> "[I]nvesting in the development of innovative and pioneering technologies will assist California in achieving the 2020 statewide limit on emissions of greenhouse gases … and will provide an opportunity for the state to take a global economic and technological leadership role in reducing emissions of greenhouse gases" (California Global Warming Solutions Act of 2006 section 38501(e)).

Introduction

The California Global Warming Solutions Act of 2006 and the Governor's Executive Order (S-03-5) collectively require returning the state's greenhouse gas (GHG) emissions to 1990 levels by 2020 and achieving a further 80 percent reduction by 2050. Meeting California's long-term GHG goals will require more than the accelerated diffusion of currently available technologies. Advanced technology development will play an essential role in meeting California's climate change goals and will contribute to California's economic development, efforts to improve air quality and continued global leadership.

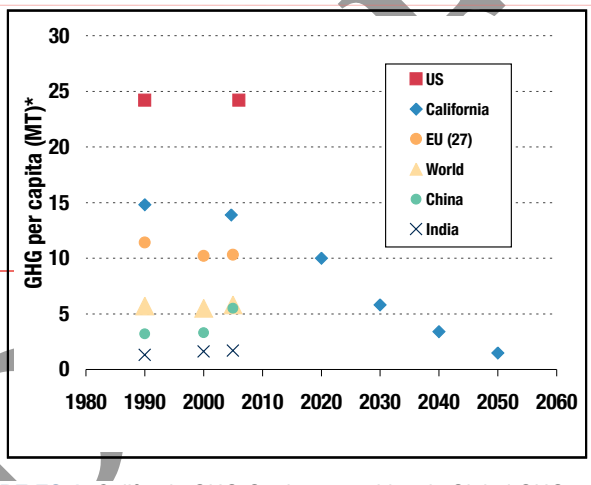

FIGURE ES-1: California GHG Goals versus historic Global GHG emissions

There are substantial market, information, government and industry/infrastructure barriers to the adoption of low- and zero-GHG advanced technologies. While injection of federal stimulus dollars will address some of these obstacles, California can play a central role by providing the complimentary policies that are often needed. Given the multitude of barriers, the magnitude of the climate change problem, and the long lead times for technology development, these policies to overcome barriers are needed immediately if we are to reach our goals for GHG reduction.

Three chapters of this Advanced Technology Development report cover renewable

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energy, energy efficiency, and transportation as examples of the need to shift to low- and zero-carbon technologies across all sectors of the economy (as noted in February 2008 ETAAC report). These three chapters also examine the status of example technologies and policies for accelerating advanced technology development. One chapter provides cross-sector insights on economic development opportunities and challenges, and while another addresses innovative financing tools to create markets for advanced technology development.

Economic Development Opportunities & Challenges

"[T]echnologies that reduce greenhouse gas emissions are increasingly in demand in the worldwide marketplace, and California companies investing in these technologies are well-positioned to profit from this demand, thereby boosting California's economy, creating more jobs and providing increased tax revenue" (California Executive Order S-3-05)

Low- and zero-carbon technologies are an estimated $4 trillion market globally[i]. Private sector "CleanTech" investment reached $150 billion globally in 2008, and government investments are expected to reach $200 billion globally by the end of 2009. California also has 100,000 direct green jobs currently, creating additional spillover economic benefits.

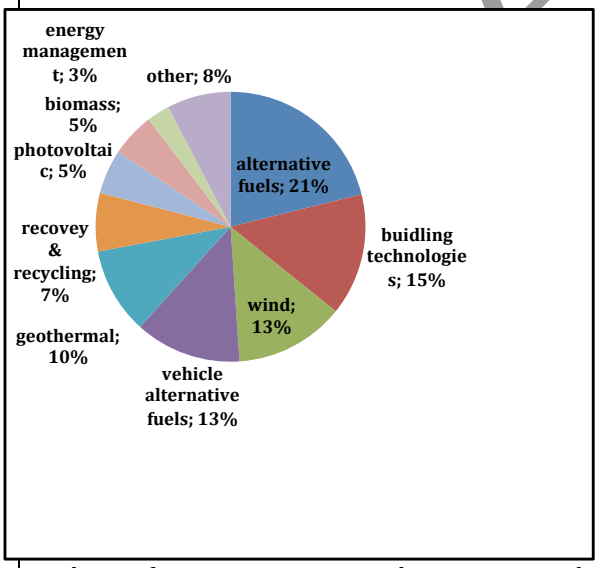

Figure ES-2: Sectors in $4 Trillion Global Low/Zero GHG Market (source: UK BERR report)

California has several unique advantages in the competition for low- and zero-carbon markets and investment capital. They include strong research and investment communities, strong climate and environmental policies, and a business community that has responded to meet these protective policies.

There are also many challenges for California to capture economic opportunities. State and US labor costs exceed those of many global competitors, and real estate and manufacturing equipment sales tax costs are higher in California than in many other states. Though California's economy is better suited for advanced technologies than high-

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volume, low-margin production, it would be unwise to take for granted that California will continue to capture the same proportion of new green jobs and investment.

