California's Clean Transportation Technology Industry

Overview, Barriers, and Opportunities for Economic and Environmental Leadership

CALSTART 2009

CALSTART is a nonprofit corporation dedicated to supporting and accelerating the growth of the clean transportation technologies industry. In supporting this industry, CALSTART's goals are to improve air quality, reduce dependence on oil, cut greenhouse gas emissions, and create high-quality jobs. CALSTART performs this role via four main activities:

- Providing value-added services for its member companies;
- Working with teams to commercialize new technologies;
- Helping fleets and ports cost-effectively "green" their operations; and
- Supporting positive pro-environment and business public policy.

One of CALSTART's main strengths is its access to an unparalleled array of information sources through its diverse activities and extensive network. The clean transportation technology industry is rapidly changing and CALSTART's close contact with fleet managers, policymakers, researchers, scientists, technology developers, and manufacturers puts the organization in a unique and valuable position.

Below is a short summary of some of CALSTART's many accomplishments and activities:

- Providing Critical Assistance to Companies: CALSTART has helped a number of companies achieve their business goals. For example, CALSTART secured early-stage funding for a start-up company, Amerigon, to develop its technology. In 2008, Business Week magazine named Amerigon one of the nation's "Hot 50" companies;
- Numerous Technology "Firsts": CALSTART has worked with industry teams to develop important working prototypes including the first electric station car program; the first hybrid electric transit bus; the first Class 8 hybrid electric truck; the first hydrogen hybrid transit bus; the first electric school bus; the first truck fuel cell auxiliary power unit (APU) deployed in a truck; and the first fully-integrated long-range natural gas vehicle;.
- Making Hybrid Trucks a Commercial Reality: CALSTART formed the Hybrid Truck Users Forum (HTUF) with the US Army National Automotive Center (NAC) to speed the commercialization of trucks with hybrid propulsion systems;
- Providing Guidance and Support for Critical Public Policies: CALSTART created the California Secure Transportation Energy Partnership (CalSTEP) to forge a consensus plan for California's transportation energy future. CalSTEP released a California Action Plan with 10 key transportation policy recommendations in 2007. Additionally, CALSTART provided key support for California Assembly Speaker Núñez's Assembly Bill 118 which resulted in $200 million in funding per year for transportation measures that reduce greenhouse gases.

This report was independently researched and written by CALSTART. Jamie Hall served as the principal manager, researcher, and writer. John Boesel, Mary Kathryn Campbell, Fred Silver, and Steve Sokolsky of CALSTART provided valuable assistance and review, as did Reed Addis of Conservation Strategy Group. Katherine Beach provided assistance in compiling the list of California companies. Funding for this report was provided by the Hewlett Foundation.

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EXECUTIVE SUMMARY

The environmental and economic problems caused by the world's reliance on conventional vehicles and petroleum fuels for transportation require innovative solutions. A wide range of clean and advanced transportation technologies is needed, along with changes in land use planning and consumer behavior. Forward-thinking companies around the world are working to develop the clean technologies that will eventually serve global transportation needs. The need for these technologies, and the industry that develops them, can be expected to grow as demand for alternatives increases. With the right policies in place, California can be a global leader in this field, and can reap significant environmental and economic benefits as a result.

CALIFORNIA CAN BE A LEADER IN CLEAN TRANSPORTATION

In a 2004 report entitled "California's Clean Vehicle Industry," CALSTART argued that California was home to a California is a world leader in technology development, innovation, and environmental regulation. Given this combination, it is no surprise that the state is developing a strong and valuable industry around clean transportation technologies. The growing industry in California can be described as a nascent clean transportation "industry cluster," not unlike the high-tech cluster in Silicon Valley. The development of a cluster benefits the state's industry and leads to competition, specialization, and attraction of additional companies, employees, and suppliers. CALSTART identified approximately 200 organizations involved in the development and manufacturing of clean transportation technologies in California. These organizations fall into 12 categories:

Technology Categories

- Advanced propulsion systems
- Alternative fuels, fuel infrastructure, and additives
- Electronics and power electronics
- Electric and alternative vehicle manufacturers
- Energy storage devices
- Engine, combustion, aftertreatment, and alternative fuel systems
- Lightweight, high strength materials
- Vehicular design, technology, and testing centers

Supporting Organizations

- Research institutions
- Investment and venture capital firms
- Industry support
- Automotive marketing and support

Additionally, the state is home to several forward-thinking fleet owners, transit properties, and individuals that contribute to the growth of the industry by providing real world testing and implementation of these technologies.

CALIFORNIA CANNOT AFFORD BUSINESS AS USUAL IN THE TRANSPORTATION SECTOR

California's transportation sector is characterized by a heavy reliance on high-emissions fuels and inefficient technologies and practices. The long-term economic and environmental costs of business as usual are staggering. The combustion of petroleum-based fossil fuels for transportation leads to high levels of criteria pollutant emissions. Largely as a result of these emissions, California has some of the most severe air quality problems in the country. In the San Joaquin and South Coast air basins alone, ozone and particulate emissions lead to more than 140,000 additional asthma attacks and nearly 4,000 premature deaths every year. Additionally, the transportation sector is the largest single source of greenhouse gas emissions in California. The expected effects of climate change on California's environment and economy are severe, with an estimated $2.5 trillion of real estate estimated to be at risk, and water shortages expected to become more frequent and severe. Furthermore, the state's dependence on oil carries with it significant economic risks for both consumers and businesses in the form of volatile oil prices and the potential for supply disruptions. Clean transportation technologies can both reduce these costs and provide economic benefits to the state.

CLEAN TRANSPORTATION PROVIDES SIGNIFICANT ENVIRONMENTAL AND ECONOMIC BENEFITS

Clean transportation technologies can reduce the harmful transportation-related emissions that are polluting the state's air and contributing to global climate change. Technology can also address the issues of energy security and price volatility by reducing California's dependence on imported oil. Additionally, a robust clean transportation technology industry can be expected to generate high quality green jobs and economic growth in the state. The reduction of criteria and GHG emissions from transportation is essential to the health of California's residents, environment, and economy. Both criteria and GHG emissions are a function of (1) vehicle efficiency and technology, (2) emissions intensity of fuels and vehicles, and (3) vehicle miles traveled. Clean transportation technologies can help address all three of these crucial emissions drivers, though technology will have the greatest impact on vehicle efficiency and emissions intensity. Alternative fuels, lightweight materials, and advanced propulsions systems can all help to reduce emissions. Furthermore, advanced public transit systems have the potential to significantly reduce vehicle miles traveled, particularly if coupled with smart growth and effective land use policies.

The clean transportation technology industry can also improve energy security and reduce oil dependence by increasing efficiency and by providing alternative fuels, vehicles, and modes of travel. A shift toward clean alternative fuels would shield the economy from volatile and rising fuel prices, which hurt both businesses and individuals by driving prices up and decreasing predictability. Additionally, the state could improve the security of its energy supply by decreasing its reliance on oil, which is particularly subject to supply disruptions. A clean and diversified fuel supply would make California a more affordable, attractive, and sustainable place to live, invest, and do business.

The clean transportation technology industry offers yet another important economic opportunity for California: the potential to retain and create high quality green jobs and encourage in-state economic growth. The California Economic Strategy Panel estimates that the state is already home to over 43,000 "green" jobs in various industries, 41% of which are in manufacturing. As investment continues and California transitions to a greener economy, these numbers should grow dramatically. If California is able to establish itself as a leader in the development and commercialization of clean transportation technologies, the state's industry should have significant export and growth potential.

POLICY IS A KEY MARKET DRIVER

California is well-positioned to build a successful clean transportation technology cluster. The state already has the necessary foundations for the development of the industry, including large local markets, relevant business and technology expertise, access to capital, and forward-thinking public policy. It is in this last area – proactive public policy – that the state has the greatest potential to drive the growth of the industry, make California a leader, and reap the environmental and economic rewards that clean transportation technologies offer.

The role of public policy in creating and sustaining the conditions necessary for the success of clean transportation technologies in California cannot be overstated. Comprehensive and proactive public policies are necessary for the industry's growth. Short-sighted and uncoordinated policies, on the other hand, could act as a significant barrier, ultimately delaying solutions to environmental problems and causing the state to miss out on economic opportunities. Public policy can address these problems and drive innovation and industry growth in three key ways:

- Increasing market demand for goods and services through standards, regulations, and purchase incentives
- Providing financial support through R&D funding, loan guarantees and project finance, direct investment, tax breaks, and other avenues
- Creating a favorable business environment through consistency, predictability, and non-financial assistance to the industry

California has planned and implemented a number of policies designed in part to achieve these goals, including the Global Warming Solutions Act of 2006 (AB 32, Núñez), the Alternative and Renewable Fuel, Vehicle Technology, Clean Air, and Carbon Reduction Act of 2007 (AB 118, Núñez), and the Low-Carbon Fuel Standard. Timely and effective implementation of these and related policies should support the development and deployment of clean transportation technologies and provide significant benefits for the state.

SIGNIFICANT DEVELOPMENT AND DEPLOYMENT BARRIERS REMAIN

While California is a very good place to develop technologies and start companies, there are a number of barriers to in-state manufacturing, production, and industry growth. These fall into four general categories:

Transition Barriers:

New transportation technologies face many transition barriers that can hinder commercialization and widespread deployment.

- **Refueling infrastructure needs** are a significant market barrier for alternative fuels and vehicles that must compete for customers with existing technologies that have established and widespread fueling networks already in place.
- **Codes, standards, and certifications** are needed for new fuels, vehicle technologies, and fueling systems. Delay and confusion in these administrative processes can have a detrimental effect on deployment.
- **Slow and arduous permitting processes** can act as a barrier to the construction of production facilities and fueling infrastructure. These delays can hold up technology deployment and discourage businesses from locating in California.
- **High incremental costs** present another major hurdle for new technologies during the transition period. New technologies have high costs and purchase prices as a result of low production volumes and lack of experience and movement down the learning curve. High prices tend to suppress demand and hinder deployment.

Clean Transportation Investment Economics:

Traditional market barriers and economic realities pose problems for the development of the clean transportation technology industry.

- **Insufficient investment in technology development and deployment** is a significant issue in the clean transportation industry. The private sector under-invests in innovation from a societal perspective because the financial returns do not justify the risk and investment. The problem is particularly severe during the transition from laboratory to market, often referred to as the "valley of death," because both risks and capital demands are large at this stage.
- **Tight credit markets and a lack of risk capital** due to the current financial crisis are further complicating the economics of investment in clean transportation. Many companies are delaying investments, expansions, and the introduction of new products and technologies.
- **Volatile oil prices** present problems for entrepreneurs attempting to build a business case for investment in clean transportation alternatives, because it is difficult to predict the cost of the conventional fuels with which they are competing. The recent freefall in oil prices hurts the clean transportation industry, as technologies and investments that were attractive with gasoline at $4.00 per gallon do not look as good with prices below $2.00.

Regulatory Issues:

Environmental policies sometimes create hurdles or have unintended consequences that can delay the development and deployment of environmentally friendly technologies.

- **Uncertainty and inconsistency in policies and incentives** are frequently cited as barriers to investment and industry growth. Investors and businesses need consistent, predictable regulation that provides certainty and price signals over time. They cannot build a business on short-lived subsidies and tax credits, or on unclear and changing technology standards and mandates.
- **A lack of coordination** in the design and implementation of air quality, climate change, and petroleum reduction policies creates barriers and missed opportunities. These are closely related issues that require integrated solutions.
- **Overly prescriptive or idealistic regulations** can lead to unintended consequences and failed policy initiatives. Prescriptive policies that focus on a single technology effectively stifle innovation and could prove problematic if the chosen technology does not perform as expected. Similarly, mandates and targets can create barriers if they are unrealistic and do not take into account market and technology realities.

California's Ability to Attract and Retain Business:

Despite California's track record of innovation and economic growth, the state has a reputation as a difficult place to do business. Other states and countries, eager to take advantage of technologies and ideas that often originate in California, are aggressively and successfully recruiting businesses to move or expand outside of California.

- **Doing business in California can be expensive** and complicated compared with operating in other states and countries. Business costs in California are high, and the tax burden is greater than in neighboring states. Environmental regulations and slow bureaucratic policies create an additional burden.
- **California needs to be more proactive** in working to recruit and retain business. The state lacks a coordinated strategy to compete for businesses in the clean technology sector. Other states and countries have larger and more successful recruitment and retention strategies, and they continue to target and lure away California-grown companies.

SMART POLICIES CAN GROW THE INDUSTRY AND GENERATE IN-STATE BENEFITS

The following principles and recommendations are intended to provide guidance for California policymakers on ways to grow the clean transportation technology industry and capture the related economic and environmental benefits.

Take an Integrated and Comprehensive Approach to Policymaking

The related problems of air quality degradation, climate change, and petroleum dependence require an integrated and comprehensive approach. The focus should be on synergies and solutions that achieve multiple benefits. Specific recommendations include

- Create incentive programs and regulations that explicitly consider air quality, climate change, and petroleum reduction with the goal of increasing efficiency and taking advantage of synergies.
- Encourage greater coordination and cooperation among state agencies in order to increase efficiency and better address the state's closely related emissions and petroleum dependence problems.
- Consider looking at net benefits when analyzing and choosing between technology and policy options.

Focus on End Results and Technology Pathways

In order to be effective in driving technological development and deployment, policymakers should take a balanced approach that is at once ambitious, pragmatic, and flexible. The focus should be on end results and strong but realistic targets and schedules. Specifically, technology policy should:

- Remain technology neutral to the extent possible.
- Consider the realities of the market, technology advancement, and relevant data when setting targets and standards.

Create Stable, Long-Term Price and Regulatory Signals

Stable, long-term price and regulatory signals are essential for the development and deployment of clean transportation technologies. Companies and investors require stable incentives and regulatory signals to make the business case for developing new technologies, while consumers require long-term signals to permanently change their behavior. Specific recommendations include the following:

- Move forward with timely and effective implementation of key policies such as AB 32 and the Low-Carbon Fuel Standard (LCFS).
- Consider implementing a variable transportation fuel surcharge to create a price floor for oil and provide clear long-term price signals for both investors and consumers.
- Create long-term schedules and targets for legislative and regulatory initiatives.
- Provide stable, long-term production and purchase incentives when necessary and appropriate from a technology-advancement standpoint.

Minimize Bureaucratic and Regulatory Delays in the Transition Period

Bureaucratic and regulatory delays can act as a hurdle to technology deployment and commercialization. Policymakers should recognize clean transportation as a priority and actively work to address these delays and facilitate deployment, without relaxing important environmental protections. The following actions should accelerate technology deployment and make California a more attractive place to do business:

- Put a high priority on creating standards and certification processes for new fuels and transportation technologies.
- Consider the creation of simplified interim processes for new technologies to facilitate early deployment while more robust standards-setting, testing, and certification processes are underway.

Address Market Barriers through Strategic Public Investment

The targeted and strategic use of public funds can both accelerate the deployment of clean transportation technologies and make California a more attractive place to do business. In the process, this investment should generate significant environmental and economic benefits for the state. The following recommendations should generate in-state air quality, climate change, petroleum reduction, and economic development benefits:

- Invest revenues from AB 32 regulations such as a cap and trade program in clean transportation technologies.
- Increase and accelerate AB 118 funding for clean transportation to maximize its impact and leverage private investment.
- Focus on deployment and results as well as R&D and workforce training.
- Act as an early adopter of new transportation technologies.

Be More Proactive in Attracting and Retaining Business

California needs a dedicated, coordinated, and proactive plan to recruit and retain businesses. The following recommendations would help California encourage both research and manufacturing facilities in-state:

- Create a "one-stop shop" with adequate resources to coordinate the state's business development efforts.
- Increase targeted marketing and outreach efforts.
- Be more creative with assistance for the clean transportation technology sector.
- Consider some form of tax break for in-state manufacturing in targeted sectors.

1) INTRODUCTION

This is a very important time for clean transportation technologies in California and around the world. Warnings about climate change from the scientific community are growing more serious and frequent, and transportation sector emissions are one of the most stubborn problems. Air pollution from transportation is increasing with population growth and sprawl. Petroleum consumption and related emissions are expected to continue increasing in developing economies such as China and India. The past several months have seen almost unprecedented volatility in oil prices, contributing to economic difficulties in petroleum-dependent societies. Investment in clean transportation technologies has increased dramatically in recent years as a result of these concerns. However, low oil prices and a global economic recession are now threatening to disrupt the movement toward cleaner, more efficient transportation technologies.

The need for clean transportation technologies will continue to grow, and policymakers in California and elsewhere have signaled a desire to encourage continued innovation in this space. Given the fact that oil is a limited resource, the clean transportation technology industry can be expected to grow both in the U.S. and abroad. California is well-positioned to be a leader in this important market, and public policy will be the key driver as the state and the country try to transition away from oil. However, the deepening recession and growing state budget crisis could present significant barriers to progress in this area. There is a real threat that the budget crisis could lead to delayed or weakened regulations and reductions in funding for key initiatives. California has not yet solidified its position as the global leader in the clean transportation field, and the next few years will be critical.

This report focuses on the economic, environmental, and public policy issues surrounding the clean transportation technology industry in California. It begins with an overview of the industry and the technology categories in Chapter 2. Chapter 3 describes the relevant environmental and economic issues. Chapter 4 outlines the essential building blocks of a clean transportation industry cluster, and highlights the role of policy as a market driver. Chapter 5 identifies major barriers to the growth of the industry, and Chapter 6 provides recommendations for addressing those barriers and investing in California's future by encouraging in-state development and deployment of clean transportation technologies.

2) CALIFORNIA'S CLEAN TRANSPORTATION TECHNOLOGY INDUSTRY

California is a world leader in technology development, innovation, and environmental regulation. Given this combination, it is no surprise that the state is developing a strong, innovative, and valuable industry around clean transportation technologies. CALSTART identified a large and growing number of organizations involved in California's clean transportation technology industry. Additionally, the state is home to several forward-thinking fleet owners and transit properties, as well as countless individual car owners and transit users, who take advantage of these technologies on a daily basis.

AN EMERGING CLEAN TRANSPORTATION TECHNOLOGY INDUSTRY CLUSTER

In a 2004 report entitled "California's Clean Vehicle Industry," CALSTART argued that California was home to a nascent "clean car cluster.[1] The growing industry might more accurately be described as a "clean transportation cluster," as the technologies being developed have important applications beyond passenger cars.

An industry cluster, as defined by renowned Harvard business professor Michael Porter, is a "concentration of companies and industries in a geographic region that are interconnected by the markets they serve and the products they produce.[2] Clusters offer many benefits for companies and surrounding areas. The proximity and shared interest of companies in a cluster leads to competition, specialization, and attraction of additional companies, employees, and suppliers. This shared access to both prospective employees and specialized business services such as law firms, financial institutions, suppliers, and other supporting industries provides a competitive advantage for the cluster and opportunities for the surrounding area.[3]

The presence of a cluster can also help both the companies and the surrounding area from the standpoint of branding, credibility, and name recognition. The name "Silicon Valley," for example, is synonymous for most people with technology innovation, computers, and the Internet. Similarly, Hollywood is the world's undisputed movie-making capital, complete with countless studios, entertainment law firms, video and graphics technology companies, training programs, and eager would-be employees. The wine industry centered in California's Napa and Sonoma valleys is another example. In each of these cases, being part of the cluster gives credibility and importance to companies in the eyes of consumers, investors, and prospective employees.[4]

INDUSTRY OVERVIEW

CALSTART has identified 195 California organizations involved in some aspect of this industry, from vehicular design and alternative fuels to energy management, advanced component design and manufacturing, and industry support. 146 of these companies are directly involved in technology development andmanufacturing, while 49 are research and support institutions with significant relevance to the industry. This report divides California's clean transportation industry organizations into twelve categories and four support categories.

The categories are defined and discussed below, along with examples of California companies in each technology area. The companies mentioned below are representative of the industry, but the list is by no means exhaustive. A map showing the locations of California's clean transportation companies and organizations can be found in Appendix A, and a full list of organizations by technology category follows in Appendix B.

