ETAAC Advanced Technology Development Report

Part A - Introduction

The need for advanced technology development to meet GHG goals

The purpose of this report is to build on the original ETAAC February 2008 report, consider new events such as technology development and the federal stimulus bill, and specifically focus on the challenges & opportunities for advanced technology development needed to meet California's long-term GHG reduction goals. This report also explains how advanced technologies are necessary to meet California's air quality goals, and to compete in the marketplace of tomorrow.

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 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 a long-term 2050 GHG emission reduction goal 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, the same type of shift to zero and low-carbon technologies will be needed across energy and all major sectors to meet long-term GHG reduction goals as well as 2020 goals.

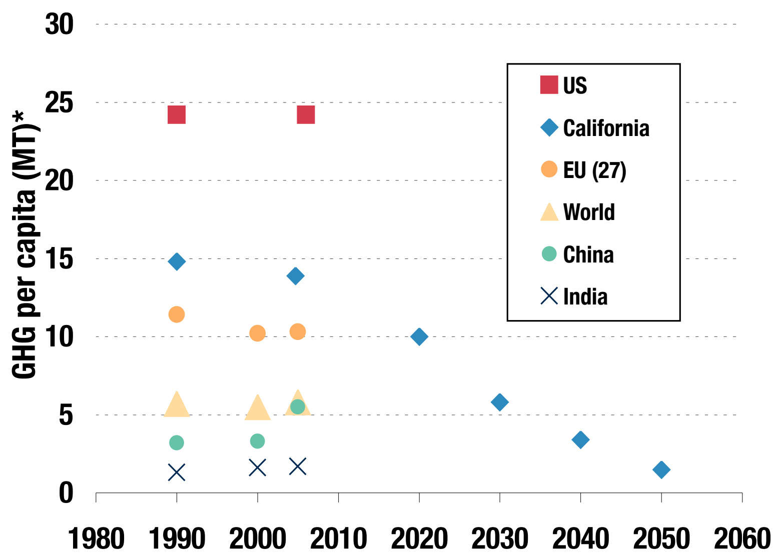

Figure X ICCT

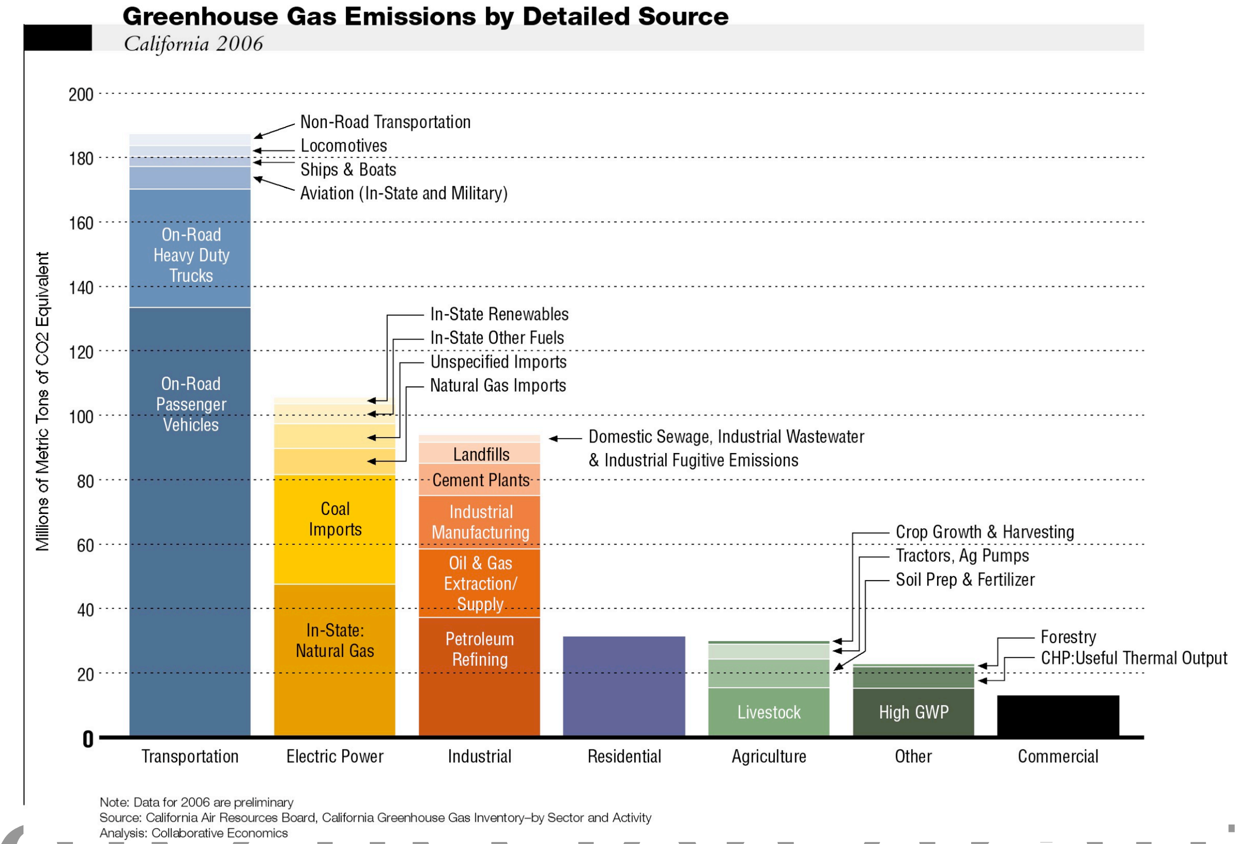

Figure X Next10

While these technologies are needed for long-term goals, California must facilitate the technology development pathway now. Fossil fuel fired power plants have a 30-50 year lifetime, and new technologies require a significant lead-time for development and commercialization. Passenger vehicles have