fuels that, on average, meets the requirement or to purchase low carbon fuel credits. Companies that produce low-carbon fuels such as advanced biofuels,

⁸ References:

California Air Resources Board (CARB), 2009. Proposed Regulation to Implement the Low Carbon Fuel Standard. Volume I Staff Report: Initial Statement of Reasons, California Environmental Protection Agency, Air Resources Board, Stationary Source Division: Sacramento, CA.

Greentech Media, 2009. Algae Biodiesel: It's \$33 a Gallon. Retrieved from <http://www.greentechmedia.com/articles/read/algae-biodiesel-its-33-a-gallon-5652/>.

Sheehan, J., Dunahay, T., Benemann, J., Roessler, P., 1998. A Look Back at the U.S. Department of Energy's Aquatic Species Program: Biodiesel from Algae. Closeout Report, NREL/TP-580-24190, NREL: Golden, CO.

West, T., Dunphy-Guzman, K., Sun, A., Malczynski, L., Reichmuth, D., Larson, R., et al. , 2009. Feasibility, Economics, and Environmental Impact of Producing 90 Billion Gallons of Ethanol per Year by 2030. Sandia National Laboratories: Livermore, CA. Retrieved from <http://www.sandia.gov/news/publications/white-papers/90-Billion-Gallon-BiofuelSAND2009-3076J.pdf>.

⁹ See CARB website at <http://www.arb.ca.gov/fuels/lcfs/lcfs.htm>.

electricity, natural gas, and hydrogen will benefit because they can generate LCFS credits.

The California Air Resources Board (CARB) estimates that to meet the 10 percent reduction requirements in 2020, the California LCFS would likely require the use of 2.18 to 3.08 billion gallons (bgal) of low carbon ethanol and another 0.8 bgal of biodiesel and renewable diesel.^{10,3} In addition, it will require 0.6 to 1.3 million plug-in electric, battery electrics, and fuel cell vehicles fueled on low-carbon electricity or hydrogen.¹¹

Production of sufficient low-carbon biofuel volumes to meet the 2020 levels will necessitate building additional biofuel production facilities (or potentially modifying existing facilities). The 2020 standard will necessitate the construction or conversion of roughly 60 to 80 mid-sized, commercial-scale biofuel facilities.¹² The LCFS creates an incentive to locate these facilities in or near California to reduce transportation costs. In California, CARB estimates thirty facilities producing corn ethanol (6), cellulosic ethanol (18), and biodiesel (6) could be operational by 2020.¹³

The LCFS creates a larger market for ultra-low carbon biofuels in California compared to the federal Renewable Fuel Standard 2 (RFS 2). The federal RFS 2 mandates specific volumes and types of biofuels to be used nationwide and would result in about a 3% reduction in GHG by 2020 nationwide.¹⁴ California's proportional share of the federal RFS 2 mandates for advanced and cellulosic biofuels would result in about 1.7 bgal of ethanol use in the state (*Figure X, to be added*) compared to the 2.18 to 3.08 billion gallons required under the LCFS.¹⁵

The LCFS will not just create a larger demand for advanced and cellulosic ethanol in California, but it also creates an incentive for those gallons to have lower greenhouse gas emissions than otherwise. The RFS 2 has qualification standards of 50% and 60% for advanced and cellulosic ethanol respectively and does not provide any incentive to improve beyond those levels.¹⁶ On the other hand, the LCFS provides incentives for

¹⁰ Low-carbon ethanol includes low carbon-intensity corn-starch based ethanol and cellulosic ethanol or other advanced biofuel replacing gasoline.

¹¹ CARB, *Proposed Regulation to Implement the Low Carbon Fuel Standard*, Volume II, Appendices, release date: March 5, 2009, Tables E-1a to E-8a.

¹² This assumes a mid-sized, advanced biofuel facility produces 50 million gallons per annum.

¹³ CARB, *Proposed Regulation to Implement the Low Carbon Fuel Standard*, Volume I, Staff Report: Initial Statement of Reasons, release date: March 5, 2009, page VII-2.

¹⁴ <http://www.epa.gov/otaq/renewablefuels/index.htm>

¹⁵ CARB estimate based on 15 billion gallons of advanced and cellulosic ethanol as required by the RFS 2 and a California market share of the national gasoline market of 11.3% (see See CARB Table VIII-23, *Proposed Regulations to Implement the Low Carbon Fuel Standard, Volume I, Staff Report*, Initial Statement of Reasons, release date: March 5, 2009.)

¹⁶ The EPA Administrator is allowed by statute to relax the standard by up to 10%.

continuous improvement in greenhouse gas performance, thereby creating a powerful incentive for producers to innovate new, low carbon production practices. For example, under the RFS 2, cellulosic ethanol has no incentive to improve beyond 60% reduction in greenhouse gases, even though CARB estimates the reductions to be 80%.¹⁷

C. Biofuels Study Recommendation

NOTE: The ETAC Advanced Technology Group has not yet reviewed the following submissions from subject matter experts and is reviewing them concurrently with the public review process

ETAAC feels that further technical study is needed in certain areas and solicits comments on potential areas of focus as we further research and review potential areas of study.

draft

¹⁷ See CARB Table VI-3, *Proposed Regulations to Implement the Low Carbon Fuel Standard, Volume I, Staff Report*, Initial Statement of Reasons, release date: March 5, 2009.