Technology Categories

- Advanced propulsion systems
- Alternative fuels, fuel infrastructure, and additives
- Electronics and power electronics
- Electric and alternative vehicle manufacturers
- Energy storage devices
- Engine, combustion, aftertreatment, and alternative fuel systems
- Lightweight, high strength materials
- Vehicular design, technology, and testing centers

Supporting Organizations

- Research institutions
- Investment and venture capital firms
- Industry support
- Automotive marketing and support

Advanced Propulsion Systems

This category includes electric, hybrid electric, hybrid hydraulic, fuel cell, and other propulsion technologies that improve upon the internal combustion engines that have been the standard since Ford began producing the Model T around 100 years ago. As consumers, manufacturers, and regulators look to move beyond the combustion engine for economic and environmental reasons, California companies are among the leaders in the development of electric drive and fuel cell technologies. **AeroVironment** (Monrovia) developed core components for the General Motors EV-1 Prototype, and **AC Propulsion** (San Dimas) will be supplying the drivetrain for the MINI E. **Enova Systems** (Torrance) and **ISE Corporation** (Poway) work on hybrid electric and fuel cell applications for buses and trucks. Superprotonic (Pasadena) is designing solid acid fuel cell technologies that can be used in mobile applications.

Alternative Fuels, Fuel Infrastructure, And Additives

Alternative fuels and additives, together with the infrastructure they require, are an important and rapidly growing sector of the clean transportation industry. Natural gas, various biofuels, and hydrogen fuel cells are some of the more promising technologies, and California companies are working on each. Advanced biofuels are often mentioned as an important (and sometimes controversial) part of the transportation energy future, and California companies are active in this area. For example, **BlueFire Ethanol** (Irvine) converts wood waste, urban trash, and agricultural residues into liquid fuel. There are also several companies in California working on non-ethanol biofuels. (see "Next Generation Biofuels" box on page 5).

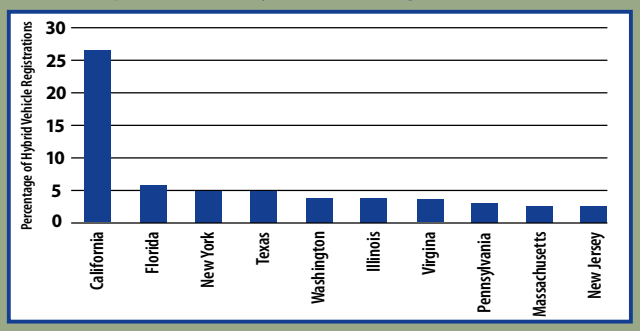
Hybrid Electric Vehicles Technologies

Hybrid electric vehicles combine a small conventional engine with an electric motor to increase overall vehicular efficiency and decrease emissions. Regenerative breaking technologies capture the energy that would normally be lost in breaking and use it to recharge the battery. Plug-in hybrid electric vehicles (PHEVs) can travel significant distances on their electric motor alone, providing even greater efficiency gains.

Demand for hybrid vehicles is strong and growing, particularly in California. California accounted for more than a quarter of all new hybrid vehicle registrations nationwide in 2007, with 91,417 new vehicles registered (see Figure 1 below). In addition to the growing passenger vehicle market, hybrid technology is emerging in the trucking industry, and every major truck manufacturer has produced at least a working prototype vehicle. California is well-positioned to be a leader in the development of this important and evolving technology, as the state has the expertise and the market demand to drive innovation and industry development.

Hybrid vehicles require a wide range of innovative technologies, and California companies are involved in the design and manufacturing of both components and vehicles. **ISE Corporation** (Poway) and **Enova Systems** (Torrance) both supply hybridelectric drive systems for heavy duty trucks and buses. **Quallion** (Sylmar) and **Maxwell Technologies** (San Diego) are among the providers of the advanced batteries and ultracapacitors needed for hybrid applications and regenerative breaking technologies. **US Hybrid** (Torrance) designs and manufactures critical components for hybrid vehicles, including power converters, motors and controllers, and energy management systems for advanced batteries. California is also home to the North American headquarters of two of the world's largest hybrid vehicle manufacturers: **Toyota** and **Honda** (Both in Torrance).

FIGURE 1: Top 10 States for Hybrid Vehicle Registrations, 2007



California leads the nation in new hybrid vehicle registrations, accounting for 26.1% of all new hybrid vehicle registrations nationwide. Source: U.S. Department of Energy [5]

The PHEV movement also originated in California, and **UC Davis** has the nation's leading PHEV engineering program. **Fisker Automotive** (Irvine) is designing a high-end PHEV using an advanced PHEV system designed by **Quantum Technologies** (Irvine). The system, called Q Drive, allows up to 50 miles of emissions free driving on a full charge.

Next Generation Biofuels

California has a high concentration of companies working on creating and producing next generation biofuels through innovative processes that might seem like science fiction at first glance. Many started as biotechnology companies focusing on pharmaceuticals or other industries. They now aim to produce renewable alternatives to traditional fuels that do not require costly new vehicle technologies and refueling infrastructure.

Solazyme (South San Francisco) is producing renewable oil, diesel, biodiesel, and jet fuel from a seemingly humble source: algae. Solazyme's fuels meet existing American Society for Testing and Materials (ASTM) specifications and can be used with existing infrastructure. Solazyme's biodiesel algae can produce much more oil per acre than other plants used for biofuels, and can be grown in marginal locations. Furthermore, algae can be expected to grow even better when fed excess CO2.

Solazyme's algal crude oil

Amyris Biotechnologies (Emeryville) has developed a way to engineer microbes that produce renewable diesel through a process of synthetic biology. Amyris opened its first pilot plant in California in November 2008, producing a renewable diesel fuel that is compatible with existing vehicles and refueling infrastructure.

LS9's pilot plant fermentation dome

Codexis (Redwood City) uses a complex process to design enzymes in the way that Mother Nature designs them: through evolution (though with some targeted and decidedly unnatural selection in the process). Using proprietary technology, Codexis evolves an enzyme to fit the properties of interest.

LS9 (South San Francisco) uses proprietary microbes to turn glucose or other sugars into ultra-clean diesel in a one step process. Like the others mentioned above, LS9's fuels will be a "drop in product" that can be used without modifications.

On the infrastructure side, **Primafuel** (Long Beach) recently established a new fuel terminal at the Port of Sacramento that will only handle low carbon fuels. **Propel** (Sacramento) is rapidly building alternative fuel stations and seeks to become a leading retailer of low-carbon fuels.

Hydrogen has long been touted as the transportation fuel of the future, and there are a number of companies in California working to make this vision a reality. Among these are **Harvest Energy Technology** (Sun Valley), which develops hydrogen generators for fuel cell vehicle fueling applications, and **Hydrogenics USA** (Valencia), which develops and commercializes various hydrogen and fuel cell products. Natural gas is another alternative to traditional transportation fuels, and natural gas vehicles are on the road today. **Clean Energy** (Seal Beach) is the largest provider of vehicular natural gas (CNG and LNG) in North America. Meanwhile, many of the state's leading utilities are also working on producing a repowering network for plug-in vehicles.

Electronics And Power Electronics Organizations

The increasing electrification of vehicles and vehicle functions will require a suite of electric and power electronic technologies. The electric drive and regenerative breaking capabilities of popular hybrid electric vehicles require many electronic components, including semiconductors, power inverters, and electronic control units for engine control. Demand for these components can be expected to increase as hybrid electric vehicles become more widespread and less common technologies such as full electric vehicles and plug-in hybrids enter commercial production. **US Hybrid** (Torrance) specializes in the design and manufacture of integrated power conversion components for electric, hybrid, and fuel cell vehicles. Well-known electronics industry leaders such as **Intel** and **NEC** (both in Santa Clara) also produce semiconductors that are used in advanced transportation applications.

Electric And Alternative Vehicle Manufacturers

While many California companies concentrate on electronics and electric drive technologies, the state is also home to a number of electric vehicle manufacturers that design and produce the advanced vehicles themselves. **Tesla Motors** (San Carlos) is designing and building full electric vehicles. Tesla's high performance Roadster is currently in production and the much anticipated Model S is now slated for production in mid-2011.[6] **Fisker Automotive** (Irvine) has designed a luxury PHEV sedan called the Karma, using technologies developed by **Quantum Technologies** (Irvine). Production is expected to start in late 2009, and final assembly will take place in Finland.

A number of California companies are questioning the standard assumptions about basic vehicle design. **Persu Mobility** (formerly known as Venture Vehicles) is designing an innovative, three-wheeled "Urban Life Vehicle," with availability expected in early 2010. The Persu Hybrid uses a patented electro-hydraulic tilt steering control technology that allows it to tilt like a motorcycle while turning. **Aptera Motors** (Carlsbad) is another California company designing next generation electric vehicles. Aptera's Typ-1 is a futuristic three-wheeled vehicle that will be offered in both full electric and hybrid electric versions, with production expected to start in 2009. Both Persu and Aptera are initially releasing their vehicles exclusively in California.

Persu's hybrid "Urban Life Vehicle" is a two-passenger, fully enclosed, tilting three-wheel vehicle that will be introduced in California in early 2010.

Energy Storage Devices

Energy storage is a very important part of the advanced transportation technology industry. Battery technology in particular has seen increased interest and investment in recent years as a result of the trend toward electrification of cars. **Quallion** (Sylmar) and **PolyPlus Battery** (Berkeley) are focused on providing lithium battery solutions for the electric, hybrid electric, and plug in hybrid vehicle markets.

In addition to batteries, advanced vehicle manufacturers rely on electrochemical ultracapacitors and mechanical flywheels for their energy storage needs. Ultracapacitors manufactured by companies such as **Maxwell Technologies** (San Diego) are particularly well-suited for regenerative breaking applications because of their ability to soak up energy quickly. On the mechanical storage side, **Pentadyne Power** (Chatsworth) designs, manufactures, and markets advanced flywheel power systems that provide ride-through power and voltage stabilization for power quality and power recycling applications.

California is also home to manufacturers of specialized, high pressure storage devices for alternative fuels and other gases. The ability to store compressed natural gas and other gaseous fuels at very high pressures increases the ability of alternative fuels and alternative fuel vehicles to compete with traditional technologies on cost and performance. **Structural Composites** (Pomona) and **Luxfer Gas Cylinder** (Riverside) are two companies focused on gaseous storage tanks and technologies.

Engine, Combustion, Aftertreatment, and Alternative Fuel Systems

Advanced engine, combustion, aftertreatment, and alternative fuel systems are among the simplest and most widely available measures for reducing vehicle emissions. These technologies can be added to conventional engines to directly reduce their emissions, improve their efficiency, or enable their use with cleaner alternative fuels.

Several California companies, including **Cleaire** (San Leandro) and **Extengine** (Irvine) manufacture retrofit technologies that can be used to reduce criteria pollutant emissions from diesel engines. By reducing these emissions to levels allowed under state regulations, these technologies enable the more widespread use of diesel and lean burn engines, which offer greenhouse gas benefits over gasoline engines. These retrofit technologies are therefore particularly valuable, in that they both reduce emissions directly and enable environmentally beneficial fuel switching. Other California companies make direct engine modifications that increase engine power and efficiency, thereby reducing emissions. **Garrett Engine Boosting Systems** (Torrance) and **Turbonetics** (Simi Valley) are two companies operating in this space. On the fuel side, **IMPCO Technologies** (Santa Ana) designs, manufactures, and markets products and systems that allow internal combustion engines to operate on clean burning alternative fuels such as propane and natural gas.

Lightweight, High-Strength Materials

By reducing the energy needed to accelerate and climb grades, the use of lightweight, high-strength materials can increase vehicular efficiency and reduce fuel consumption and emissions. **CellTech Metals** (San Diego) is designing and producing "Green Metals" that the company describes as "lighter, stronger, greener." **Hexcel Composites** (Dublin) and **Kaiser Aluminum** (Foothill Ranch) are two additional California companies supplying these types of valuable materials to the automotive industry.

Vehicular Design, Technology, and Testing Centers

Clean vehicles can be made more effective and efficient through aerodynamic and advanced vehicle designs. There are many entities throughout California working on these design issues, including **BMW DesignWorks** (Newbury Park), **Volvo Monitoring** and **Concept Center** (Camarillo) and **Art Center College of Design** (Pasadena). Before advanced designs and technologies can be fully commercialized, they must also undergo extensive testing. **Southern California Edison's EV Technical Center** (Pomona) and **TUV America** (Huntington Beach) are two California locations that are focused on testing and evaluation in the advanced transportation arena.

Research Institutions

California is home to several leading research institutions and collaborative enterprises involving both government and private entities that are valuable resources for the state and the clean transportation technology industry. The state's research institutions provide valuable early stage R&D and also act as a key source of innovation, entrepreneurship, and start-up companies. Examples of important research institutions working on transportation issues in California include the state's various public and private universities, the **Lawrence Berkeley National Laboratory** (Berkeley), **Sandia National Laboratory** (Livermore), and the **Jet Propulsion Laboratory** (Pasadena).

The recent increase in the number and size of public-private collaborations in the clean technology space should further contribute to the state's environmental and economic goals. The Institute of Transportation Studies at **UC Davis** (ITS-Davis) is a national leader in transportation research, and has formed strategic relationships with industry companies and governmental agencies. The Global Climate and Energy Project (GCEP) at **Stanford University** (Palo Allto) is an international collaboration of energy experts from academia and private industry whose focus includes research in advanced transportation, biodiesel, and hydrogen. In addition to Stanford researchers, GCEP enjoys the support and participation of four large corporations: **ExxonMobil, General Electric, Schlumberger**, and **Toyota.** The recently established **Energy Biosciences Institute** (EBI) is a $500 million partnership among **UC Berkeley,** the **Lawrence Berkeley National Laboratory, University of Illinois at Urbana-Champaign** and **BP** with a focus on bioenergy, including biofuels for transportation.

Investment and Venture Capital Firms

Interest from finance and investment firms is vital to the growth and success of California's clean transportation technology industry, as innovative technologies will never make it to market without early stage financial backing. Fortunately, California has a healthy finance and venture capital industry with a history of nurturing developing industries. This is particularly true in Silicon Valley, where the large venture capital community has been instrumental in supporting the internet and biotechnology industries. An increasing number of the venture capital firms in the state are focusing on the clean technology, or "cleantech," industry. Cleantech is the venture capital

industry's fastest growing sector, and California leads the nation in attracting investments. **Kleiner Perkins Caulfield & Byers (KPCB), Mohr Davidow Ventures (MDV),** and **Khosla Ventures** (all in Menlo Park), along with CMEA Ventures (San Francisco) are among the higher profile venture firms in the state focusing in large part on cleantech investments. Khosla Ventures is particularly involved in the cellulosic ethanol space. **Nth Power** (San Francisco) and **NGEN Partners** (Santa Barbara) are examples of venture firms focused exclusively on cleantech investments.

Industry Support

California is home to several private and nonprofit organizations and coalitions that provide support for the clean transportation technology industry. This support can come in the form of consulting, policy development and analysis, coalition building, consortium organization, business development assistance,and technology development, demonstration, and commercialization assistance. Notable California organizations providing industry support include. CALSTART (Pasadena), which is a multiple-technology industry consortium, and the California Fuel Cell Partnership (Sacramento), which is focused on a single technology.

Automotive Marketing and Support

Importantly, California is also home to the North American sales and marketing operations of two of the world's major automakers: **Honda** and **Toyota** (both in Torrance). While these locations are not directly involved with technology development, they are important for elevating California's status in the automotive world and for assessing the market applicability of new designs.

What is Cleantech?

As defined by the Cleantech Venture Network, the cleantech sector includes eleven categories of innovative and environmentally friendly products and services. Cleantech involves the use of new, innovative technologies to create products and services that create economic as well as environmental value.

The eleven categories are:

- Energy generation
- Energy storage
- Energy infrastructure
- Energy efficiency
- Transportation
- Water and wastewater
- Air and environment
- Materials
- Manufacturing and industrial
- Agriculture
- Recycling and waste

The clean transportation technology industry in California touches on many of these categories, including energy generation, energy storage, infrastructure, and materials, in addition to transportation itself.

FLEETS, TRANSPORTATION AGENCIES, AND USERS OF CLEAN TRANSPORTATION TECHNOLOGIES

The reach of the California's clean transportation technology industry goes far beyond these categories and organizations, extending to fleet owners, transit properties, and vehicle maintenance workers, as well as the countless individual users of advanced transportation technology both in California and elsewhere. Thanks in part to proactive public policies, California's public transportation fleets are among the leading users of advanced transportation technologies. The **SunLine Transit Agency** (Coachella Valley) has a fleet composed entirely of alternative fuel vehicles, including vehicles running compressed natural gas (CNG) and hydrogen. The Los Angeles County Metropolitan Transportation Authority, or **LA Metro** (Los Angeles County), is one of the nation's largest transit properties. LA Metro operates over 2,500 CNG buses, representing more than 95% of the fleet. These transit agencies play an important role in helping to speed development and deployment of new technologies by acting as anchor tenants and providing early market demand.

An increasing number of California's businesses and residents are also taking advantage of clean transportation technologies. Many private fleets in the state use clean and alternative fuel vehicles and infrastructure. While they still make up less than one percent the state's passenger vehicle fleet, alternative fuel vehicles are becoming more common. From 2000-2005, alternative fuel vehicle registrations increased by 18 times.[7] Transit ridership has also been increasing in recent months.[8]

3) CLEAN TRANSPORTATION, THE ENVIRONMENT, AND THE ECONOMY

California's transportation sector is characterized by a heavy reliance on high-emissions fuels and inefficient technologies and practices. The long-term economic and environmental costs of business as usual are staggering. Clean transportation technologies can both reduce these costs and provide economic benefits to the state.

THE COSTS OF BUSINNESS AS USUAL

Conventional transportation technologies are a major driver of air pollution as well as climate change, both of which have severe economic implications for California. Furthermore, the state's dependence on oil carries with it significant risks for both consumers and businesses.

Criteria Emissions and Air Quality

The combustion of petroleum-based fossil fuels for transportation leads to high levels of criteria pollutant emissions. Largely as a result of these emissions, California has some of the most severe air quality problems in the country. The San Joaquin Valley and South Coast areas have been particularly hard hit. Of primary concern are nitrogen oxides (NOx) and volatile organic compounds (VOC), both of which contribute to ozone and smog, and particulate matter (PM). Ozone and PM resulting in part from transportation emissions cause significant health issues, including respiratory problems, asthma, cardiovascular disease, cancer, and premature deaths. They also damage ecosystems and reduce visibility.

Large scale reductions in emissions from this sector are necessary from an air quality and public health perspective. With the projected growth in population, miles traveled, and congestion, it is clear that these reductions will require significant technological advances as well as lifestyle changes.