a 10-20 year lifespan, and it has taken the last decade for hybrid technology to reach a 5% market share in California. Infrastructure built to serve today's technological infrastructure 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 be 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 (UK low carbon market report) globally. However, the technology race in areas such as electric vehicles and renewable energy is dramatically escalating. In addition to providing zero and low-greenhouse gas goods and services, California businesses themselves will need to apply 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 be steep in terms of increasing the inevitable 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.

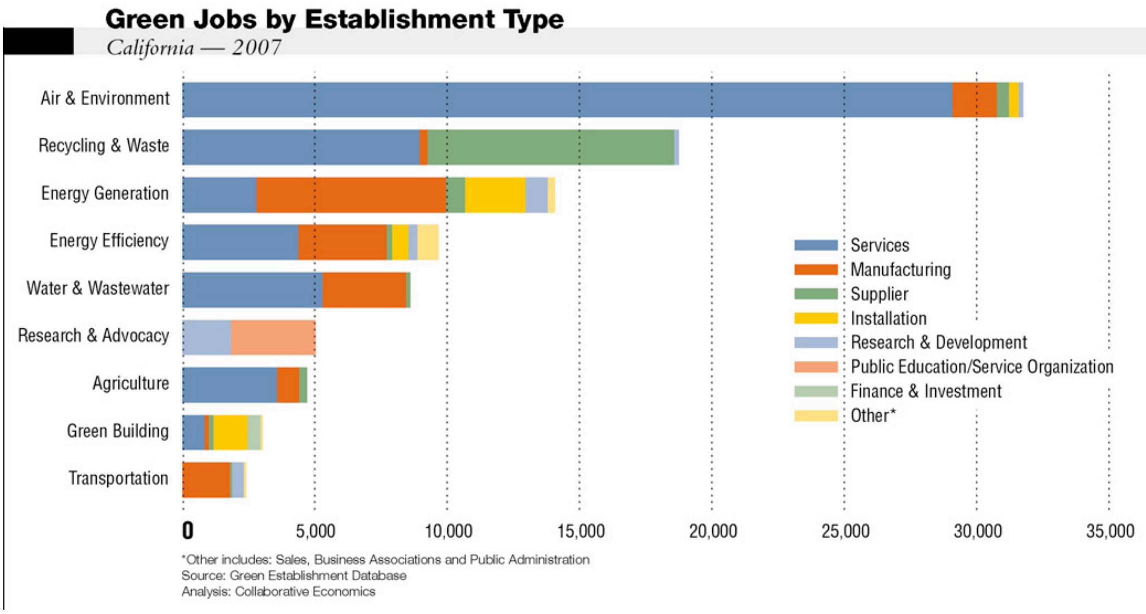

Figure X (source: Next 10)

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 covering 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 30% in 2020 through energy efficiency and renewable energy technologies would avoid over 7,500 tons per year of emissions that cause ozone and fine particulates. 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 2020 (ICCT, CARB’s CEFS 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 seem in figure X, global energy demand in developing nations is forecast to increase by over 70% between 2006 and 2030 - more than current total North American energy consumption.