There are several examples to help California businesses become more competitive by reducing their own carbon footprint and transitioning to providing the products demanded by a low carbon economy. One example is the United Kingdom's Climate Levy. Much of the Climate Levy paid by businesses on their energy usage has been recycled back to provide technical and capital assistance for transitioning to a lower GHG footprint. GHG allowances (and fees on high global warming gases) could be used to help California businesses apply technologies that reduce their own costs and GHG footprint and transition to providing zero and low GHG technologies. While federal stimulus dollars will provide some immediate capital, effective coordination with California businesses on stimulus funding (including workforce training) is important, particularly for smaller businesses.

Innovative Financing

The upfront costs of more efficient advanced technologies are often a barrier, even when those investments pay for themselves over time. This report identifies a number of innovative financing strategies that can "pull" advanced technologies into the market and reinforce economic development by improving efficiency.

Many of these strategies provide upfront capital that is repaid out of downstream savings. One type of approach is utility on-bill financing and related off-bill loans where customers repay up-front costs from energy savings. This approach has been tested in California, generally with a focus on energy efficiency, and broad deployment over the next three years will set an important precedent for other areas. Municipal financing approaches backed by property tax repayments are another encouraging approach for energy efficiency and renewable energy. California's experience should also be tracked for potential application to the transportation sector, for example in home- or business-based vehicle charging or fueling infrastructure.

Financing strategies are also needed for renewable energy technologies that face a potential "valley of death" at the demonstration phase. California offers funding through the Public Interest Energy Research program at the pilot plant scale, which typically requires far less funding than the demonstration phase. Debt markets are available once technologies have successfully been demonstrated. Innovative strategies are needed to bridge the financial gap between those two stages and to help facilitate demonstration of promising emerging renewable energy technologies that have not yet reached that milestone.

Renewable Energy

Renewable energy must play a key role to meet California's 2020 33% renewable

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energy target and GHG reduction goals,[ii] and to put the state on a trajectory for longer-term reductions. Advanced technology renewable resources also have an important role in meeting California's air quality challenges.

Developing renewable energy in California offers economic opportunities as well. Renewable energy is already a large international market – the global market for wind, solar, biomass, and geothermal technologies is estimated at about $1.5 trillion US dollars annually[iii] - and renewables are a leading sector with high market growth potential. Over two-thirds of venture capital invested in California in 2008 was invested in renewable energy (primarily solar). Locally developed renewable energy can also produce economic benefits by replacing fossil fuel imports.

The ETAAC examined both crosscutting and technology-specific issues to renewable energy advanced technology development. The key crosscutting issues are grid upgrades and expansion and energy storage. There is broad recognition today that the nation's transmission infrastructure needs to be expanded to accommodate renewable energy. Many renewable technologies are site-specific, distant from load centers and lacking sufficient transmission to get energy to market. A key to accomplishing grid expansion is updating the standard policy framework governing interstate transmission financing and cost recovery.

Distribution system upgrades will also be necessary to accommodate a major ramp-up of distributed renewable generation such as photovoltaic solar, which can avoid transmission bottlenecks and help achieve Zero Net Energy homes. Smart Grid-related technology and especially "smart inverters" are key distribution system technologies to effectively manage local power distribution.

Energy storage is another important enabling technology. Energy generated outside of peak demand periods can be stored through stationary or vehicle batteries, compressed air, pumped storage (hydro-electric) or hydrogen for use during peak demand. The US Department of Energy's proposed $200 million investment in energy storage demonstration projects is an important first step. New storage technologies will also present new planning, rate recovery and ratemaking issues. They will also require that regulators shape policies to better define how costs should be allocated among different jurisdictions and how owners of storage assets will be compensated for grid benefits.

This report also examines the progress of several individual technologies. Photovoltaic solar technology has advanced with technology using thin films moving to the production line and producers announcing that they have broken the $1/Watt cell cost barrier. To further improve PV solar's competitiveness, California can support technology developments in more efficient inverters, solar concentrators, and tracking devices as well as mounting systems that are easier to install. In addition, policies such as feed-in tariffs and net metering would facilitate increased PV deployment in addition to the current "California Solar Initiative."

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Solar thermal generating technology has also progressed and a number of projects have applied for licenses from the California Energy Commission (CEC). However, the technology faces land use, and also transmission challenges if not generated where used.

Wind power, an integral part of California's renewable resources, is subject to these same types of constraints. Other solutions that would facilitate increasing levels of wind power in California include further technology development and greater understanding of impacts on birds and bats as well as cross-cutting solutions on grid expansion and energy storage.

Geothermal power is another important part of the Western United State energy supply mix, producing 4.5% of California's electricity in 2007. 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.[iv] Credit challenges and relatively high project development costs remain constraints to geothermal development, along with recent concerns that such certain technologies could induce low-magnitude seismic events known as "microearthquakes". Ongoing federal research and resource leasing can help advanced geothermal technology development. Solutions to crosscutting issues with transmission and energy storage of off-peak power (geothermal production is generally constant year-round) will also help boost geothermal power.