California has some of the nation's worst air quality

The Costs of Air Pollution in the South Coast and San Joaquin Valley

Excessive ozone and particulate emissions in the San Joaquin Valley and South Coast air basins cost the California economy $28 billion annually from premature deaths, illnesses, and lost productivity. The total costs of exceeding federal emissions limits are over $1,600 per person per year in the San Joaquin Valley and over $1,250 per person per year in the South Coast. These estimates, published in a recent study funded by the **Hewlett Foundation**,[9] represent the combined costs of:

- 3,860 additional premature deaths among those age 30 and older
- 13 additional premature deaths in infants
- 1,950 additional new cases of adult onset chronic bronchitis
- 3,517,720 additional days of reduced activity in adults
- 2,760 additional hospital admissions
- 141,370 additional asthma attacks
- 1,259,840 additional days of school absence
- 16,110 additional cases of acute bronchitis in children
- 466,880 additional lost days of work
- 2,078,300 additional days of respiratory symptoms in
- 2,800 additional emergency room visits

Greenhouse Gases and Climate Change

In recent years, increasing attention has been given to another type of emissions: the greenhouse gases that scientists believe are responsible for global climate change. The transportation sector accounts for around 40% of all anthropogenic greenhouse gas emissions in California, making it the state's largest source of these emissions. This number increases to nearly 50% if you take into account the related emissions from oil refineries. GHG emissions come from all aspects of the transportation sector, but the use of gasoline to power the state's vehicle fleet is the dominant source.[10]

Climate Change, Climate Policy, and the California Economy

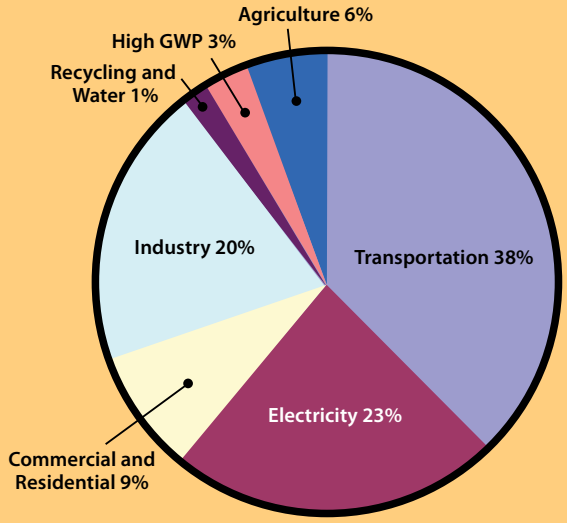
A recent report by Next 10 estimated the annual economic impacts of climate change in California.[12] The report's findings suggest that extreme weather events, wildfires, sea level rise, and other effects carry a very high price tag for California.

Annual Damage Estimates in 2006 USD (billions)			
	LOW	HIGH	ASSETS AT RISK
Water	N/A	0.6	5
Energy	2.7	7.5	21
Tourism and Recreation	0.2	7.5	98
Real Estate	0.3	3.9	2500
Agriculture, Forestry, Fisheries	0.3	4.3	113
Transportation	N/A	N/A	500
Public Health	3.8	24.0	N/A
TOTAL	7.3	46.6	

The economic analysis included in the California Air Resources Board's Climate Change Scoping Plan found that, when compared with the costs of inaction, the recommendations in the scoping plan should lead to significant increases in gross state product, per capita income, and jobs, as well as improvements in public health.

The expected effects of climate change on California's environment and economy are severe, and include an increase in the frequency and duration of droughts and fires as well as a significant decrease in Sierra snowpack. All of these environmental impacts will have dire economic implications for the state. $2.5 trillion of real estate assets are estimated to be at risk from climate-related threats.[11]

FIGURE 2: California's Greenhouse Gas Emissins (2002-2004 Average)



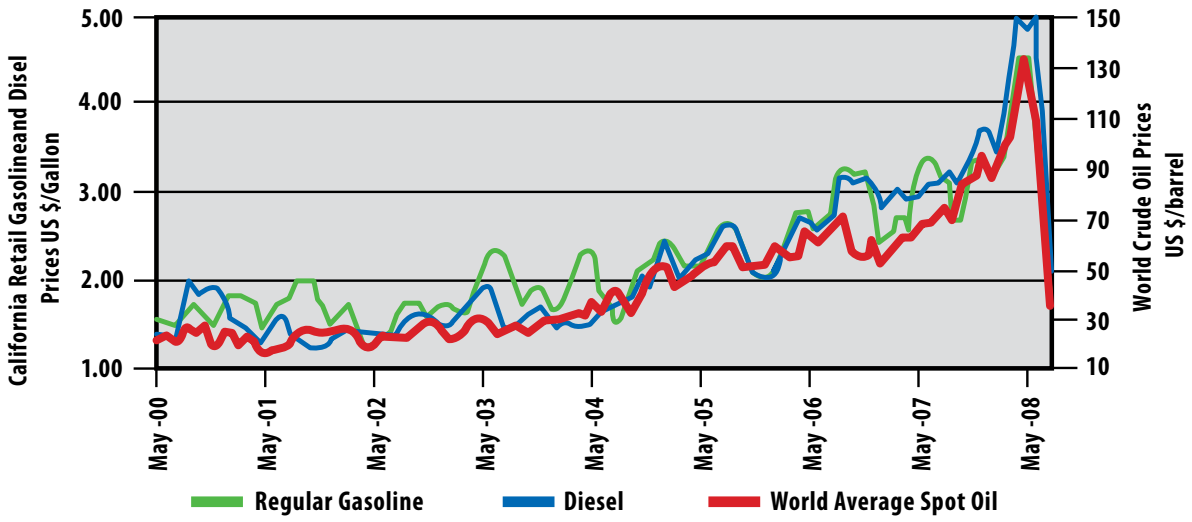
California passed AB 32, the Global Warming Solutions Act of 2006, in response to these threats. Any meaningful attempt to meet the ambitious reduction requirements of AB 32 – or any future federal legislation – will have to address GHG emissions from transportation through cleaner fuels and vehicles as well as reductions in miles traveled.

Petroleum Dependence and Energy Security

California currently depends on petroleum fuels for 96 percent of its transportation energy needs.[13] This reliance on a single source of fuel presents many serious problems for California's residents and businesses. Reduced oil dependence is critical for California's energy security and would strengthen the state's economy. A switch to cleaner forms of energy is also necessary from an environmental standpoint.

Without access to a diverse portfolio of alternative fuels, California's consumers and businesses must depend on a single source of fuel that is subject to supply disruptions and extreme price volatility. National disasters, wars, and political realities in oil-producing countries can have a significant impact on the availability of oil at both the global and local levels. The many pressures on the price of oil lead to unstable prices for both oil and gasoline, as shown in Figure 3 - Page 11.

FIGURE 3: Volatility In Oil, Gasoline and Disel Prices



Source: Energy Information Administration [14]

The threat of supply disruptions and volatile prices presents problems for businesses and individuals who are unable to adequately plan for these contingencies. Airlines, trucking fleets, and others who are unable to respond to high prices by simply cutting demand have been particularly hard hit. These issues would be compounded if global "peak oil" predictions come true, as oil and gasoline prices are predicted to reach levels that could seriously damage the California economy.

High prices and lack of crude oil supplies are not the only limiting factor on California's ability to meet its transportation energy needs. The production of gasoline, diesel, and jet fuel requires oil refinement, and demand for these finished products already exceeds the state's refining capacity. California can meet this excess demand through imports of refined fuels, but doing so adds to the state's trade deficit. According the California Energy Commission, the state produces only 37.2 percent of the oil it uses. A reliance on imports also puts California at greater risk for supply disruptions because California regulations require a special blend of gasoline that is not readily available from all refiners. The gap between the state's demand and refining capacity is projected to continue growing over time, adding to the costs of petroleum dependence and increasing the likelihood of serious economic destabilization.[15]

California's petroleum dependence also contributes to climate change and air pollution problems, both of which have negative long-term implications for the state's ecosystems, economy, and health.

> **"It is more important than ever that we secure our state's long-term competitiveness – and green technology is the future. We are all going through tough economic times, and this is exactly why I am talking about investing in clean, green technology. It's one of the best investments out there, and it's where the innovation and job growth will be, which is why California is leading the way with smart policies that unleash our ingenuity."**
>
> ***– Governor Arnold Schwarzenegger*** [16]

CLEAN TECHNOLOGY AS A SOLUTION AND AN OPPORTUNITY

Clean transportation technologies can reduce the harmful transportation-related emissions that are polluting the state's air and contributing to global climate change. Technology can also address the issues of energy security and price volatility by reducing California's dependence on imported oil. Additionally, a robust clean transportation technology industry can be expected to generate high quality green jobs and economic growth in the state.

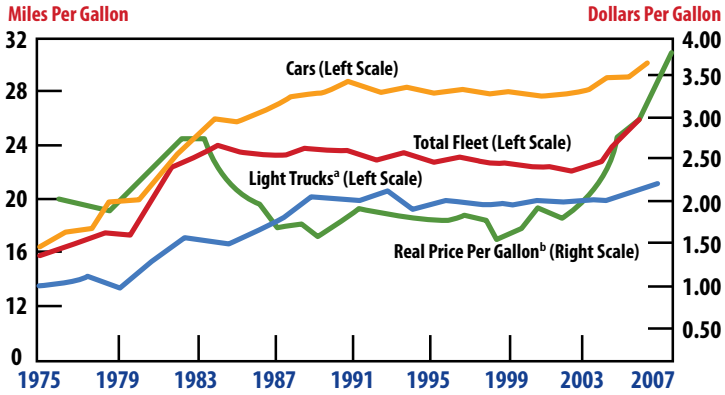
Decreasing Criteria and Greenhouse Gas Emissions

The reduction of criteria and GHG emissions from transportation is essential to the health of California's residents, environment, and economy. Both criteria and GHG emissions are a function of (1) vehicle efficiency and technology, (2) emissions intensity of fuels and vehicles, and (3) vehicle miles traveled. Clean transportation technologies can help address all three of these crucial emissions drivers, though technology will have the greatest impact on vehicle efficiency and emissions intensity. While air quality and climate change emissions are closely related, there are cases in which technologies involve tradeoffs: a certain technology may bring about a decrease in one pollutant at the cost of an increase in another. These relationships are a strong argument for coordinated emissions reduction policies.

Vehicle Efficiency and Technology

The energy efficiency of passenger and freight vehicles is a driver of both emissions and economic costs associated with transportation. As technologies improve, vehicle efficiency should increase, leading to a drop in the total energy needed for transportation and a corresponding drop in emissions. However, average on-road fuel economy has actually decreased slightly over the past 20 years because of a shift toward heavier vehicles and faster acceleration (see figure 4 below). There are many technologies at various stages in the commercialization process that can help reverse this trend and drastically increase the energy efficiency of vehicles. Recent research suggests that U.S. fuel use could be cut in half within 30 years through a dedicated focus on fuel economy, even in the absence of major breakthroughs in fuel technology or energy storage.[17] Truly advanced technologies could bring even greater efficiency savings and emissions reductions.

FIGURE 4: Average Weighted Fuel Economy for New U.S. Passenger Vehicles and the Real Price of Gasoline



Source: Congressional Budget Office based on data from the EPA [18]
a) includes sport utility vehicles and minivans
b) 2008 price is Energy Information Administration's estimated annual average as of July 2008

Several technologies and engine modifications can improve the efficiency of an internal combustion engine. Full electric and hybrid electric drive technologies offer significant efficiency gains due to the greater efficiency of electric motors. The regenerative breaking technologies used in electric and hybrid vehicles increases efficiency by capturing and reusing energy that would otherwise be lost. Batteries, ultracapacitors, and hybrid hydraulic systems can all be used to capture and store this energy.

There are many other, less complicated technological improvements that can increase vehicle efficiency without requiring revolutionary engine technology. Lightweight, high strength materials can boost efficiency by reducing vehicle weight and energy demand. Turbochargers can increase engine power and efficiency directly. Switching from spark ignition gasoline engines to compression ignition diesel engines offers efficiency gains, but the emission of some criteria pollutants may increase. Several California companies manufacture products to reduce these criteria emissions and thereby enable the use of these more efficient engines.

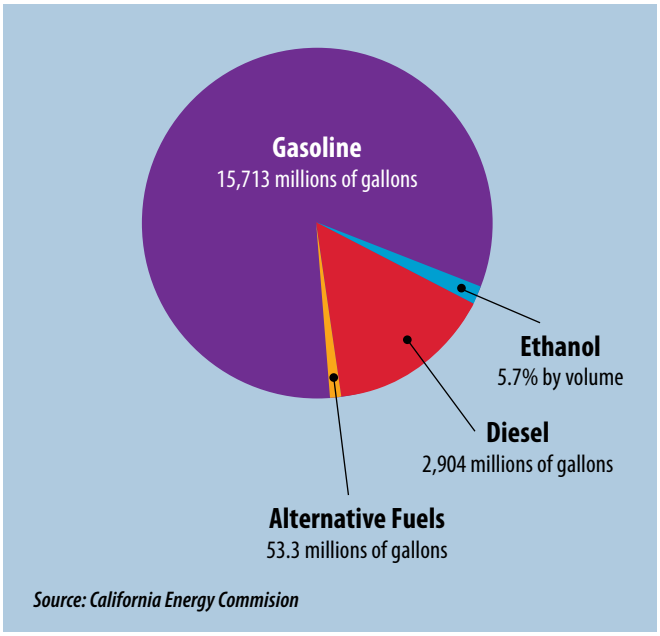
Emissions Intensity of Fuels and Vehicles

Another key factor influencing emissions in the transportation sector is the emissions intensity of fuels and vehicles, which can be thought of as the emissions produced per unit of energy used. Emissions intensity is partially driven by the inherent properties of the energy input – the fuel itself – and partly driven by the technology in the vehicle and the degree to which it generates emissions in converting the fuel to energy.

The inherent emissions intensities of the conventional and alternative transportation fuels vary significantly from fuel to fuel. Some fuels may offer emissions reductions for some pollutants, but increases for others. Biodiesel, for example, produces lower levels of GHG than the diesel it replaces, but it can increase NOx emissions. Natural gas offers significant criteria pollutant emissions reductions when compared with gasoline, but the GHG benefits are less clear. The feedstock used for a given fuel will have a significant effect on its lifecycle emissions intensity, complicating the comparison between fuels. The benefits of using ethanol, for example, are much greater when the fuel is cellulosic rather than corn-based, and the benefits of switching to electricity are much greater if the electricity comes from clean, renewable sources.

Though the calculations may be complicated, the concept is simple: switching from gasoline and diesel to electricity, biofuels, natural gas, and other alternative fuels can greatly reduce emissions intensity for both criteria pollutants and GHG. Demand for alternative fuels is still very small, as shown in Figure 5 below, but California has set ambitious targets for alternative fuel use.

FIGURE 5 California's Petroleum and Alternative Fuels Demand - 2005



In addition to reducing the inherent emissions intensity of fuels, new and advanced technologies that are a part of the vehicle or engine can be used to capture or otherwise reduce emissions from transportation. Catalytic converters, particulate filters, and related technologies manufactured by companies in California and elsewhere can reduce criteria pollutant emissions from vehicles. It may also be possible to design and install devices that capture or reduce GHG emissions.

Vehicle Miles Traveled

Perhaps the most obvious and stubborn driver of transportation sector emissions is transportation activity levels, typically measured in vehicle miles traveled, or VMT. In order to reduce VMT, people have to walk, bike, telecommute, and use clean public transportation more instead of driving passenger vehicles. Overall systems for distribution and goods-movement will have to be redesigned so as to minimize travel and maximize efficiency. The major drivers for these changes will come from policies, incentives, and price signals that affect lifestyle, behavior, business operations, and land use. However, advanced transportation technologies can play an enabling role by increasing the availability and attractiveness of alternative modes of transportation.

Clean, advanced public transit systems have the potential to significantly reduce VMT, particularly if coupled with smart growth and land use policies. Advances in drive systems, materials, and fuels can improve public transit systems just as they improve passenger and freight vehicles. For example, the hybrid and full electric buses that can be used in Bus Rapid Transit (BRT) and other municipal bus systems are quieter, cleaner, and offer better acceleration and smoother breaking than conventional buses. This makes them faster and more efficient, as well as more pleasant for passengers.

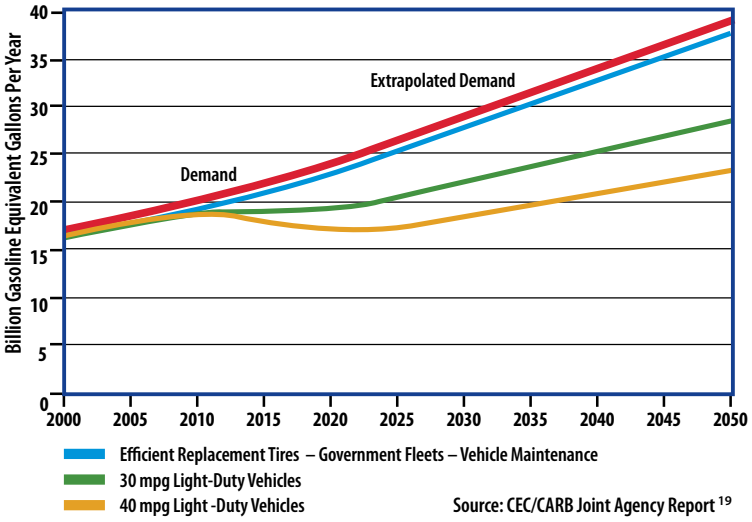
Reducing California's Dependence on Oil

Reducing California's dependence on oil is both necessary and beneficial for the state of California. A reduction in petroleum consumption would decrease the harmful criteria and greenhouse gas emissions that contribute to air quality problems and climate change. A shift toward clean alternative fuels would also shield the economy from volatile and rising fuel prices, which hurt both businesses and individuals by driving prices up and decreasing predictability. Additionally, the state could improve the security of its energy supply by decreasing its reliance on oil, which is particularly subject to supply disruptions. A clean and diversified fuel supply would make California a more affordable, attractive, and sustainable place to live, invest, and do business.

The clean transportation technology industry can reduce California's oil dependence by increasing efficiency and by providing alternative fuels, vehicles, and modes of travel. Most of the above-mentioned emissions reduction strategies can also help wean the state off of oil. New materials, hybrid drive, and other technological improvements offer the potential for more efficient use of petroleum using existing and near-term technologies and infrastructure. The long-term reduction in petroleum demand from selected fuel efficiency options is shown in Figure 6, Page 14.

Though California cannot pass vehicle fuel economy standards, advanced transportation technologies can help push new vehicles toward higher efficiency. Hybrid vehicles such as the Toyota Prius can get well over 40 mpg.

FIGURE 6 Petroleum Demand Reduction of Selected Fuel Efficiency Options



Source: CEC/CARB Joint Agency Report [19]

In addition to reducing oil dependency through increased vehicle efficiency, the clean transportation technology industry can provide alternative fuels to replace petroleum in new and existing vehicles. The state has set alternative fuel use targets of nine percent for 2012, 11 percent for 2017, and 26 percent for 2022. Alternatives include, but are not limited to, electricity, natural gas, propane, hydrogen, ethanol, renewable diesel, and biodiesel. Advanced transportation technologies will be needed to meet these goals. As part of the State Alternative Fuels Plan called for by AB 1007 (Pavley), the Energy Commission calculated the maximum feasible alternative fuels use in California under business as usual, moderate, and aggressive assumptions (see Table 2). Both the moderate and aggressive assumptions will require technological advances in vehicles, fuels, and fueling infrastructure. This move toward alternative fuels could also improve California's balance of trade, as there are in-state sources for many alternative fuels.

Table 2: Maximum Feasible Alternative Fuel Use - BGGE

Scenario	2012	2017	2022
Business As Usual	1.4	1.7	2.1
Moderate (AB 1007)	2.4	3.7	5.3
Aggressive	2.9	6.8	11.3

Source: California Energy Commission [20]

The clean transportation technology industry can also reduce the state's dependence on petroleum by providing alternatives to passenger cars in the form of more efficient or more effective public transit. This should help reduce both vehicle miles traveled and petroleum demand.

> **"We want these cutting-edge companies not to just start in California and do their research and development here – we want them to build in California"**
>
> ***– Governor Arnold Schwarzenegger***

Creating Green Jobs and Economic Growth

The clean transportation technology industry offers yet another important economic opportunity for California: the potential to retain and create high quality green jobs and encourage in-state economic growth. The California Economic Strategy Panelestimates that the state is already home to over 43,000 "green" jobs in various industries, 41% of which are in manufacturing.[21] As investment continues and California transitions to a greener economy, these numbers should grow dramatically. Over the long-term, the US Council of Mayors estimates that "green" employment in the Los Angeles area alone could grow from around 20,000 in 2006 to almost 160,000 in 2038.[22]

A recent report estimated that every $100 million of cleantech venture capital leads directly to the creation of 2,700 jobs, as well as many more indirect jobs and incremental revenues for future investment.[23] California alone attracted $1.8 billion dollars of cleantech investment in 2007, the majority of which went to energy generation, transportation, energy efficiency, energy storage, materials, and infrastructure. Investments in transportation technologies grew faster than those in any other cleantech sector, increasing by 12-18% from 2005-2007.[24] Worldwide investment continues to grow despite the economic downturn: the total investment of $2.6 billion in the third quarter of 2008 was an all time record.[25] These investment trends are an encouraging sign with regard to the future of the industry in California.