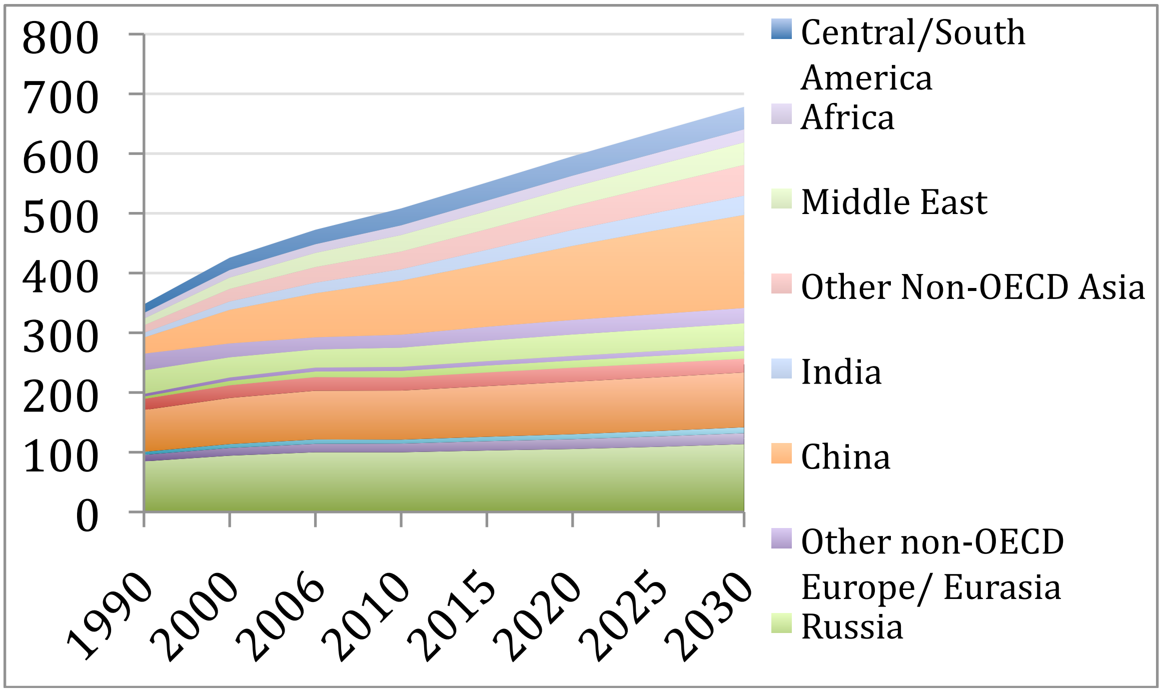

Figure X Energy Consumption in quadrillion BTUs, (data source: EIA) (EIA, http://www.eia.doe.gov/oiaf/ieo/ieorefcase.html)

Technology Development & Commercialization Pathways & 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 the most effective state role, bridging the traditional federal focus on basic scientific research with industry's focus on commercializing available technology and product development (Cal Economic Strategy Panel). This report focuses on transportation, energy efficiency, and renewable energy sectors and on technologies within those sectors that will play an important role in meeting Caliornia's long-term GHG and environmental goals, and also offer economic development opportunities. ETAAC notes that there are also a number of other important recommendations on advancing science and technology that fall outside of these three sectors from the original