Challenges for biomass power plant technologies include siting and permitting as well as feedstock availability and transportation. Converting woody feedstock to pellets can help overcome transportation barriers for combustion technologies.

Feedstock (including organic wastes) converted into biogas can power fuel cells that are highly-efficient and produce near-zero emissions of conventional pollutants. Biogas can also be transported via pipeline to end-users and displace natural gas combustion.

Energy Efficiency

California has long supported energy efficiency as a low-cost means of achieving critical air quality, energy use reduction and greenhouse gas (GHG) mitigation goals. The success of existing programs has played a major part in California's ability to keep electricity demand flat, rather than follow the national trend of increasing per-capita demand for electricity.

The development of new, advanced technologies for both electricity and natural gas efficiency will be required for meeting California's long-term, i.e. post-2020, GHG goals. Like renewable energy, energy efficiency investments also play a role in meeting broader air quality goals. Energy efficiency can also lower energy bills over

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time, which in turn could promote the competitiveness of California business.

A wide variety of promising new energy efficiency technologies for California homes, industries, and businesses can help meet GHG reduction goals and promote economic development. Several examples are solid-state lighting, more efficient air conditioning and heating, and home area networks that give commercial and residential customers real-time information about their electricity usage. These technologies will also support the ambitious goal of net-zero energy residential and commercial buildings.

There are three common obstacles to adoption of these energy efficient advanced technologies: (1) higher upfront costs often accompany more energy-efficient technologies, (2) lack of familiarity with a new technology combined with risk aversion discourages adoption, and (3) split incentives are a market barrier, such as when the owner of a residential rental property is responsible for the cost of upgrades but is not responsible for energy bills.

The financing strategies described earlier are one important part of the solution, and California's energy efficiency programs (in collaboration with utility, federal and other partners) have a key role to play in the success of these technologies.

Transportation

Within the transportation sector, the role of standards and incentives will be key for meeting 2020 goals (which will rely mainly on technologies such as more efficient internal combustion engines and non-plug-in hybrids) and for promoting electric-drive vehicle technologies that are vital over the longer term. Significant technology challenges remain for tackling the leap to dramatic carbon reductions. For plug-in hybrids (PHEVs) and battery electric vehicles (BEVs), reducing battery cost and size are key vehicle challenges. Fuel cell electric vehicle (FCEV) costs have come down substantially, but further reducing fuel cell cost is a remaining challenge. Durability and public acceptance are additional challenges for these three technologies.

Electric drive vehicles will get a large boost from over $10 billion in US federal and state funding, as well as large investments overseas. Current pilot-scale deployments of PHEVs and BEVs are expected to broaden rapidly into early commercialization over the next few years, followed by FCEVs in 2015 if FCEV technology and infrastructure development remains on track. For California, electric-drive technology is critical for both economic and environmental reasons. California is expected to lose jobs from conventional vehicle manufacturing, despite aggressive efforts to keep them, and gain jobs through electric drive vehicle and infrastructure manufacturing.

The state can play an important role making these deployments a success through infrastructure policies and investments, which will require effective decision-making and coordination among various actors.

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For medium and heavy duty vehicles, California will be best served by a comprehensive long-term vision. In the near term, continued and expanded state leadership on black carbon can inspire international efforts to reduce this climate change-forcing pollutant while improving public health. California can also use incentive programs to demonstrate new technologies such as medium duty hybrid vehicles and potential future heavy-duty technologies that emerge from federally funded research and development (R&D) as well as fuel cell buses.

Advanced biofuels are another opportunity for state leadership. National and federal standards and R&D will help promote advanced biofuels technologies, but there are no assurances on how much production of biofuels will occur in California. Further study on in-state feedstock availability and advanced technology biofuels production will help inform both public & private decision-making and investments.

Conclusion

Promoting long-term technology development is a critical and immediate opportunity for California. While there are many remaining challenges, California cannot afford to step back and take a wait-and-see attitude while others attempt to surmount these obstacles. Pursuing the abundant opportunities for innovative approaches will promote advanced technology development for energy efficiency, renewable energy, transportation and other sectors of the economy.

By pursuing advanced technology development, California will continue its global leadership role while simultaneously making giants steps forwards towards its GHG, air pollution and economic development goals.

[i] UK BERR Report. Additional references are included in the main report.

[ii] The ARB's Scoping Plan shows that a 33% RPS could contribute up to 21.3 million metric tons per year of carbon dioxide (equivalent) emission reductions.

[iii] Low Carbon and Environmental Goods and Services: an industry analysis, page 75, Innovas, May 6, 2009, commissioned by the United Kingdom's Department for Business Enterprise & Regulatory Reform. Exchange rate of 1 US dollar to .611 UK pounds as of 10-18-09.

[iv] 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.

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