These trends also suggest that investors expect market demand for clean technologies to continue increasing. High gas prices and increasing environmental regulation in countries all over the world are two factors that should contribute to this demand. If California is able to establish itself as a leader in the development and commercialization of clean transportation technologies, the state's industry should have significant export and growth potential.

4) THE CRUCIAL ROLE OF POLICY

California already has the necessary foundations for the development of a successful clean transportation technology industry cluster. Through proactive public policy, the state has the power to drive the growth of the industry, make California a leader, and reap the environmental and economic rewards that clean transportation technologies can offer.

ESSENTIAL BUILDING BLOCKS OF A CLEAN TRANSPORTATION CLUSTER

California's clean transportation technology industry has the potential to develop into a world class industry cluster, which would have substantial economic benefits for the state. The creation of a successful industry cluster requires the right conditions, policies, expertise, and people. Key factors for the successful development of a clean transportation technology industry include:[26]

- Entrepreneurial culture and talent
- Public and private sector technology innovation and commercialization expertise
- Management talent with experience in startups and growing industries
- Proactive public policies related to the environment, business development, and technology
- Access to capital and other financing across all phases of the technology innovation and commercialization process
- Proximity to leading universities that can supply research expertise and an educated workforce
- Significant local demand for products and services

Most of these essential elements are already in place in California. A very similar combination of factors led to the development of a high-tech cluster in Silicon Valley. The entrepreneurial culture, management talent, and technology expertise that have contributed to the success of the computing, Internet, and biotechnology industries are transferable to the clean transportation field. Though the industries are not identical, and environmental technologies present some unique challenges, California's experience with all aspects of technology innovation and commercialization is invaluable.

An extensive network of financial institutions with experience providing access to venture capital and other financing for innovative technologies already exists in California. Venture investors, who play a vital role in the development and commercialization of new technologies, see California as a good place to invest. Four of the world's top five venture investors are in Silicon Valley, and California attracted 40% of US cleantech venture investment dollars in Q2 2008.[27] Furthermore, the state is home to many large banks, lenders, and private equity firms.

California is also home to a world class university system, with school such as UC Berkeley, Stanford, Caltech, and UCLA providing crucial research, a source of educated workers, and other valuable resources. Large scale collaborations between research institutions and private companies are a testament to the value of the state's university system and have the potential to make significant contributions to the clean transportation field.

The Economic Benefits of University Research

A 2003 ICF Consulting report found that the UC system is a key source of innovation and entrepreneurs for the state.[28]

- Through UC R&D, California will realize productivity gains estimated at $5.2 billion during 2002-11, supporting the creation of more than 104,000 jobs
- UC is a national leader in number of patents developed. From FY 1998-99 through 2000-01, UC campuses reported more than 2,600 inventions created with university resources
- Over 160 companies have been founded through technology licensing agreements with UC

As the world's eighth largest economy, California offers a substantial local market for the products and services offered by California's clean transportation technology industry. The state's ambitious environmental laws, regulations, and policies have helped to increase local demand for environmentally friendly products.

POLICY IS A KEY DRIVER

The role of public policy in creating and sustaining the conditions necessary for the success of clean transportation technologies in California cannot be overstated. Comprehensive and proactive public policies are necessary for the industry's growth. Short-sighted and uncoordinated policies, on the other hand, could act as a significant barrier, ultimately delaying solutions to environmental problems and causing the state to miss out on economic opportunities.

> **"Unlike the Silicon Valley revolution, which was led by computer scientists, in this [cleantech] revolution the winners and losers will be decided in large part by policy wonks."**
>
> ***– Robert Hertzberg,***
> ***cleantech entrepreneur and former California legislator*** [29]

Smart policies are needed to encourage and accelerate the development and deployment of clean transportation technologies. This is because there are several market failures and barriers that tend to work in favor of the status quo and against clean alternative technologies. The cost of pollution is not factored in to the price of energy, for example, so "dirty" conventional technologies are less expensive than they should be, and generally less expensive than clean alternatives. New transportation technologies also face a host of consumer acceptance issues because of a lack of infrastructure and familiarity. Furthermore, the innovation process itself is hampered by market failures that result in an underinvestment in the development of new technologies.

Public policy can address these problems and drive innovation and industry growth in three key ways:

- Increasing market demand for goods and services through standards, regulations, and purchase incentives
- Providing financial support through R&D funding, loan guarantees and project finance, direct investment, tax breaks, and other avenues
- Creating a favorable business environment through consistency, predictability, and non-financial assistance to the industry

Policy Attracts Investment and Drives Sales

Recent industry research suggests that California policy is an important driver for clean technology investment and business.

- In a survey conducted by E2 and the Cleantech Venture Network, 91% of venture capitalists stated that environmental policies and regulations can be a driver in bringing new business and investment to a state, and regulatory climate ranked second only to entrepreneurial culture and management talent in the list of reasons why venture capitalists like investing in California companies.[30]
- A 2004 survey of air pollution control equipment manufacturers found that the most important factors driving sales were:
  (1) enforcement of air quality regulations,
  (2) local and regional standards in California air districts, and
  (3) California state air quality standards.[31]

INNOVATIVE TECHNOLOGY AND ENVIRONMENTAL POLICY IN CALIFORNIA

California leads the nation with regard to pro-environmental public policies. The state's forward-thinking policies have been instrumental in driving the development and commercialization of environmentally friendly advanced technologies. California also has a history of policy innovation and a willingness to "think big" and try new approaches.

California's public servants have shown exceptional leadership at all levels of government, from Governor Schwarzenegger and key legislators such as Fabian Núñez, Fran Pavley, and Darrell Steinberg, to the board members, staff, and commissioners of the state's relevant agencies. Key regulations, both planned and existing, are helping to encourage a transition to advanced transportation alternatives and aid in the growth of the state's clean transportation industry. Examples of laws and regulations that are particularly relevant to technology development and deployment are below.

Global Warming Solutions Act of 2006 (AB 32, Núñez)

California's most high-profile environmental legislation is the Global Warming Solutions Act of 2006, also known as AB 32. This groundbreaking law calls for a significant reduction in GHG emissions by the year 2020, and has sent a clear signal to investors that California is serious about combating climate change. AB 32 helps to create demand for low carbon transportation technologies andstandards would be the first in the nation. The bill's implementation has been held up by legal challenges and by a denial on the part of the EPA to issue the waiver California needs to set its own air pollution standards. If the regulations are enacted, they can be expected to generate significant investment in low carbon vehicle technology by instantly creating demand for cleaner vehicles.

Green Collar Jobs Initiative (AB 3018, Núñez)

In 2008, Governor Schwarzenegger signed AB 3018, which creates a green jobs council within the California Workforce Investment Board to address the training needs and resource requirements necessary to foster the state's emerging green economy. This initiative will help ensure that California has a well-trained workforce to develop and service emerging clean technologies in transportation and other sectors.

Low-Carbon Fuel Standard (LCFS)

The Low-Carbon Fuel Standard, established through a 2007 Executive Order by Governor Schwarzenegger, calls for a 10% reduction in the carbon intensity of transportation fuels sold in California by 2020. California's LCFS is the world's first climate change standard for transportation fuels, marking yet another environmental policy innovation in California. The LCFS should increase demand for and investment in alternative fuels and alternative fueling infrastructure. A 2007 E2 report estimated that the LCFS will triple the size of California's renewable fuels market.[32]

Vehicle Greenhouse Gas Emissions Standards (AB 1493, Pavley)

In 2002, California passed AB 1493, also known as the "Pavley bill." This bill would require the Air Resources Board to develop standards for greenhouse gas emissions from passenger vehicles.

California'sprovides price signals to investors by effectively increasing the price of conventional fuels and technologies. Moreover, California's leadership on this issue is likely to influence policy at the regional and national leves.

SB 375 (Steinberg)

Though it does not relate directly to technology development, California's landmark smart growth bill deserves mention as an important and innovative step toward decreasing vehicle miles traveled and transportation-related emissions. SB 375 requires metropolitan planning organizations to align their regional transportation, housing, and land-use plans and prepare a "sustainable communities strategy" to reduce vehicle miles traveled and transportation-related emissions.

Alternative and Renewable Fuel, Vehicle Technology, Clean Air, and Carbon Reduction Act of 2007 (AB 118, Núñez)

AB 118 represents a very important investment in California's clean energy future. Through small increases in various DMV fees, AB 118 will raise approximately $200 million per year to be invested in advanced vehicle technologies, alternative fuels, fueling infrastructure, and fleet modernization. This investment should help California transition toward a cleaner and more efficient transportation system that is not overly dependent on petroleum. In the process, it will provide much-needed support for the clean transportation technology industry in the form of direct financial assistance and purchase incentives.

The California Secure Transportation Energy Partnership (CalSTEP)

In 2005, CALSTART convened a diverse partnership of group of industry, automotive, business, academia, policy, and nongovernmental professionals to provide guidance on transportation policy issues for California. The group, called CalSTEP, released an Action Plan in 2007 with ten forward-thinking policy recommendations. The CalSTEP effort focused broadly on increasing fuel choice and efficiency, with the ultimate goal of reducing the state's petroleum dependence and transportation-related emissions. This report on California's clean transportation technology industry represents the next phase of the CalSTEP effort, and focuses more narrowly on technology and related issues.

PRIMARY ACTIONS	
Alternative Fuels Portfolio Standard (AFPS) AFPS would increase the availability of alternative fuels by requiring 20% of the state's fuel supply to be alternative fuels by 2020 ◊*	
Energy Security Tax Relief and Realignment (ESTRR) ESTRR would consist of a variable tax or fee on petroleum coupled with a tax rebate for all California tax payers. This revenue-neutral fee would provide price signals for investors and consumers without acting as a drain on the economy	
Smart Communities Program Smart communities would encourage and reward energy-efficient and climate-friendly land use planning ◊	
SUPPORTING ACTIONS	
Diversify The State's Fuel Supply	California Alternative Fuels Infrastructure Partnership ◊* California Renewable Fuel Production Initiative ◊*
Improve Vehicular Efficiency	State Fleet Leadership Challenge ◊ New Transportation Future and Revolving Loan programs ◊ Energy-Independent Vehicle Labeling
Reduce The Need To Drive	Neighborhood Planning Revolving Loan and Transit Use Assistance Programs ◊ Usage-Based "Pay As You Drive" Insurance ◊*

◊ General concept adopted in original or modified form * Regulations still under development

California's progress on the innovative policies outlined in the Action Plan is yet another example of the state's leadership on environmental policy issues. Eight of the ten recommendations are currently being implemented either as originally proposed or in a modified form. Recent highlights include:

- The Low-Carbon Fuel Standard (LCFS) should achieve many of the goals set out by the AFPS, including increased fuel choice and decreased emissions
- SB 375 (Steinberg) is an important first step toward encouraging better land use planning, in line with the recommendations set out in CalSTEP's Smart Communities Program
- AB 118 (Núñez) provides vitally important funding for clean transportation technology development and deployment in California, as recommended in CalSTEP's New Transportation Future and Revolving Loan programs

While California policymakers have made significant progress, important work remains. For example, the ESTRR proposal has been held up by political concerns and perceptions, despite the clear advantages of a revenue-neutral increase in transportation fuel retail prices. Furthermore, the state's budgetary problems present a real threat to AB 118 and other programs that have already been implemented. Policymakers have a difficult but important task ahead of them in implementing policies that encourage long-term prosperity in California while also dealing with short term constraints.

5) BARRIERS TO THE GROWTH OF THE CLEAN TRANSPORTATION TECHNOLOGY INDUSTRY

While California remains is a very good place to develop technologies and start companies, there are a number of barriers to in-state manufacturing, production, and industry growth. Many of these issues are specific to the transition period faced by new technologies. Others stem from the economics of innovation and project finance in the transportation sector. Regulatory issues can also act as a major hurdle for clean transportation technologies. California also faces problems in terms of its ability to compete for businesses with other states and countries. The following is an outline of some of the high priority issues that are impeding the growth of the clean transportation technology industry in California.

TRANSITION BARRIERS

New transportation technologies face many transition barriers that can hinder commercialization and widespread deployment. These include infrastructure development, codes and standards, permitting, and high costs resulting from low production volumes. The state can play an important role in addressing each of these barriers and accelerating the transition toward cleaner transportation technologies.

Infrastructure Needs

The transition toward alternative fuels and advanced vehicles requires extensive fuel infrastructure development. The infrastructure needs are a significant market barrier for alternative fuels and vehicles that must compete for customers with existing technologies that have established and widespread fueling networks already in place. Alternative fuels present a classic "chicken and egg" problem: consumers generally will not buy alternative fuel vehicles without widespread and convenient refueling options, while station owners will not install alternative fuel equipment without sufficient demand and ready customers. The state can help develop this crucial infrastructure by providing funding for demonstrations, providing incentives for the construction of alternative fuel stations, and expediting the permitting process to the extent possible.

A quick look at the numbers of refueling stations for various alternative fuels in California illustrates the size of the problem (see TABLE 3 right). Early adopters of alternative transportation technologies must learn the locations of local filling stations and plan ahead for longer trips. Publications and websites can help make this easier, but alternative fuels will face market barriers and consumer reluctance until the refueling infrastructure is significantly expanded.

TABLE 3: Refueling Stations in California

FUEL TYPE	NO. OF CALIFORNIA STATIONS
Biodiesel	45
Compressed Natural Gas (CNG)	149
Ethanol (E85)	14
Electric	347
Liquid Natural Gas (LNG)	42
Hydrogen (H2)	32
Conventional - Gasoline/Diesel	9696

Source: CALSTART Clean Car Maps; US Department of Energy; California Energy Commission

The different alternative fuels and alternative fuel vehicles are at various stages of the commercialization and deployment process. So-called "flex fuel" vehicles that can run on gasoline or ethanol (E85) are widely available. In fact, the state itself has a fleet of well over 1000 flex fuel vehicles, but these have run almost exclusively on gasoline. This is largely due to the fact that California has only 14 E85 stations. Compressed Natural Gas (CNG) vehicles are at a slightly later stage of development. There is currently one light-duty compressed natural gas (CNG) vehicle commercially available from an original equipment manufacturer (the **Honda Civic GX**) and several medium- and heavy-duty options. CNG drivers have approximately 150 public filling stations to choose from throughout the state. While most of these are being upgraded to 3600 psi, some still operate at 3000 psi, providing relatively low pressure fills and limited range. Hydrogen is often cited as the future of transportation, but fuel cell vehicles

are not yet commercially available. The state has 35 planned and operational hydrogen stations, most of which are primarily used for demonstrations, as part of the Hydrogen Highway program. These stations are clustered around Los Angeles and San Francisco, reflecting a strategy to create "mini-networks" of fueling stations able to support near-term fuel cell deployments.[33]

Codes, Standards, and Certifications

Various codes, standards, and certifications are needed for new fuels, vehicle technologies, and fueling systems. Delay and confusion in these administrative processes can have a detrimental effect on deployment. Funding and technical assistance are needed for technology certification and for the creation of codes and standards. Examples of roadblocks are below.

New fueling infrastructure requires safety certifications and permitting guidelines. A number of alternative fuels, including E85 and biodiesel, do not yet have tanks and fueling equipment that have been fully certified for safety by Underwriters Laboratories (UL). Local Fire Marshalls require this certification, and the delay sometimes acts as a roadblock to infrastructure development.[34] New refueling stations also require approval and permitting from state and regional agencies. The California Air Resources Board has issued an Executive Order concerning E85 and the local air districts are now regularly approving permits on a case-by-case basis, but the process at the local level can still be slow. There are still issues with the California Water Resources Board as they have yet to certify E85 tanks specifically for groundwater leakage, leaving the final approval to local health districts.

Approval and standards are also needed for new fuels. Standards vary across states, and are set in California by the Division of Measurement Standards. No standards currently exist for natural gas. For biodiesel, blending and rule exemptions have reduced the effectiveness of state standards and certifications, which has proven problematic from a fuel quality and consistency standpoint. Furthermore, emissions testing is difficult for biodiesel and other fuels with emissions properties that vary with changes in feedstocks. Faster and more predictable validation, approval, and standards-setting processes are needed to facilitate the development and deployment of alternative fuels.

Engines also require emissions certifications. A manufacturer seeking funding for emissions reductions from advanced technologies can only get credit for certified technologies. As new vehicles and fuels enter the market, certification issues become increasingly tricky. Vehicle and engine emissions differ across fuels, so an engine manufacturer needs different certifications for different fuels and fuel blends. Furthermore, hybrids present a unique challenge because they often operate with their primary engine off. Therefore, the standard practice of certifying the engine rather than the entire vehicle does not give hybrids sufficient credit for emissions reductions. Certification of the hybrid system or the entire vehicle could address this problem, but the data gathering and certification process is lengthy and expensive, creating yet another barrier to technology deployment.

Permitting

Slow and arduous permitting processes can act as a barrier to the construction of production facilities and fueling infrastructure. For example, because the Air Resources Board has not yet given complete guidance to local air districts regarding evaporative emissions and other issues concerning E85 fueling stations, the air districts have been issuing permits on a case-by-case basis. These types of delays and hurdles have contributed to the lack of E85 stations in California – there are almost 2000 stations that sell E85 in the United States, but only 14 are in California. Permitting delays have also been an issue for fuel production facilities. In recent months, investors have warned that the slow permitting and regulatory processes in California were causing certain biofuels companies to look at other states.[35] At least one of these California companies has since moved to Colorado.

> **"This [Cilion] is a company building corn ethanol plants in the central valley. The permitting cycles are so long, they're starting to look out of the state and out of the country."**
>
> ***– Venture Investor Vinod Khosla*** [36]

Past research by the Air Resources Board on the issue of permitting found that it is not necessarily the costs of permitting and compliance that pose problems for

businesses, but rather the length and complexity of the process. In a 1996 research note on air quality regulations and business locations decisions, CARB staff noted that "the primary cause of complaints about air pollution regulations is the complex, slow, and sometimes costly process of getting information about the regulations and obtaining permits…Because negative attitudes toward environmental regulation are due largely to the frustrations businesses feel in dealing with the process of regulation rather than the actual expenses of compliance, the solution will require the restructuring of permitting and compliance processes so that they are more customer oriented."[37]

Low Volumes and High Incremental Costs

High incremental costs present another major hurdle for new technologies during the transition period. Innovative new vehicles, drive systems, and other technologies in the early stages of deployment and commercialization are very expensive to produce, and have high purchase prices as a result. As demand and production volumes increase over time, and as the innovation cycle continues with process improvements and movement up the learning curve, these costs can be expected to come down. However, the high purchase costs tend to suppress the demand that is needed to justify increased production volumes and take advantage of economies of scale. Some sort of public sector intervention is therefore needed to help new technologies through this transition period of low volumes and high costs. The state can (and often does) drive demand directly by acting as a major purchaser of new technologies. Policymakers can also help buy down the cost of new vehicles and technologies through rebates and tax credits, which will also lead to increased demand.

Purchase Price is a Hurdle for Hybrid Trucks

In response to fuel prices and the threat of climate change, truck and hybrid system manufacturers have developed technologies that significantly increase fuel efficiency and decrease emissions. The replacement of conventional trucks with those powered by hybrid systems could improve fuel efficiency by 20-50%, and reduce criteria emissions and cut greenhouse gas emissions by similar amounts depending on duty cycle.[38] Fleet owners and drivers are willing to pay a premium for hybrid trucks because they are clean, quiet, and low-maintenance. However, production volumes are low in this fledgling market and incremental costs for hybrid trucks are currently as much as 50% or more. Despite the many advantages of hybrid trucks, a 50% price premium is more than most fleet owners are able or willing to spend. In the words of John Formisano, Vice President of Global Vehicles for FedEx Express (an early adopter of hybrid truck technology),

> **"If we can get hybrid trucks at the same premium that hybrid cars are at … the manufacturers will be able to sell as many as they can make."**
>
> ***– John Formisano,*[39]**
> ***FedEx Express***

THE ECONOMICS OF INVESTMENT IN CLEAN TRANSPORTATION

Traditional market barriers and economic realities pose problems for the development of the clean transportation technology industry. From a public policy perspective, the level of investment in technology research, development, demonstration, and deployment (RDD&D) is too low, particularly in the clean technology space. The current financial crisis and lack of capital for investment exacerbates the problem. Furthermore, the volatile and falling price of oil presents serious challenges for clean transportation companies and investors.