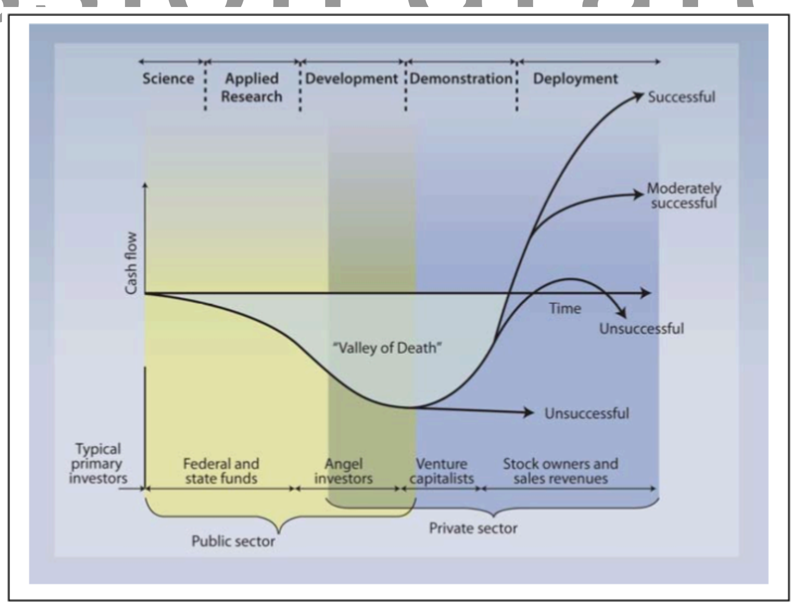

Figure X "Carbon Lock-in, Barriers to Deploying Climate Change Mitigation Technologies"

February 2008 ETAAC report.

The technology development & commercialization pathway involves challenges identified in figure X from the US Climate Technologies program "Carbon Lock-in" report.

> "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. "

Figure X Text box from carbon lock-in report

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. This process is essential to the energy challenge - and may be more difficult than for other technology types. The "Valley of Death" represents a formidable financial challenge where the amount of capital needed is greater than typically available as equity. (CalCEF) For instance UK Carbon Trust analysis of representative technologies found that demonstration projects required 40 times the resources of projects at the R&D stage. At the same time, technologies not yet proven at scale are unlikely to qualify for traditional commercial loans. As noted below, many of the most serious barriers to advanced technology development apply to the demonstration phase.

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

Cost and Market Barriers		
External Benefits	Frequency- **high** Severity- mostly **high**, some responses said 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.
Up-Front Capital Costs	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.
Demonstration Costs & Risks	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.
Market Demand	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.
Misplaced Incentives	Frequency- medium Severity-medium (a few low or high responses)	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		
Incomplete and Imperfect Information	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.
Lack of Specialized Knowledge	Frequency – med/**high** Severity- 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

Note to ETAAC reviewer: half of ETAAC responded, with just under half of responses representing the electric power sector and other responses representing each of the other sector categories. All options with multiple responses are listed, with most common response listed first.

ETAAC Review of Potential Barriers to the Commercialization and Deployment of Low and Zero Greenhouse Gas Technologies		
Government Barriers		
Unfavorable Standards	Frequency- med Severity- med (some **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.
Uncertain Standards	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.
Unfavorable Fiscal Policy	Frequency – med Severity – med (some 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.
Uncertain Fiscal Policy	Frequency – med (some **high**) Severity- med (some **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.
Unfavorable Approval Processes	Frequency – med Severity – **high** (some 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.
Uncertain Approval Processes	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		
Existing Infrastructure "Lock-in"	Frequency- med/**high (even split)** Severity- med/**high (even split)**	Existing large and investments such as long-term power and transportation fuels production and distribution can "lock-in" existing technologies.
Lack of Needed Infrastructure for New Technology	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.
Incumbent Industry Market Dominance	Frequency- **high** , also low and med Severity-mostly **high** also some low	Natural monopolies or large incumbents with market power may disenable technological innovation to prevent disruption of existing profitable markets & investments.
Industry Segmentation or Fragmentation	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.
Intellectual Property	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.

Figure X Prioitizing Barriers

Public policy solutions are needed if new technologies are to overcome a daunting array of potential challenges (as described in further detail in the US Climate Change Technology Office's "Carbon Lock-in, Barriers to Deploying Climate Change Mitigation Technologies" report). Some of these barriers apply generally to low and zero carbon technologies in California, while others may apply in some instances but not others. The original ETAAC report identifies a number of recommendations for overcoming barriers to promote R&D and technology development, as shown in Appendix X of this report.

The ETAAC has identified the cost and market barriers category as both the most frequent and the most severe category of 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. Demonstration costs & risks are generally (although not universally) considered to be a frequent and severe barrier as well. This holds true generally for the transportation, energy efficiency, and renewable energy technologies described later in this report for example. 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 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 consensus that government standards, fiscal policies, and approval processes are sometimes but not frequently 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 siting new renewable energy technologies typically involves approval processes that do not apply to existing fossil-fuel power plant.

Public policy solutions will need to address a range of barriers typically faced by advanced technology development. While the federal stimulus bill and other existing programs play an important role removing barriers as noted in a later chapter, 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 example technologies in the transportation, renewable energy, and energy efficiency sectors.