Underinvestment in Technology Development and Deployment

The development and deployment of clean transportation technologies generates significant economic and environmental benefits that are not captured by entrepreneurs and investors. These benefits, in the form of reduced emissions and valuable knowledge, "spill over" to competitors and to society as a whole. As a result, the private sector under-invests in innovation from a societal perspective because the financial returns do not justify the risk and investment. Financing gaps exist at various stages of the innovation process, including basic research and development, technology demonstration, and early implementation. The public sector has a history of involvement in basic research and development, and increased investment in transportation technology R&D can be expected to generate long-term advances and emissions reductions. Many promising technologies and companies have emerged from research conducted at California universities, including Amyris Biotechnologies (U.C. Berkeley) and SuperProtonic (CalTech).

However, the transition from laboratory to market can be very difficult for technologies. During this period, often referred to as the "valley of death," the viability of a new technology must be demonstrated in a commercial setting and the technology must move toward implementation at commercial scale. These steps are both risky and resource-intensive. Commercial demonstrations of vehicles or fuel production facilities require enormous sums of risk capital, which is increasingly unavailable in today's financial markets. Commercial demonstrations also require consumers who are willing to take a risk on an early stage, unproven technology. The issues are similar as technologies move toward commercial scale production. The first commercial scale production facility for a new biofuel, for example, may be considered too risky for debt financing and too expensive for venture financing. Many technologies tend to stall at this stage of development.

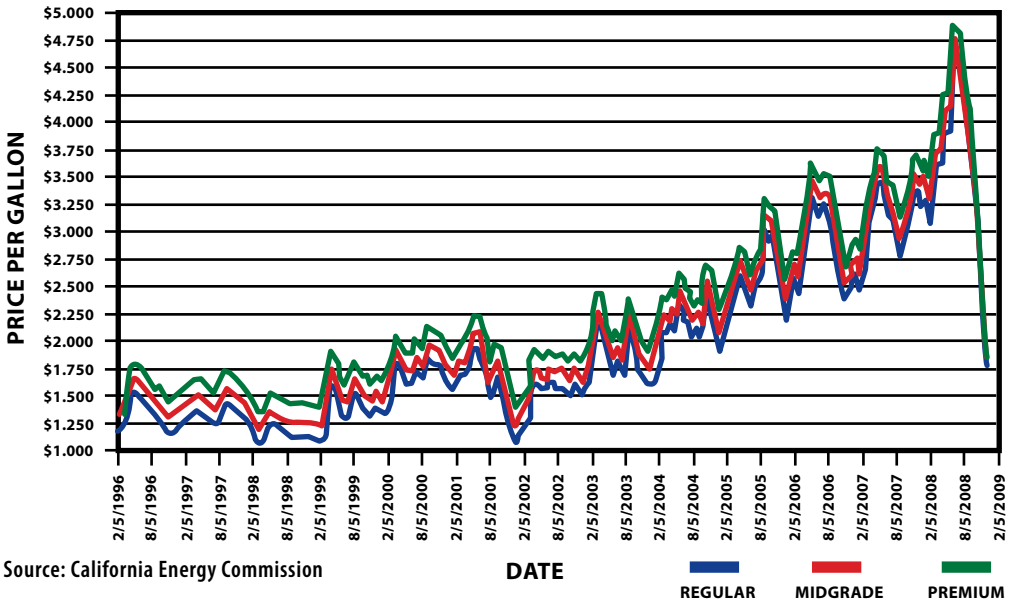
Lack of Available Capital

While financing gaps in the innovation process always exist to some extent, the recent financial crisis has made the situation much worse. Frozen credit markets and a general lack of risk capital hurt start-ups and established companies alike. In the words of V. John White of the Center for Energy Efficiency and Renewable Technology, "Everyone is in shock about what the new world is going to be. Surely, renewable energy projects and new technologies are at risk because of their capital intensity".[40] Tesla Motors recently announced that it was delaying production of its Model S Sedan, closing offices, and laying off workers.[41] This decision was driven in part by the fact that Tesla was having difficulty raising equity capital in the market, and decided instead to wait for low-cost capital with a DOE loan guarantee.[42] GM is delaying the release of an advanced Saturn Vue hybrid to save money in the face of severe problems in the auto industry.[43]

The Impact of Oil Prices

Volatile oil prices are both a reason for and a barrier to investment in clean transportation technologies. Investors in clean transportation technologies must make the case that a given technology can compete with traditional technologies, which are powered by gasoline and diesel. Volatile and unpredictable prices for oil (and therefore gasoline and diesel) make this a very difficult task. Furthermore, prices have plummeted in recent months as a result of the global economic slowdown. (see FIGURE 7 below).

FIGURE 7 California Gasoline Prices 1996 – 2009



Source: California Energy Commission

Technologies and investments that were promising to investors and attractive to consumers with gasoline at $4.00 per gallon do not look as good with prices below $2.00. There is a real danger that low oil prices and a struggling economy will halt the progress being made on the clean transportation front. This has happened before: high oil prices in the 1970's and early 1980's led to increased investment in alternative fuels and clean technologies, but the momentum was lost when prices declined. Without long-term price signals for both investors and consumers, it will be difficult to transition the state toward alternative fuels and cleaner technologies.

Environmental policies sometimes create hurdles or have unintended consequences that can delay the development and deployment of environmentally friendly technologies. Inconsistent, disjointed, or unrealistic policies can be ineffective or counterproductive despite good intentions. The permitting and standards-setting issues discussed earlier are another potential regulatory barrier to clean technology deployment.

Uncertainty and Inconsistency in Policies and Incentives

Investors and businesses need consistent, predictable regulation that provides certainty and price signals over time. While political realities and election cycles often lead to technology incentives with very short lifetimes and to policy environments that are constantly in flux, companies considering capital investments must think in terms of the long-term market viability of their products. They cannot build a business on short-lived subsidies and tax credits, or on unclear and changing technology standards and mandates.

> **"Generally, business is very much in favor of a regulatory environment which is predictable. People don't like a regulatory environment which is on the left one day and on the right the next day, and just flip-flops back and forth, because it doesn't provide a context in which you can make 20- and 30-year investments."** [44]
>
> ***– Paul Willems,***
> ***Vice President, BP***

Need for Greater Coordination and Consideration of Tradeoffs

Although air quality, climate change, and petroleum dependence are closely related problems, many existing and proposed policies address them in a disconnected fashion. Regulatory agencies and departments tend to focus on individual pollutants and policy goals rather than on the big picture. For example, many existing air quality funding programs such as Proposition 1B, AB 2276, and the Carl Moyer program do not place any value on decreasing GHG emissions. A more integrated approach would allow policymakers to take advantage of synergies and support technologies that provide substantial benefits when looking broadly at the state's environmental goals, but might not perform as well when viewed through a narrower lens.

Overly Prescriptive or Idealistic Regulations

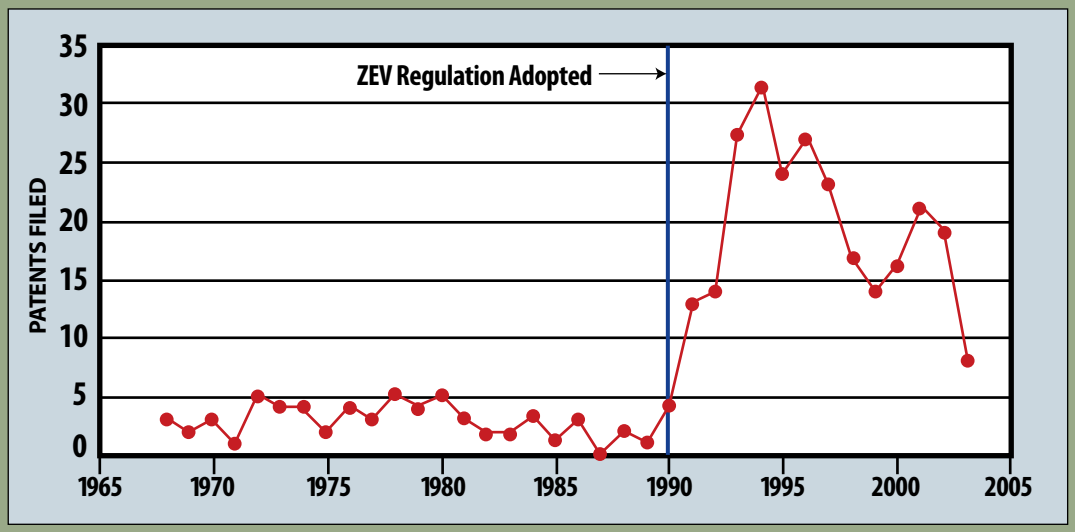
Attempts to further technological development can create barriers if they are overly prescriptive or idealistic. Policies that "pick winners," or focus on a single technology, effectively stifle innovation and create technology losers as well. Such policies are also very risky from a policy perspective, because of the inherent uncertainty in determining which technology is likely to be the "best" to achieve a goal, and how quickly it will develop. California's Zero Emission Vehicle program provides some valuable lessons in the challenge of using technology mandates to drive environmental policy (see "Lessons Learned" Page 24).

Mandates and targets can also create barriers if they are too idealistic and do not take into account market and technology realities. Some well-meaning policies in California have imposed requirements on new technologies and fuels that may end up delaying or preventing deployment. For example, current state law requires that a significant percentage of hydrogen used for transportation come from renewable sources. While this makes sense as an end goal for the technology, it may prove challenging in the short run and could prevent or delay the deployment of hydrogen as a transportation fuel. Policies that account for technology pathways are necessary to encourage deployment and bring more technologies and fuels over the so-called "implementation chasm" and to the market.

The Zero Emission Vehicle Program (ZEV): Lessons Learned

The Zero Emission Vehicle (ZEV) Program was intended to drive the development and deployment of zero emission vehicles in California. The regulations initially led to a significant increase in investment in electric cars (see Figure 8 below). However, delaysand backtracking in the implementation of the regulations eventually acted as both a barrier to investment in the sector and a cautionary tale for investors who based their business plans on regulations that were later delayed or relaxed.

FIGURE 8 Number of Patents Filed for Battery Electric Vehicle-Related Technologies



Patents for battery electric vehicle-related technologies increased drastically with the implementation of the ZEV mandate, then dropped off over time. Source: Public Policy Institute of California

A study by the Public Policy Institute of California found that the problem was that "The program's regulatory goals were tightly tied to this single, very advanced technology—and overestimated how rapidly battery-electric vehicles could become market-ready. When the technology failed to live up to performance or cost expectations, the state made major changes to the program. This sent uncertain demand signals to business—potentially slowing industry innovation.[45] Though the regulation may well have played an important role in jump-starting the hybrid vehicle industry, the anticipated emergence of zero-emission cars was not realized.

CALIFORNIA'S ABILITY TO ATTRACT AND RETAIN BUSINESS

Despite California's track record of innovation and economic growth, the state has a reputation as a difficult place to do business. Operating in California is expensive, and the regulatory barriers are more significant than they are in many neighboring states. Other states and countries, eager to take advantage of technologies and ideas that often originate in California, are aggressively and successfully recruiting businesses to move or expand outside of California.

Challenges of Doing Business in California

California is an expensive place to do business, especially when compared with nearby western states. California has the sixth highest business costs in the country, according to the 2007 Cost-of-Doing Business Index put out by the Milken Institute, a Santa Monica-based economic think tank. The index ranks states on cost of wages, tax burden, electricity, industrial rent, and office rent. This is a slight improvement from 2004, when California ranked third, but it still presents significant challenges from a business development standpoint.[46]

In addition to generally high costs, manufacturing groups and companies point to tax policies in California as one reason why many businesses choose to locate or expand manufacturing facilities outside of California. The report by the state's Economic and Technology Advancement Advisory Committee formed under AB 32 states that "California's corporate income tax apportionment formula imposes a higher tax burden on those hiring and investing within the state's borders.

Imposition of a sales tax on manufacturing equipment installed for in-state use makes capital-intensive expansion in California significantly more expensive than in almost any other state.[47] Indeed, California is one of only three states that taxes manufacturing equipment purchases with no credit or exemption. Manufacturers note that this amounts to "double taxation," because the final product is also taxed, and claim that this single tax policy could potentially drive businesses out of the state. A recently implemented program addresses this issue for manufacturers of zero emissions vehicles, but alternative fuels and other technologies are still subject to sales tax on capital equipment investments.[48]

Environmental regulations and slow bureaucratic processes are often cited by manufacturers as an additional burden of doing business in California.[49] While the protections provided by California's proactive environmental policies are necessary and important, it may be possible in some cases to minimize costly delays while still protecting the health of the state's residents and environment.

Actively Competing With Other States and Countries

California is a target for other states and countries looking to recruit innovative and successful businesses. Many of these states and countries are making a very concerted effort and successfully convincing California companies to relocate or expand outside the state. This is not a new thing, but experts say the recruitment intensifies when California is experiencing political and financial troubles.[50]

California has lost 440,000 manufacturing jobs since January 2001.[51] Anecdotal evidence suggests that the efforts made by other states and countries to lure companies away are contributing to this loss of jobs. In addition to lower overall costs, other states are offering lucrative incentives that target the clean technology sector as a whole. They are also being proactive in targeting specific companies. States like New Mexico, Arizona, and Massachusetts are actively pursuing companies and dedicating resources to working with them, offering things like fast tracked permitting and assistance with plant location. California, by comparison, is seen by many as being more expensive, slower and more bureaucratic, and less willing and able to really "go the extra mile" to attract and retain business.[52]

Other States "Starting to Eat California's Lunch"

Joel Makower, founder of cleantech research and publishing firm Clean Edge, recently remarked that other states are "starting to eat California's lunch" when it comes to attracting and retaining clean technology companies.[53] This trend is not new. In August of 2003, during the last budget crisis and recall election, the Sacramento Bee ran an article entitled "Other States Set Bait to Lure California Companies Amid State's Budget Crisis." The article outlined some of the aggressive advertising and recruiting aimed at California companies. A corporate redevelopment consultant in New Jersey was quoted saying that "it's open season on California. There are war chests that have been accumulated. Economic development warchests."[54]

Now, five years later, California is in the middle of another crisis and many in the industry believe the state is in danger of losing its dominance in the clean technology field as companies are lured away. At a recent cleantech event, venture investor Vinod Khosla warned that high costs and slow permitting processes were threatening to drive many advanced biofuels companies out of California. An economic development officer for a large Bay Area company echoed these concerns, noting that "Oregon and New Mexico, in particular, have been offering companies great incentives. Employers are streaming out, being driven by high energy costs and taxes. California really needs to figure out how to incent cleantech companies to remain here."[55]

At one time, California had a Technology, Trade, and Commerce Agency that oversaw business development initiatives. The agency was eliminated during the budgetary problems of 2003-2004 because of issues with its performance and leadership. Some of its functions were transferred to various other state agencies, with California Business Investment Services (CalBIS) taking on many of the business development and facilitation responsibilities. While CalBIS is effective at responding to inquiries, California lacks a proactive and coordinated marketing and recruitment strategy for clean transportation and other valuable sectors. Labor and Workforce Development Agency spokesman Paul Feist told Sustainable Industries in a recent interview that, while the state is constantly working to improve the business climate for biotech and life sciences, there has not yet been a focus on cleantech as a category.[56]

6) POLICY RECOMMENDATIONS

California policymakers can play an important role in growing the clean transportation technology industry and capturing the related economic and environmental benefits. The recommendations presented here are based on a review of the literature and input from industry stakeholders. While some elements and examples are specific to certain technologies, the recommendations fall into general categories that apply across technology areas. First of all, the state should take an integrated, comprehensive, results-oriented, and ambitious but realistic approach to policymaking. Second, it is important to establish a favorable business climate by creating stable and predictable price and regulatory signals, and by reducing bureaucratic delays. Third, the state should use public funds to minimize market barriers for new technologies. Finally, California should be more proactive in seeking to attract and retain clean transportation technology companies. Encouraging the growth of this industry and the spread of these technologies can help the state meet its economic and environmental goals.

TAKE AN INTEGRATED AND COMPREHENSIVE APPROACH TO POLICYMAKING

The related problems of air quality degradation, climate change, and petroleum dependence require an integrated and comprehensive approach. The focus should be on synergies and solutions that achieve multiple benefits. Focusing exclusively on one problem or desired result is inefficient and could lead to unintended consequences. State policymakers should:

Create incentive programs and regulations that explicitly consider air quality, climate change, and petroleum reduction with the goal of increasing efficiency and taking advantage of synergies. Existing air quality funding programs such as Proposition 1B, AB 2276, and the Carl Moyer program do not place any value on decreasing GHG emissions. New incentive programs for reducing GHG's are likely to overlap with these programs and coordination is essential.

Encourage greater coordination and cooperation among state agencies so as to increase efficiency and better address the state's closely related emissions and petroleum dependence problems.

Consider looking at net benefits when analyzing and choosing between technology and policy options. Economic and environmental tradeoffs are inevitable, and a more integrated approach to policymaking would allow for consideration of all relevant costs and benefits.

FOCUS ON END RESULTS AND TECHNOLOGY PATHWAYS

In order to be effective in driving technological development and deployment, policymakers should take a balanced approach that is at once ambitious, pragmatic, and flexible. The focus should be on end results and strong but realistic targets and schedules. Policies that are overly prescriptive or aggressive are not likely to be successful. Specifically, technology policy should:

Remain technology neutral to the extent possible. Policymakers should avoid "picking winners," and focus instead on end results. It is important to recognize that technologies are not mutually exclusive, and there are many potential solutions for a given problem. Taking a technology neutral approach encourages innovation and allows the state to hedge its bets. This added flexibility should result in novel solutions and specialized technologies tailored to specific needs and situations.

Consider the realities of the market, technology advancement, and data requirements when setting targets and standards. Policies that get too far ahead of the market and the development of technology often require revision and result in mixed signals for consumers and investors. Similarly, certification processes that require data that is not yet available for new technologies may result in delayed deployment and commercialization. Policymakers should consider the realities of technology pathways and data constraints when setting standards and targets. It is important not to let the desire for perfection stand in the way of beneficial technologies and policies that can act as valuable interim solutions.

CREATE STABLE, LONG-TERM PRICE AND REGULATORY SIGNALS

Because conventional technologies start out with competitive advantages in terms of upfront costs and existing infrastructure, the early success of clean alternatives depends in part on various regulations and incentives. Stable, long-term price and regulatory signals are essential for the development and deployment of clean transportation technologies. Companies and investors require stable incentives and regulatory signals to make the business case for developing new technologies, while consumers require long-term signals to permanently change their behavior. Short-term subsidies and overly flexible or short-lived regulations do not provide the certainty necessary to justify large scale investments. Similarly, short-term incentives are unlikely to produce lasting change in consumer behavior. Specific recommendations include the following:

Move forward with timely and effective implementation of key policies such as AB 32 and the Low-Carbon Fuel Standard (LCFS). It is vitally important that these programs and regulations proceed on schedule and without major modifications or backsliding on key provisions. Consistent, predictable, and ambitious policies are needed to drive behavior changes, investment, and innovation. State leaders should be working to send consistent and strong messages to industry about their intent to follow through on the timely implementation of these critical measures.

Consider implementing a transportation fuel surcharge to create a price floor for oil and provide clear long-term price signals for both investors and consumers. The resulting increase in gasoline and diesel prices would be a very effective and direct way to encourage reductions

Higher Gas Taxes: a "win, win, win, win, win"

While the virtues of a higher gas tax are clear and substantial, raising taxes remains difficult and unattractive from a political standpoint. Support for the idea is growing, however, and creative proposals are coming from both ends of the political spectrum. Johns Hopkins author and foreign policy specialist Michael Mandelbaum was quoted in a recent Thomas Friedman editorial stating that a gasoline tax "is not just a win-win, it's a win, win, win, win, win."[57]

- The California Secure Transportation Energy Partnership (CalSTEP), a blue ribbon commission formed to provide guidance on transportation energy policy for California, recommended a steadily increasing price floor on gasoline, with revenues returned to consumers through rebates or tax reductions. The proposal, called Energy Security Tax Relief and Realignment (ESTRR) is detailed in the 2007 CalSTEP Action Plan.[58]
- UC Berkeley Business and Public Policy Professor Severin Borenstein has called for for a Fuel Price Stabilization Program at the state level that would consist of a variable surcharge, with revenues used to address the state budget deficit.[59]
- Conservative columnist Charles Krauthammer published a recent editorial in the Weekly Standard calling for a "net-zero" gas tax of at least one additional dollar per gallon at the federal level, offset by a reduction in the payroll tax. Speaking about the environmental benefits of such a tax, Krauthammer says, "If you want to shift to fuel-efficient cars, don't mandate, don't scold, don't appeal to the better angels of our nature. Find the price point, reach it with a tax, and let the market do the rest."[60]
- Harvard economists Robert Lawrence and N. Gregory Mankiw, both former members of the Presidents Council of Economic Advisers (Lawrence under President Bill Clinton and Mankiw under President George W. Bush), have both recommended higher gas taxes. Lawrence proposed a variable tax that would create a gasoline price floor somewhere around $4-5 as an important step toward driving demand for cleaner vehicles.[61] Mankiw supports a one dollar increase in the gas tax, gradually phased in over a ten year period.[62] Mankiw's blog includes a growing list of distinguished economists and other experts, both conservative and liberal, who support higher Pigovian taxes, including higher gas taxes.[63]

in vehicle miles traveled in the short term. Over the longer term, the higher expected prices would drive investment in and demand for clean and efficient transportation technologies. Unlike many other policies and incentives designed to achieve these same goals, this option would avoid market distortions and could be implemented without significant government expenditures. The surcharge could be administered as a flat per-gallon tax, or as a variable fee designed to create a price floor for fuels derived from oil.

Create long-term schedules and targets for legislative and regulatory initiatives such as AB 32. More information about both the end goal and the schedule for getting there will allow companies and investors to make long-term investment decisions.

Provide stable, long-term production and purchase incentives when necessary and appropriate from a technology-advancement standpoint. Long-term financial incentives are necessary to provide the certainty that companies need for capital investments and technology development.

MINIMIZE BUREAUCRATIC AND REGULATORY DELAYS IN THE TRANSITION PERIOD

Bureaucratic and regulatory delays can act as a hurdle to technology deployment and commercialization. Policymakers should recognize clean transportation as a priority and actively work to address these delays and facilitate deployment, without relaxing important environmental protections. The following actions should accelerate technology deployment and make California a more attractive place to do business:

Put a high priority on creating standards and certification processes for new fuels and transportation technologies. These processes should be fast-tracked whenever possible, and the state should consider using public money to complete the necessary testing.

Consider the creation of simplified interim processes for new technologies to facilitate early deployment while more robust standards-setting, testing, and certification processes are underway. Many new vehicles and other technologies lack the testing and performance data necessary for precise emissions certifications. The lack of certified emissions reductions acts as a barrier to public funding and deployment, despite the potential environmental benefits. Some sort of interim certification process could help get these technologies through the transition period. Such a process might be imprecise in the short term, but given the relatively low production and sales volumes at this stage, the problem would be small and the costs would be outweighed by the benefits.

ADDRESS MARKET BARRIERS THROUGH STRATEGIC PUBLIC INVESTMENT

The targeted and strategic use of public funds can both accelerate the deployment of clean transportation technologies and make California a more attractive place to do business. In the process, this investment should generate significant environmental and economic benefits for the state. Public investment in transportation technologies may seem difficult given the state's current financial situation, but there are significant existing and potential revenue sources that are intended for such uses. For example, AB 118, the California Alternative and Renewable Fuel, Vehicle Technology, Clean Air, and Carbon Reduction Act of 2007, provides approximately $200 million annually through 2015 for three new programs to fund air quality improvement projects and develop and deploy technology and alternative and renewable fuels. While this is a significant amount of money, climate change[64] regulations could provide an even larger source of funds for targeted investment. The recently released AB 32 Scoping Plan calls for an auction of emissions allowances under a state cap and trade program, which should generate hundreds of millions to billions of dollars in revenue. Furthermore, the plan states that these revenues should be used to "further the policy objectives of California's climate change program." The following recommendations should generate in-state air quality, climate change, petroleum reduction, and economic development benefits:

Invest revenues from AB 32 regulations in clean transportation technologies. The transportation sector is the largest single source of GHG emissions in the state, and contributes to air quality problems as well. Targeted investment of allowance auction revenues in this sector could help achieve the goals of AB 32 and improve California's competitive position in an important and growing clean transportation technology industry.

Increase and accelerate AB 118 funding for clean transportation to maximize its impact and leverage private investment. AB 118 provides a significant and important source of funds for driving clean transportation technology deployment and reducing harmful emissions. Policymakers should fully fund this program and accelerate the investment of funds. Given the state's current financial situation, there may be some pressure to use AB 118 funds to help address the budget deficit. This would be a mistake, as this program represents an investment in the state's economic and environmental well-being.

Focus on deployment and results as well as R&D and workforce training. Public investment can also play a valuable role in addressing barriers to technology development and commercialization. Stakeholders in the AB 118 process have emphasized a need for spending on deployment, which should have positive effects on the state's environment and economy in the near to medium term.[65] The following would be productive uses of public funds:

- Expanding the refueling infrastructure for alternative fuels
- Creating demand through purchase incentives or state purchasing
- Financing technology demonstrations and pilot plants
- Providing funding and assistance for testing and certifications

Act as an early adopter of new transportation technologies. The state can help create early demand for new technologies while demonstrating their viability in a real world setting. This is extremely valuable from the standpoint of investment and business plan development for technology companies, and also presents an opportunity for California to be a leader and "walk the walk."

BE MORE PROACTIVE IN ATTRACTING AND RETAINING BUSINESS

California needs a dedicated, coordinated, and proactive plan to recruit and retain businesses. California's "innovation infrastructure" makes it a very good place to found a company or develop a technology, and the state has made some efforts to attract and retain business. For example, Enterprise Zones provide business development incentives for targeted areas, and California Business Investment Services (CalBIS) interacts with companies to facilitate expansion or location within the state. However, California continues to struggle somewhat with retaining companies in general and manufacturing operations in particular. The state's efforts are more focused on responding to inquiries than on actively recruiting. Furthermore, interacting with California is seen as a complicated and time-consuming process that does not appeal to busy entrepreneurs trying to decide where to site a plant. The following recommendations would help California encourage both research and manufacturing facilities in-state.

Create a "one-stop shop" with adequate resources to coordinate the state's business development efforts. California needs a dedicated staff with adequate time and resources to compete with other states and countries for business attraction and retention. CalBIS has a staff of four to handle inquiries, coordination, and interaction with companies and state agencies. With more resources, an agency such as CalBIS could more effectively coordinate business development efforts, encourage companies to locate in the state, and act as liaison to regulatory agencies and local government offices.

Increase targeted marketing and outreach efforts. There are many reasons why cleantech businesses should want to locate in California, including the state's "innovation infrastructure," proactive public policies, large local markets, an educated workforce, and proximity to leading research institutions. However, in an increasingly global and competitive market, the state cannot take its position as a cleantech leader for granted. Targeted and proactive marketing and outreach efforts at the state level should help attract business.

Be more creative with assistance for the clean transportation technology sector. The state of California may not have the ability or the desire to offer financial incentives on the level of those offered by neighboring states or by cities such as San Jose, but the state can offer other valuable forms of assistance. For example, fast-tracked permitting for specific companies or technologies could make California a more attractive place to do business. California could also potentially play a role in coalition building and coordination of feedstock or off-take agreements for biofuels companies.

Consider some form of tax break for in-state manufacturing in targeted sectors. California is one of only three states in the country that taxes manufacturing equipment purchases. This creates an incentive for companies to locate their manufacturing facilities outside of the state. While the state may not currently be in a position to reduce taxes, proponents of a sales tax exemption on manufacturing equipment claim that it would create jobs as well as additional tax revenues in a relatively short timeframe. Governor Schwarzenegger, the State Treasurer, and the California Alternative Energy and Advanced Transportation Financing Authority (CAEATFA) have already recognized and addressed this issue for some of the industry by creating a program that waives the sales tax on investment in new manufacturing equipment for Zero Emission Vehicles (ZEVs), and this program was instrumental in bringing Tesla's manufacturing facility to California.[66] A similar program could benefit biofuels producers or others in the clean transportation technology industry.[67]

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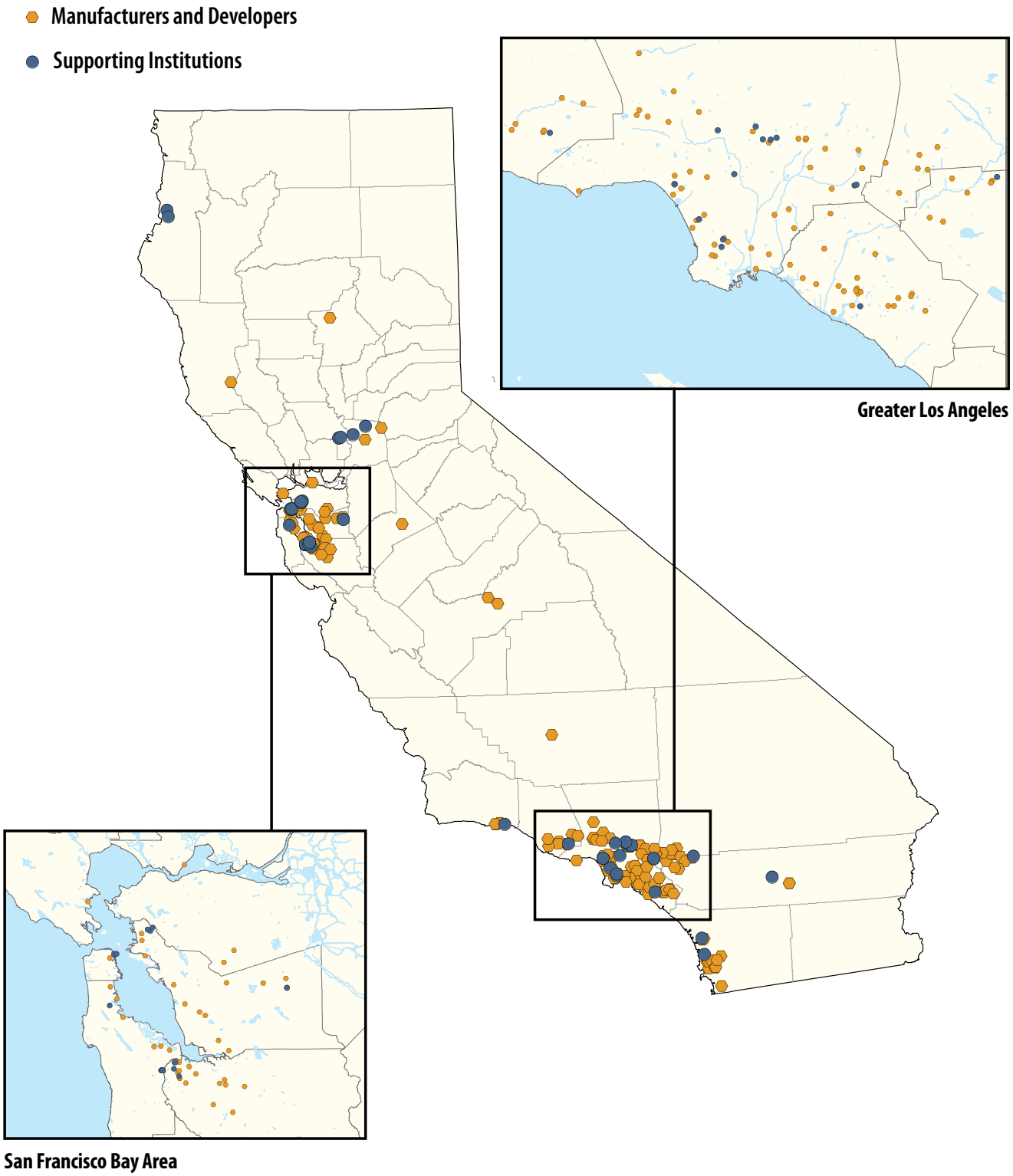
APPENDIX A

CALIFORNIA CLEAN TRANSPORTATION TECHNOLOGY INDUSTRY



APPENDIX B

CLEAN TRANSPORTATION TECHNOLOGY ORGANIZATIONS OPERATING IN CALIFORNIA

CALSTART identified 195 clean transportation technology manufacturers, developers, and supporting institutions operating in California. The following list divides these companies into categories based on technology and organization type.

ADVANCED PROPULSION SYSTEMS

AC Propulsion 441 Borrego Court San Dimas, CA 91773 www.acpropulsion.com	Manufactures electric vehicle propulsion systems. Designs and engineers motors, inverters, chargers, battery systems and complete vehicles, and conducts R&D programs in electric and hybrid vehicle development, battery testing and hybrid power unit development.
AeroVironment 181 W. Huntington Dr., Suite 202 Monrovia, CA 91016 www.aerovironment.com	Develops and manufactures electric and hybrid electric vehicle systems, including power processing systems, fast chargers and stations, battery management systems and integrated drivetrain development.
Agile Turbine Technology 3020 Highland Ave. Manhattan Beach, CA 90266	Developing advanced gas turbines that offer higher efficiencies than comparable diesel engines over the full operating range and have faster response to a load change.
Asia Pacific Fuel Cell Technologies 7217 E. Dapple Circle Orange, CA 92869 www.apfct.com	Designs and manufactures PEM fuel cell stacks and storage and distribution systems for various mobile applications.
CalNetix 12880 Moore St. Cerritos, CA 90703 www.calnetix.com	Designs and manufactures high speed, high performance motors and generators for turbocompressors, energy storage flywheels, microturbines, expanders, laser systems, medical applications and other industrial applications.
Capstone Turbine 21211 Nordhoff St. Chatsworth, CA 91311 www.capstoneturbine.com	Manufactures low-emission, compact microturbine systems for hybrid vehicle and other applications.
DTI Energy 5325 Venice Blvd. Los Angeles, CA 90019 www.dtienergy.com	Has worldwide licensing rights to patented Direct Methanol Fuel Cell technology that can be used in vehicle applications.
Energy Control Systems Engineering (EnergyCS) 715 S. Myrtle Monrovia, CA 91016 www.energycs.com	Provides consulting, design and prototyping services for system integration and monitoring of electrochemical energy systems such as batteries and fuel cells, focusing on EV/HEV transportation and alternative energy. Delivered the first Toyota Prius retrofitted with plug-in hybrid technology to the South Coast AQMD.
Efficient Drivetrains (EDI) 319 Ramona St. Palo Alto, CA 94301	Works with car and truck OEM, conversion and first tier suppliers to embed innovative drivetrain system designs, components and technologies to deliver advancements in fuel economy, reductions in vehicle cost and overall vehicle performance in hybrid, electric and plug-in hybrid electric vehicles (PHEVs).

Enova Systems 19850 S. Magellan Dr. Torrance, CA 90502 www.enovasystems.com	Manufactures electric, hybrid electric and fuel cell drive systems for trucks and buses.
Fallbrook Technologies 9444 Waples St., Suite 410 San Diego, CA 92121 www.fallbrooktech.com	Revolutionary drivetrain technology using a traction-based transmission – a continuously variable planetary drive based on spheres instead of gears. Primarily used by bicycle and light electric vehicle makers.
Honeywell Turbo Technologies 23326 Hawthorne Blvd., Suite 200 Torrance, CA 90505 www.honeywell.com/sites/ts/tt	Manufactures turbochargers and conducts R&D on CO remediation in an automotive PEM fuel cell power plant, a turbocompressor for PEM fuel cells, and renewable energy technology to convert vegetable and algal oils to military jet fuels.
Intelligent Energy 2955 Redondo Ave. Long Beach, CA 90806 www.intelligent-energy.com	International fuel cell power systems company focusing on hydrogen generation, fuel storage and power generation.
ISE Corporation 12302 Kerran St. Poway, CA 92064 www.isecorp.com	Supplier of integrated hybrid-electric drive systems and control software for large buses and trucks.
Oorja Protonics 40923 Encyclodpedia Circle Fremont, CA 94538 http://www.oorjaprotonics.com	Designs and manufactures powerful and advanced direct methanol fuel cells that provide battery charging for forklifts, pallet loaders, automated guided vehicles and other material handling equipment.
Parker Hannifin / Racor Division 3400 Finch Rd. Modesto, CA 95354 www.parker.com/racor	Developing advanced fuel cell components and products. World leader in hydraulic systems that have applications to hydraulic hybrids.
Polyfuel 1245 Terra Bella Ave. Mountain View, CA 94043 www.polyfuel.com	Developer and manufacturer of engineered hydrocarbon-based membranes that provide clean, long-running and cost-effective power for both portable direct methanol fuel cells and automotive hydrogen fuel cells.
Powerzinc Electric 17800 Castleton St., Suite 435 City of Industry, CA 91748 www.powerzinc.com	Research, development and manufacturing of zinc air fuel cells for electric vehicle propulsion; establishing fuel cell refuel service platforms.
Quantum Technologies 17872 Cartwright Road Irvine, CA 91324 http://www.qtww.com/	Major Tier 1 supplier of clean vehicle technologies, including hybrid electric vehicles and propulsion systems, natural gas vehicles and engines, hydrogen systems, propane vehicles and engines, and engineering, integration, and aftermarket services.
Soligen Technologies 19408 Londelius St. Northridge, CA 91324 www.soligen.com	Produces complex cast metal prototypes for automotive powertrain applications.
Symyx Technologies 3100 Central Expressway Santa Clara, CA 95051 www.symyx.com	Works to discover and optimize advanced materials that enable emissions reduction, the development of next-generation fuel cells, fuel processing and polymers.

Wesgo Metals (Morgan PLC) 2425 Whipple Rd. Hayward, CA 94544 www.wesgometals.com	Manufactures and supplies noble and non-precious metals and alloys for the automotive and other markets.

ALTERNATIVE FUELS, FUEL INFRASTRUCTURE, AND ADDITIVES

AltraBiofuels 11911 San Vicente Blvd., Suite 325 Los Angeles, CA 90049 www.altrabiofuels.com	Develops, licenses, acquires and produces biofuels technologies. Operationalizing technologies in cellulosic ethanol and phasing cogeneration technology into its plants; also aggressively evaluating technologies in algaculture and thermal depolymerization.
Air Products 1969 Palomar Oaks Way Carlsbad, CA 92009 http://www.airproducts.com	Supplier of hydrogen for transportation fuels.
Amyris Biotechnologies 5980 Horton St., Suite 450 Emeryville, CA 94608 www.amyrisbiotech.com	Leveraging breakthroughs in synthetic biology to provide a consistent, cost-effective supply of biofuels and other high-value natural compounds, including gasoline and diesel substitutes that are fully compatible with existing cars and petroleum infrastructure.
Better Place 1070 Arastradero Road, Suite 220 Palo Alto, CA 94304 http://www.betterplace.com/	Working to develop an electric car network using charging spots and interchangeable batteries.
Biodiesel Industries 435½ El Sueno Rd. Santa Barbara, CA 93110 http://www.biodieselindustries.com/	Produces and develops biodiesel production facilities in the U.S. Holds a patent for a modular, multi-feedstock processing unit.
Bioenergy Solutions 200 New Stine Rd., Suite 220 Bakersfield, CA 93309 www.bioensol.com	Provides the infrastructure necessary to create renewable natural gas from animal waste, then shares the revenues from the sale of gas and carbon credits with the farmer or food processor.
Bio-Friendly Fuel Partners 4115 Blackhawk Plaza Circle Danville, CA 94506	Develops biofuel manufacturing facilities and produces biodiesel.
Biotane Fuels 86-600 Avenue 54 Coachella, CA 92236 www.biotanefuels.com	Utilizes renewable agricultural resources and recyclable waste cooking oils for the production of its Biotane biodiesel fuel.
BlueFire Ethanol 31 Musick Irvine, CA 92618 www.bluefireethanol.com	Uses the Arkenol patented process for cellulose-to-ethanol conversion, derived from wood wastes, urban trash, rice/wheat straws and other agricultural residues, to develop and operate high-value carbohydrate-based transportation fuel production facilities/biorefineries.
Carbon Sequestration 306 Brightstone Circle Folsom, CA 95630 www.carbonsequestrationllc.com	Provides solutions to the recovery of energy from bio-solids and organic wastes (biomass).

Ceres 1535 Rancho Conejo Blvd. Thousand Oaks, CA 91320 www.ceres-inc.com	Plant biotechnology company utilizing cutting-edge genomics technologies to deliver sustainable solutions in energy production (specifically, ethanol derived from cellulosic biomass) and other areas.
Cilion P.O. Box 819 Goshen, CA 93227 www.cilion.com	Producer and distributer of low cost, environmentally sustainable biofuels. Cilion's ethanol plants are strategically located near large population and livestock market areas.
Clean Energy 3020 Old Ranch Pkwy, Suite 200 Seal Beach, CA 90740 www.cleanenergyfuels.com	Largest provider of vehicular natural gas (CNG and LNG) in North America with a broad customer base in the refuse, transit, shuttle, taxi, police, trucking, airport/municipal fleet markets. Also designs, builds and operates natural gas fueling stations.
Clean Fuel Connection 127 La Porte Ave., Unit M Arcadia, CA 91006 www.cleanfuelconnection.com	Provides infrastructure for zero and low emission vehicles, including natural gas-powered vehicles; installs electric vehicle chargers and photovoltaic systems.
Cobalt Biofuels 6110 Bollinger Rd. San Jose, CA. 95129 www.cobaltbiofuels.com	Developing advanced methods of producing biofuels via the bacterial fermentation of renewable plant materials.
Codexis 200 Penobscot Drive Redwood City, CA 94063	Developing next-generation biofuels from non-food feedstocks using a biocatalytic approach
Cryogenic Experts 531 Sandy Circle Oxnard, CA 93036 www.cexi.com	Builds cryogenic vaporizers for the industrial gas marketplace for most gases and liquids, including hydrogen.
FST Energy 601 Van Ness Ave., Suite E3613 San Francisco, CA 94102 www.fstenergy.com	Sells systems for storing and transporting solid-state energy; developed hydrogen compression and distribution technology.
Gas Reaction Technologies (GRT) 861 Ward Drive Santa Barbara, CA 93111 http://grt-inc.com/	Develops and commercializes new fuel production and chemical processes based on its core technology in halogen (Bromine) based hydrocarbon activation and conversion, and halogen recovery and recycle.
Genencor 925 Page Mill Rd. Palo Alto, CA 94304 www.genencor.com	R&D location of major biotechnology company developing products that provide sustainable, renewable fuel sources, including producing cellulosic ethanol fuel from agricultural and forestry by products.
General Atomics 3550 General Atomics Ct. San Diego, CA 92121 www.ga.com	Harnessing the power of nuclear technologies to develop high-technology systems for various areas, including advanced electric technologies and power systems to produce hydrogen using hydrothermal processing.
Golden Cheese Company 1138 W. Rincon St. Corona, CA 92880 http://ourworld.compuserve.com/homepages/gccc/	Cheese and whey processing facility that produces ethyl alcohol for fuel additives from fermented residual milk sugar.

Greenline Industries 24 Tiburon St. San Rafael, CA 94901 www.greenlineindustries.com	Develops, fabricates and produces groundbreaking technology in biodiesel production equipment employing waterless technology.
Green Star Products 858 Third Ave., Suite 455 Chula Vista, CA 91911 www.greenstarusa.com	Manufactures lubricant and anti-friction metal treatments; developing greenhouse gas reducing, power improvement and emission reduction technologies for internal combustion engines and hybrid electric drive systems.
HBS BioEnergy 1127 Harker Ave. Palo Alto, CA 94301 http://www.humanbiosystems.com/hbs_bio_energy.htm	Early stage biofuels company that plans to produce renewable fuel sources for the U.S. market.
Harvest Energy Technology 9253 Glenoaks Blvd. Sun Valley, CA 91352 www.harvest-technology.com	Develops energy technologies for licensing through collaborative partnerships, specializing in demonstrating new process concepts at the pilot scale. Currently developing hydrogen generators for refueling stations, small industrial markets and PEM fuel cells.
Hydrogenics USA 27201 Tourney Rd., Suite 201J Valencia, CA 91355 www.hydrogenics.com	Develops clean energy solutions, advancing the hydrogen economy by commercializing hydrogen and fuel cell products.
Imperial Western Products 86-600 Avenue 54 Coachella, CA 92236 www.imperialwesternproducts.com	Provides products and services to the livestock feed, biodiesel, industrial and manufacturing industries.
The Linde Group 660 N. Baldwin Park Boulevard City of Industry, CA 91746 http://www.linde.com/hydrogen	Major supplier of hydrogen fuel and refueling infrastructure.
LS9 1300 Industrial Rd., Suite 16 San Carlos, CA 94070 www.ls9.com	Biotechnology company pursuing industrial applications of synthetic biology to produce proprietary biofuels designed to closely resemble petroleum derived fuels, but be renewable, clean, domestically produced and cost competitive.
Lubrizol 30211 Ave De Las Bandera, Suite 200 Rancho Santa Margarita, CA 92688 www.lubrizol.com	Manufactures lubricants and fuel additives that reduce the environmental impacts of its customer products.
Makel Engineering 1585 Marauder St. Chico, CA 95973 www.makelengineering.com	Develops industrial, automotive, military and space grade intelligent sensors and chemical conversion systems. Designs and manufactures hydrocarbon reformers for fuel cells as well as systems for leak detection.
Pacific Ethanol 5711 N. West Ave. Fresno, CA 93711 www.pacificethanol.net	Produces low-carbon ethanol. Also working to identify and develop other renewable fuel technologies, such as cellulose-based ethanol production and bio-diesel.
Parallel Products 12281 Arrow Route Rancho Cucamonga, CA 91739 www.parallelproducts.com	Ethanol production facility developing technologies for the processing of food and beverage wastes that transform by-products into useful resources.

Praxair 2678 Bishop Dr., Suite 118 San Ramon, CA 94583 www.praxair.com	Supplies atmospheric and process and specialty gases (including hydrogen and hydrogen refueling capabilities) and high-performance coatings. San Ramon is location of one of Praxair's sales offices.
Primafuel One World Trade Center, 8th Floor Long Beach, CA 90831 www.primafuel.com	Builds infrastructure, develops technology and advises government and companies on renewable energy projects and solutions. In May 2007, CARB awarded Primafuel with a $640,000 grant towards the construction of a biodiesel production facility at the Port of Sacramento.
Procter and Gamble 8201 Fruitridge Rd. Sacramento, CA 95826 www.pgchemicals.com	Methyl ester production facility, with most ester consumed as either biodiesel or in lubricant and metalworking applications.
Propel 1215 K Street, Suite 1717 Sacramento, CA 95814 http://www.propelfuels.com	Builds, owns, and operates a growing network of clean fueling points.
RIX Industries 4900 Industrial Way Benicia, CA 94510 www.rixindustries.com	Manufactures reciprocating piston compressors for industrial gases (including natural gas and hydrogen) and breathing air, specializing in oil-free technology and high pressures.
RKI Instruments 33248 Central Ave. Union City, CA 94587 www.rkiinstruments.com	Manufactures, services and distributes gas detection units for hydrogen and natural gas that are critical safety equipment for vehicles and refueling stations.
Superprotonic 530 S. Lake Ave., Suite 312 Pasadena, CA 91101 www.superprotonic.com	Developer of advanced fuel cell capable of running on multiple fuels; developing solid acid fuel cell stacks for portable, back-up power, auxiliary power unit and commercial/industrial applications.
Tellurian Biodiesel 228 Main Street, Suite 5 Venice, CA 90291 www.tellurianbiodiesel.com	Biodiesel production, marketing, and distribution company. Emphasis on locally available recycled and second-use feedstocks.
Yokayo Biofuels 150 Perry St. Ukiah, CA 95482 www.ybiofuels.org	Produces and distributes biodiesel.

ELECTRONICS AND POWER ELECTRONICS

BAE Systems 1930 South Vineyard Avenue Ontario, CA 91761 http://www.baesystems.com	Develops hydrogen fuel cell and hybrid electric applications for buses.
BI Technologies 4200 Bonita Pl. Fullerton, CA 92835 www.bitechnologies.com	Manufactures electronic resistive and potentiometer products for automotive applications.

Curtis PMC 235 East Airway Blvd. Livermore, CA 94551 www.curtisinst.com	Produces integrated systems for electric and hybrid electric vehicles, including motor speed control, battery measurement technology, power conversion technology and instrumentation.
DENSO Sales California 3900 Via Oro Ave. Long Beach, CA 90810 www.densocorp-na-dsca.com	First overseas affiliate of DENSO, one of the world's largest automotive suppliers. Product lines include original equipment, aftermarket and remanufactured automotive parts, heavy-duty diesel and electrical components.
Intel 2200 Mission College Blvd. Santa Clara, CA 95054 www.intel.com	Produces semiconductors and microprocessors that can be used in advanced automotive components, including hybrids.
International Rectifier 233 Kansas St. El Segundo, CA 90245 www.irf.com	Manufactures semiconductor components and solutions for the automotive market. The company has sole source contracts in several starter-alternator, electric power steering, advanced cooling and 42-volt electrical systems.
Kyocera America 8611 Balboa Ave. San Diego, CA 92123 http://americas.kyocera.com/kai/semiparts/index.cfm	Producer of ceramic semiconductor packages focusing on producing multilayer ceramic substrates for automotive engine control unit applications.
NEC Electronics 2880 Scott Blvd. Santa Clara, CA 95050 www.am.necel.com	Manufactures and supplies semiconductors used in advanced automotive components, including hybrids, employing its By-Wire Auto Design.
Tri-Circuit America 2105 South Bascom Ave., Suite 336 Campbell, CA 95008 http://www.taihong.com.tw/	Supplies multi-chip module substrates to one of the Big Three automobile manufacturers.
US Hybrid 445 Maple Avenue Torrance, CA 90503 www.ushybrid.com	Specializes in the design and manufacture of integrated power conversion components for electric and hybrid vehicles, as well as renewable energy generation and storage.
ZF Micro Devices 1000 Elwell Ct., Suite 134 Palo Alto, CA 94303 www.zflinux.com	Automotive supplier of circuit boards and semiconductors.

ELECTRIC AND ALTERNATIVE VEHICLE MANUFACTURERS

Aptera 2778 Loker Ave W Carlsbad, CA 92010 www.aptera.com	Engineers radically efficient vehicles through the fusion of advanced aerodynamics and light-weight composite technology. Developing a three-wheeled hybrid vehicle for release in California.
American Custom Golf Cars 15740 El Prado Road Chino, CA 91710 http://www.californiaroadster.com/	Designs and constructs luxury production golf cars / neighborhood electric vehicles (NEVs) that can go up to 70 miles on a single charge.

Balqon Corporation 1701 East Edinger Avenue Santa Ana, CA 92705 http://www.balqon.com/	Designs, develops, and distributes fully electric trucks for commercial and industrial applications.
Fisker Automotive 2811 McGaw Avenue, Suite B Irvine, CA 92614 http://www.fiskerautomotive.com/	Designing and producing a plug-in hybrid luxury performance car.
Ebus 9250 Washburn Road Downey, CA 90242 www.ebus.com	Develops, integrates, and manufactures electric and fuel cell buses.
El Dorado National Coach 9760 Galena Street Riverside, CA 92509 http://www.enconline.com/	Designs and manufactures alternative fueled buses, offering compressed natural gas (CNG), liquefied natural gas (LNG), propane (LPG) and diesel/electric hybrid propulsion systems.
EMC Malibu, CA http://www.electricmotorcorp.com/	EMC designs, packages, produces, and sells electric light-duty pickup trucks. They use existing chassis designs and integrate electric drive systems to produce all-electric models
Gillig 25800 Clawiter Road Hayward, CA 94545 http://www.gillig.com/	Designs and builds heavy-duty transit buses, including hybrid electric buses.
Miles Electric Vehicles 3100 Airport Avenue, Suite A Santa Monica, CA 90405 http://www.milesev.com/	Designs and produces full electric vehicles.
North American Bus Industries (NABI) 3450 East Philadelphia Street Ontario, CA 91761 http://www.nabiusa.com/	Produces advanced technology buses, using clean diesel, hybrid, CNG, and LNG propulsion systems.
Persu Mobility 1801 Century Park East Los Angeles, CA 90067 http://flytheroad.com/	Developing a three-wheeled, tilting, hybrid "Urban Life Vehicle" that gets 75 + MPG.
Phoenix Motorcars 1175 North Del Rio Pl. Ontario, CA 91764 www.phoenixmotorcars.com	Manufactures electric vehicles using the NanoSafe battery, a non-toxic, all-battery solution to eliminate noise and toxic vehicle emissions.
T3 Motion 2990 Airway Avenue Costa Mesa, CA 92626	Manufactures small electric vehicles, primarily for policing applications
Taylor-Dunn 2114 West Ball Road Anaheim, CA http://www.taylor-dunn.com/	Produces commercial and industrial vehicles, many of which have electric propulsion systems.

Tesla Motors 1050 Bing St. San Carlos, CA 94070 www.teslamotors.com	Designs and manufactures high-performance electric vehicles.
Think 2750 Sand Hill Road Menlo Park, CA 94025 http://www.think.no/think	Designs and produces environmentally friendly vehicles, including the fully electric Think city
Wrightspeed 1400 Rollins Rd., Suite B Burlingame, CA 94010 www.wrightspeed.com	Manufactures electric vehicles.

ENERGY STORAGE DEVICES

Applied Intellectual Capital 2450 Mariner Square Loop Alameda, CA 94501 http://www.apicap.com/	Engineers radically efficient vehicles through the fusion of advanced aerodynamics and light-weight composite technology. Developing a three-wheeled hybrid vehicle for release in California.
AFS Trinity Power 6724 Preston Ave., Suite D Livermore, CA 94551 www.afstrinity.com	Developing advanced energy storage systems for hybrid and plug-in hybrid vehicles, power quality and aerospace applications.
Hydrospin 5281 Research Dr. Huntington Beach, CA 92649 www.hydrospin.com	Manufactures steel and aluminum pressure vessels for use in the high-pressure composite cylinder market, including designing seamless aluminum liners for CNG fuel tanks.
Luxfer Gas Cylinder 3016 Kansas Ave. Riverside, CA 92507 www.luxfercylinders.com	Development, production and supply of seamless, extruded aluminum and composite high-pressure cylinders for the storage of gases, including CNG..
Maxwell Technologies 9244 Balboa Ave. San Diego, CA 92123 www.maxwell.com	Manufactures ultracapacitors for electric and hybrid-electric vehicles.
Pentadyne Power 20750 Lassen St. Chatsworth, CA 91311 www.pentadyne.com	Designs, manufactures and markets advanced flywheel power systems that provide ride-through power and voltage stabilization for power quality and power recycling applications.
PolyPlus Battery 2608 Ninth St. Berkeley, CA 94710 www.polyplus.com	Developing next generation lithium metal battery chemistry for applications, including electric and hybrid-electric vehicles.
Quallion 12744 San Fernando Rd. Sylmar, CA 91342 www.quallion.com	Provides lithium ion battery solutions for the HEV, EV and PHEV markets using small commercial grade lithium ion cells linked in a two-dimensional matrix configuration providing autonomous current distribution control, safety and reliability.

Structural Composites 325 Enterprise Pl. Pomona, CA 91768 www.scicomposites.com	Designs and manufactures lightweight, aluminum-lined, composite-wrapped, high-pressure cylinders, including alternative fuel tanks.
Trojan Battery Company 12380 Clark St. Santa Fe Springs, CA 90670 www.trojanbattery.com	Develops deep cycle batteries for recreational and industrial applications, such as recreational vehicles and renewable energy.
U.S. Battery Manufacturing Company 1675 Sampson Ave. Corona, CA 92879 www.usbattery.com	Manufactures and develops deep cycle batteries for various special use vehicles and other applications.

ENGINE, COMBUSTION, AFTERTREATMENT, AND ALTERNATIVE FUEL SYSTEMS

Achates Power 4060 Sorrento Valley Boulevard San Diego, CA 92121 http://achatespower.com	Developing a light and fuel efficient clean diesel engine.
Amulaire Thermal Technology 11555 Sorrento Valley Rd., Suite 201 San Diego, CA 92121 www.amulaire.com	Offers heat dissipation products that solve customers' thermal challenges, including liquid-cooled cold plates for motor drives in hybrid electric cars.
BASF Catalysts / Engelhard 46820 Fremont Blvd. Fremont, CA 94538 http://www.catalysts.basf.com/main	Manipulates basic materials for diverse applications, including development and commercialization of advanced emissions catalysts for both gasoline and diesel powered vehicles and fuel cells.
BAYTECH P.O. Box 1148 Los Altos, CA 94023 http://www.baytechcorp.com/	Designs EPA and CARB certified LEV, ULEV and SULEV low-emission CNG and propane systems for General Motors vehicles and engines. Also conducts hydrogen vehicle research.
BSST 5462 Irwindale Ave. Irwindale, CA 91706 www.bsst.com	Develops high efficiency solid-state temperature control solutions for the automotive industry.
Catalytic Solutions 1640 Fiske Pl. Oxnard, CA 93033 www.catalyticsolutions.com	Creation, manufacture and supply of unique high-performance catalysts for motor vehicle (gasoline and diesel engines), energy applications (gas turbines, boilers, gensets) and petrochemical and refinery applications.
Cleaire 14775 Wicks Blvd. San Leandro, CA 94577 www.cleaire.com	Designs, develops and manufactures retrofit emission control systems for today's existing diesel engines; offers assistance in understanding the complexities of regulations and incentives, and provides grants and financing programs.
Clean-Tech 11160 Hindry Ave. Los Angeles, CA 90045 www.clean-tech.com	Automotive systems integrator that develops, builds and commercializes advanced low- and zero-emission vehicle powertrain systems for installation into auto manufacturer or purpose-built chassis; retrofits auto manufacturer internal combustion engines with compressed natural gas fuel systems.

Clean Air Power 5131 Santa Fe St. San Diego, CA 92109 www.cleanairpower.com	Manufactures dual fuel engines, which operate primarily on natural gas, and other vehicle components.
Complete Coach Works 1863 Service Court Riverside, CA 92507 http://www.completecoach.com/	Retrofits buses and trucks with catalytic converters, alternative fuel engine conversions, and hybrid conversions.
EDrive Systems 715 S. Myrtle Monrovia, CA 91016 www.edrivesystems.com	Manufactures and markets Energy CS' PHEV retrofit of the Toyota Prius NiMH battery and battery control computer, replacing them with a larger advanced lithium-ion battery and monitoring and control system
Extengine 940 South Coast Dr., Suite125 Costa Mesa, CA 92626 www.extengine.com	Develops, manufactures and sells retrofit technology and fuels for reducing diesel emissions.
Horiba Instruments 17671 Armstrong Ave. Irvine, CA 92614 www.horibalab.com	Manufactures engine exhaust analyzers and instrumentation for engine performance, greenhouse gas and other exhaust emissions, particulate emissions, fuel cell performance, engine tuning and other applications.
IMPCO Technologies 3030 South Susan St. Santa Ana, CA 92704 www.impco.ws	Designs, manufactures and markets products and systems that allow internal combustion engines to operate on clean burning alternative fuels, primarily propane and natural gas..
Innovation Engineering 211 South Hill Dr., Suite C Brisbane, CA 94005 www.innovation-engineering.com	Manufactures "Variable Compression Axial Piston" technology that increases internal combustion engine efficiency and performance.
Johnson Matthey 1070 Commercial St., Suite 110 San Jose, CA 95112 www.matthey.com	Manufactures catalysts for automobile emission control and fuel cell catalysts and catalyzed components.
Kavlico 14501 Princeton Ave. Moorpark, CA 93021 www.kavlico.com	Produces highly integrated automotive engine sensors for critical chassis system and powertrain applications.
KleenAir Systems 27121 Aliso Creek Rd Aliso Viejo, CA 92656	Manufactures NOx and PM reduction technologies for diesel engines.
Nanostellar 3696 Haven Ave. Redwood City, CA 94063 www.nanostellar.com	Delivers nano-engineered catalyst materials for the automotive and stationary power industries that reduce exhaust emissions and increase effectiveness of precious metals in the catalysts.
Transonic Combustion 513 Calle San Pablo Camarillo, CA 93012 http://www.tscombustion.com/	Developing technology to achieve significantly higher engine efficiency through ultra-high compression ratios, precise ignition timing, and minimized waste heat generation.

Turbonetics 2255 Agate Ct. Simi Valley, CA 93065 www.turboneticsinc.com	Manufactures performance turbochargers and turbocharging accessories.

LIGHTWEIGHT, HIGH-STRENGTH MATERIALS

CellTech Metals 10051 Old Grove Road San Diego, CA 92131 http://www.celltechmetals.com/	Developing strong, light-weight, and recyclable "Green Metals" that are derived from honeycomb elements designed for the aerospace industry
Hexcel Composites 11711 Dublin Blvd. Dublin, CA 94568 www.hexcel.com	Manufactures advanced structural materials solutions, including providing advanced composites and carbon fiber to the automotive industry for improved safety, reduced emissions, improved fuel consumption, lower weight and demanding cost reductions.
Kaiser Aluminum 27422 Portola Pkwy, Suite 350 Foothill Ranch, CA 92610 www.kaiseral.com	Produces fabricated aluminum products, including aluminum control arms, drive shafts and structural products for chassis, suspension, braking and driveline systems. Aluminum's high strength-to-weight ratio translates into improved fuel economy.
Structural Composites Industries 325 Enterprise Place Pomona, CA 91768 http://www.scicomposites.com/	Produces lightweight, filament-reinforced composite cylinders, pressure vessels, and structures.
Superform USA 6825 Jurupa Ave. Riverside, CA 92517 www.superform-aluminium.com	Supplies superformed aluminum and composite panels, enabling car makers to introduce vehicles to market faster.
Superior Industries International 7800 Woodley Ave. Van Nuys, CA 91406 www.superiorindustries.com	OEM supplier of cast and forged aluminum road wheels for the automotive industry.

VEHICULAR DESIGN, TECHNOLOGY, AND TESTING CENTERS

Art Center College of Design 1700 Lida St. Pasadena, CA 91103 http://www.artcenter.edu	Offering Transportation Design program for advanced automotive design encouraging innovative, sustainable ideas that match consumer needs and expectations.
AVL California Technology Center 27031 Vista Terrace Lake Forest, CA 92630 www.avl.com	Energy management and systems integration facility, that conducts modeling and simulation, Advanced technology assessment, Mechanical and electrical integration, system controls and calibration, and Concept vehicle demonstration.
BMW Group Designworks USA 2201 Corporate Center Dr. Newbury Park, CA 91320 www.designworksusa.com	Design studio working on advanced styles and concepts in a future context.

BMW Group Technology Office 555 Hamilton Ave., Suite 300 Palo Alto, CA 94301 www.bmwgroupna.com/02C_Tech.htm	Houses engineers specializing in chemistry, information science experts, and logistics specialists working on advanced vehicle technologies.
Calty Design Research 2810 Jamboree Rd. Newport Beach, CA 92660 http://www.toyota.com/about/our_business/operations/design/	Provides innovative design solutions for Toyota, Lexus and Scion vehicles.
DaimlerChrysler Research, Engineering and Design North America 1510 Page Mill Rd. Palo Alto, CA 94304 www.dcrtna.com	Research in new technologies and trends that will sustain mobility and increase safety and comfort, focusing on Telematics Technology and Society & Technology Research, including market development for alternative fuels and drivetrains.
International Clean Technology Center 5494 E. Lamona Ave. Fresno, CA 93727 www.cleantechnologycenter.com	Clean technology center housing multiple companies that work in a collaborative environment to foster and build interest in clean energy options and showcase real world projects.
EV Technical Center **Southern California Edison** 265 N. East End Ave. Pomona, CA 91767 www.sce.com/PowerandEnvironment/ElectricTransportationNew/Technology/EVTechnicalCenter	Independent testing facility that tests, evaluates and demonstrates advanced vehicle drive systems, battery types and charging infrastructure.
General Motors Advanced Technology Center 3050 West Lomita Blvd. Torrance, CA 90505 www.gm.com/company/gmability/adv_tech	One of GM's premier technology facilities worldwide. Directly involved in developing core components for GM's advanced vehicles, including the electric EV1 and its inductive charging system
Hyundai-KIA America Technical Center 81 Bunsen Irvine, CA 92618 http://www.hatci.com/	Houses over 100 auto designers, engineers, model makers and technicians. Center led the efforts to test the company's prototype fuel cell vehicles and electric vehicles.
MC Research and Innovation Center 601 Pine Ave., Suite C Goleta, CA 93117 www.mcric.com	High-tech R&D company serving as the locus for Mitsubishi Chemical Corp.'s collaborative research projects with U.S. universities and scientists. Work includes development of next-generation materials and processes, battery and fuel cell research.
Nissan Design America 9800 Campus Point Dr. San Diego, CA 92121 http://www.nissan-global.com/EN/DESIGN/BASE/	Design studio for Nissan.
Powers Design International 828 Production Pl. Newport Beach, CA 92663 www.powersdesign.com	Independent automotive design firm focusing on transportation design and product development.

Toyota Motor Engineering & Manufacturing North America 1630 West 186th St. Gardena, CA 90248 www.toyota.co.jp/en/about_toyota/rd	California location for Toyota's R&D arm, which performs vehicle development and evaluation, certification and collection of technical information.
TUV America **Industry Service Divn. / Material Tech. & Pressure Equipment** 17011 Beach Blvd., Suite 900 Huntington Beach, CA 92647 www.tuvamerica.com	Testing, certification and safety consulting for portable, mobile, vehicle-installed and stationary fuel cell systems; homologation of fuel cell-powered vehicles and systems used in the production, distribution and application of hydrogen fuel cell technology.
Volvo Monitoring and Concept Center 700 Via Alondra Camarillo, CA 93012	Actively investigating and developing alternative drivetrains and fuels for sustainable transportation solutions. Volvo Car Corporations has Bi-fuel vehicles for sale on many markets.

RESEARCH INSTITUTIONS

Center for Environmental Research & Technology (CE-CERT) **Bourns College of Engineering** University of California, Riverside 1084 Columbia Ave. Riverside, CA 92507 www.cert.ucr.edu	Collaborates with industry and government to improve the technical basis for environmental regulations and policy; researches air pollutants, alternative fuels, autonomous vehicles, transportation systems and energy sources.
Energy Biosciences Institute University of California, Berkeley Berkeley, CA 94720 www.ebiweb.org	Bioenergy R&D organization that will bring advanced knowledge in biology, physical sciences, engineering, and environmental and social sciences to bear on problems related to global energy production, particularly the development of next-generation, carbon-neutral transportation fuels.
Electric Power Research Institute 3420 Hillview Ave. Palo Alto, CA 94304 www.epri.com	Independent, nonprofit center for public interest energy and environmental research, including bulk energy storage and plug-in hybrid vehicles.
Global Climate and Energy Project (GCEP) **Stanford University** Peterson Laboratory, Bldg. 550, Rm 556Q 416 Escondido Mall Stanford, CA 94305 http://gcep.stanford.edu/	Conducts research on technologies that will permit the development of global energy systems with significantly lower greenhouse gas emissions, including research in advanced transportation, biodiesel and hydrogen.
Institute of Transportation Studies (ITS) **University of California, Berkeley** 109 McLaughlin Hall, Mail Code 1720 University of California, Berkeley Berkeley, CA 94720 www.its.berkeley.edu	Transportation research, education and scholarship in areas such as technological advances in transportation and its social and environmental consequences.

Institute of Transportation Studies at UC Davis (ITS-Davis) University of California, Davis 2028 Academic Surge One Shields Ave. Davis, CA 95616 www.its.ucdavis.edu	Research, education and outreach specializing in sustainable transportation themes in 3 core areas: travel behavior and transport sytems modeling; advanced environmental vehicle technologies and fuels pathways; and environmental impacts. Also houses Plug-In Hybrid Electric Vehicle Research Center
Institute of Transportation Studies University of California, Irvine 4000 Anteater Instruction and Research Bldg. Irvine, CA 92697 www.its.uci.edu	Research on advanced transportation technologies, including intelligent transportation systems, transportation and activity systems, transportation planning and modeling, transportation economics, freight and logistics.
Jet Propulsion Laboratories (JPL) 4800 Oak Grove Drive Pasadena, CA 91109 http://www.jpl.nasa.gov/	Conducting research in many transportation-related areas, including advanced batteries, reversible metal hydrides, hydrogen storage engineering, and systems engineering issues for integrating clean transportation with smart grids and renewable energy technologies.
Lawrence Berkeley National Laboratory 1 Cyclotron Rd. Berkeley, CA 94720 www.lbl.gov	Multiprogram lab conducting research in advanced materials, life sciences, energy efficiency, detectors and accelerators.
Lawrence Livermore National Laboratory 7000 East Ave. Livermore, CA 94550 www.llnl.gov	Applied science laboratory focusing on national security, energy, the environment (including energy storage and flywheels in the transportation industry), health and biomedicine, economic competitiveness, and science and math education..
Oak Crest Institute of Science 2275 E. Foothill Blvd. Pasadena, CA 91107 www.oak-crest.org	Conducts research in environmental and medical science, including identification and characterization of reactive nitrogen species in automobile emissions, analysis of greenhouse gases, and remote sensing of vehicle exhausts. Works collaboratively with Pasadena City College and Caltech students.
Renewable Energy Institute International (REI International) 5022 Bailey Loop McClellan, CA 95652 www.reiinternational.org	Technology neutral non-profit that supports research, development, demonstration and deployment programs on renewable energy and alternative fuels in collaboration with government, industry, academia, institutes and non-government organizations. Its Renewal Energy Testing Center tests and validates renewable energy technologies related to biomass feedstock with a particular focus on biofuels for transportation.
Sandia National Laboratories 7011 East Ave. Livermore, CA 94550 www.ca.sandia.gov/hydrogen	Advancing the use of hydrogen as an energy carrier through research and engineering projects that are integral to the development of the hydrogen economy.
Schatz Energy Research Center Humboldt State University 1 Harpst St. Arcata, CA 95521 www.schatzlab.org	Working to establish clean and renewable energy technologies. Designs and builds prototype proton exchange membrane fuel cells and integrates them into complete power systems. Provides energy education for students, business and service groups, and the public.

Teledyne Scientific & Imaging 1049 Camino Dos Rios Thousand Oaks, CA 91360 www.teledyne-si.com	R&D in areas of electronics, materials technology, information sciences and imaging sensors. Develops products using high-power semiconductors, including the first SiC based switched reluctance motor drive.
UCI Combustion Laboratory University of California, Irvine Irvine, CA 92697 www.ucicl.uci.edu	Research focused on the conflict between energy generation and environmental impacts. Researchers apply laser diagnostics and computer modeling to practical combustion problems with the goal of reducing pollutant emissions from combustion devices while maintaining or improving combustor performance, including overall system efficiency.
UCLA Institute of Transportation Studies University of California, Los Angeles 3250 Public Policy Bldg. Los Angeles, CA 90095 www.sppsr.ucla.edu	Transportation policy and planning studies, ranging from an analysis of the travel trends and transportation needs of immigrants and low-income workers, to the testing and evaluation of innovative fare programs to increase public transit use.
The University of California Transportation Center 2614 Dwight Way University of California, Berkeley Berkeley, CA 94720 www.uctc.net	Maintains an active program of basic and applied research conducted by UC faculty and graduate student assistants involving the Center's theme, Transportation Systems Analysis and Policy. The Center supports the University's educational programs in transportation with awards of scholarships and fellowships to students planning careers in transportation.

INVESTMENT/ VENTURE CAPITAL FIRMS

Capricorn Investment Group 250 University Ave., Suite 400 Palo Alto, CA 94301 www.capricornllc.com	Private investment management firm involved in a wide variety of global investment activities, including advanced transportation technologies.
Charles River Ventures 2800 Sand Hill Rd., Suite 150 Menlo Park, CA 94025 www.crv.com	Venture capital firm focusing on early-stage investments and finding the right entrepreneurs to create the next big industry changing company, with an eye on the clean energy transportation field.
Clean Energy Asset Management 2425 Olympic Blvd., Suite 6040W Santa Monica, CA 90404 http://www.cleanenergymgmt.com/	Investment firm focusing on public companies in the alternative energy and fuel sector.
CMEA Ventures One Embarcadero Center, Suite 3250 San Francisco, CA 94111 www.cmeaventures.com	Venture capital firm focusing on life sciences, high technology, and energy and materials investments.
Draper Fisher Jurvetson 2882 Sand Hill Rd., Suite 150 Menlo Park, CA 94025 www.dfj.com	Venture capital firm concentrating on very fast growing emerging markets where new products and services address very large existing markets, focusing on information technology, nanotechnology and life sciences, and clean energy technologies.

Jane Capital Partners 505 Montgomery, 2nd Floor San Francisco, CA 94111 www.janecapital.com	Merchant and investment banking firm advising clients in the energy, environmental and industrial technology industries.
Khosla Ventures 3000 Sand Hill Rd. Building 3, Suite 170 Menlo Park, CA 94025 www.khoslaventures.com	Offers venture assistance, strategic advice and capital to entrepreneurs in both traditional venture areas and breakthrough clean technology areas such as bio-refineries for energy and bioplastics, solar, battery and other environmentally friendly technologies.
Kleiner Perkins Caufield & Byers 2750 Sand Hill Rd. Menlo Park, CA 94025 www.kpcb.com	Venture capital firm with investments in advanced biofuels, electric cars, and other areas of the cleantech sector.
Mohr Davidow Ventures 3000 Sand Hill Road Menlo Park, CA 94025 http://www.mdv.com/	Venture capital firm with investments in cellulosic biofuels and other transportation- and energy-related technologies..
Nth Power 50 California St., Suite 840 San Francisco, CA 94111 www.nthpower.com	Venture capital firm dedicated exclusively to high potential investments resulting from the restructuring of the global energy industry.
NGEN Partners 1114 State St., Suite 247 Santa Barbara, CA 93101 www.ngenpartners.com	Identifies, invests and supports emerging businesses that are enabled by cleantech and materials science, that meet growing and sustainable market demands.
Prize Capital http://prizecapital.net/	Provides capital for environmental startups using inducement prize competitions and companion investment funds. Creating a multi-million dollar prize for biofuels
Rustic Canyon Partners 2425 Olympic Blvd., Suite 6050 West Santa Monica, CA 90404 www.rusticcanyon.com	Investment firm focusing on private, growth stage companies that capitalize on opportunities created by technology change, market evolution and regulatory shifts, with clean technology as a key sector.
Vantage Point Venture Partners 1001 Bayhill Dr., Suite 300 San Bruno, CA 94066 www.vpvp.com	Venture capital firm investing in companies that can transform global markets through the power of their ideas. Sectors of investment include cleantech, semiconductors and components.
Virtual Group 1616 Camino del Mar Del Mar, CA 92014 www.leestein.com	Invests in early stage venture companies, usually in the technology sector.
The Westly Group 2750 Sand Hill Road Menlo Park, CA 94025 http://www.westlygroup.com/	Venture capital firm with investments in biofuels, electric vehicles, and other clean technologies.

INDUSTRY SUPPORT

Alternative Energy Systems Consulting 5927 Balfour Ct., Suite 213 Carlsbad, CA 92008 www.aesc-inc.com	Provides technical and management consulting services to the energy market, facilitating the deployment of efficient, cost effective, reliable and environmentally friendly energy systems. Expertise in natural gas distribution system design.
Automotive X PRIZE 130 W. Union St. Pasadena, CA 91103 auto.xprize.org	Hosts worldwide challenge for teams to design viable, clean and super-efficient cars that are also desirable to consumers.
Better World Group 150 E. Olive Ave., Suite 211 Burbank, CA 91502 www.betterworldgroup.com	Specializes in public relations, constituency building, media relations and corporate communications, focusing on the environment, advanced transportation technologies and livable communities.
The California Cars Initiative P.O. Box 61045 Palo Alto, CA 94306 www.calcars.org	Nonprofit startup of entrepreneurs, engineers, environmentalists and consumers promoting 100+MPG plug-in hybrid electric vehicles.
California Fuel Cell Partnership 3300 Industrial Blvd., Suite 1000 West Sacramento, CA 95691 www.fuelcellpartnership.org	A collaboration of auto manufacturers (including DaimlerChrysler, Ford, GM, Honda, Hyundai, Nissan, Toyota and Volkswagen), energy companies, fuel cell technology companies and government agencies working together to advance automotive fuel cells.
California Hydrogen Business Council 44109 Yucca Dr. Indian Wells, CA 92210 www.californiahydrogen.org	Works to bring a deeper understanding of the use of hydrogen in energy and transportation to a variety of market segments through facilitation of meetings, networking and solutions providing.
California Natural Gas Vehicle Coaliton 21845 Copley Dr., Suite 1137 Diamond Bar, CA 91765 www.cngvc.org	Devoted to ensuring that the state continues to set the pace in adopting natural gas vehicles.
CALSTART 48 S. Chester Ave. Pasadena, CA 91106 www.calstart.org	Non-profit organization that works with the public and private sectors to develop advanced transportation technologies and foster companies that help clean the air, lessen our dependence on foreign oil, reduce global warming and create jobs.
Coalition for Clean Air 811 West 7th St., Suite 1100 Los Angeles, CA 90017 www.coalitionforcleanair.org	Committed to restoring clean, healthy air to California and strengthening the environmental movement by promoting broad-based community involvement, advocating responsible public policy and providing technical expertise.
Hydrogen Ventures 400 Continental Blvd., 6th Floor El Segundo, CA 90245 www.hydrogen.la	Provides consulting and research services for alternative energy technology companies, including the areas of clean fuels, hydrogen and fuel cells, and advanced energy storage.
HyGen Industries P.O. Box 2872 McKinleyville, CA 95519 www.hygen.com	Develops and implements renewable energy programs to assist in society's transition to a solar hydrogen economy.

J Knapp Communications Davis, CA www.jknappcommunications.com	Provides writing, media relations, coalition management and project management services to clients in advanced transportation technology, air quality and environmental policy sectors.
Specialty Equipment Market Association P.O. Box 4910 Diamond Bar, CA 91765 www.sema.org	Represents the automotive parts and accessories industry by providing education, legislative and regulatory advocacy and trade shows. Members are the producers and marketers of specialty equipment products and services for the automotive aftermarket.

AUTOMOTIVE MARKETING AND SUPPORT

American Honda Motor 1919 Torrance Blvd. Torrance, CA 90501 www.honda.com	American headquarters for automobile manufacturer producing low greenhouse gas emitting vehicles and developing advanced internal combustion engine, hybrid and fuel cell technologies.
Toyota Motor Sales **Toyota Financial Services** 19001 South Western Ave. Torrance, CA 90509 www.toyota.com www.toyotafinancial.com	American headquarters for Toyota manufacturing and financial services.

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or visit us at www.calstart.org

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