

California's Clean Vehicle Industry

How the Drive to Reduce Automotive Global Warming Pollution Can Benefit the California Economy

A Report by:



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Executive Summary

California is a recognized world leader in developing new technologies and driving environmental protection. Because of this, the state is uniquely positioned to leverage its core strengths in high technology to solve environmental problems while concurrently pursuing unique economic opportunities. This report, “California’s Clean Vehicle Industry,” demonstrates the potential of a growing market for greenhouse gas (GHG) tailpipe emission control technologies to create high quality jobs and increase investments in California.

With the global vehicle population expected to exceed 1 billion in 15 years, the potential market for clean and efficient vehicle technologies is enormous. New programs across the globe, including Europe, Japan, China, and California, are driving to market a new generation of clean and advanced vehicle technologies, including turbochargers, hybrids, and fuel cells. This development indicates that California, with its sizeable and well developed clean car “cluster” and advanced automotive technology industry, stands in an enviable position to export the emerging solutions and products that will significantly reduce greenhouse gas emissions from vehicles while also expanding the state’s high-quality technology jobs.

Findings

California has key competitive advantages in clean vehicle technologies.

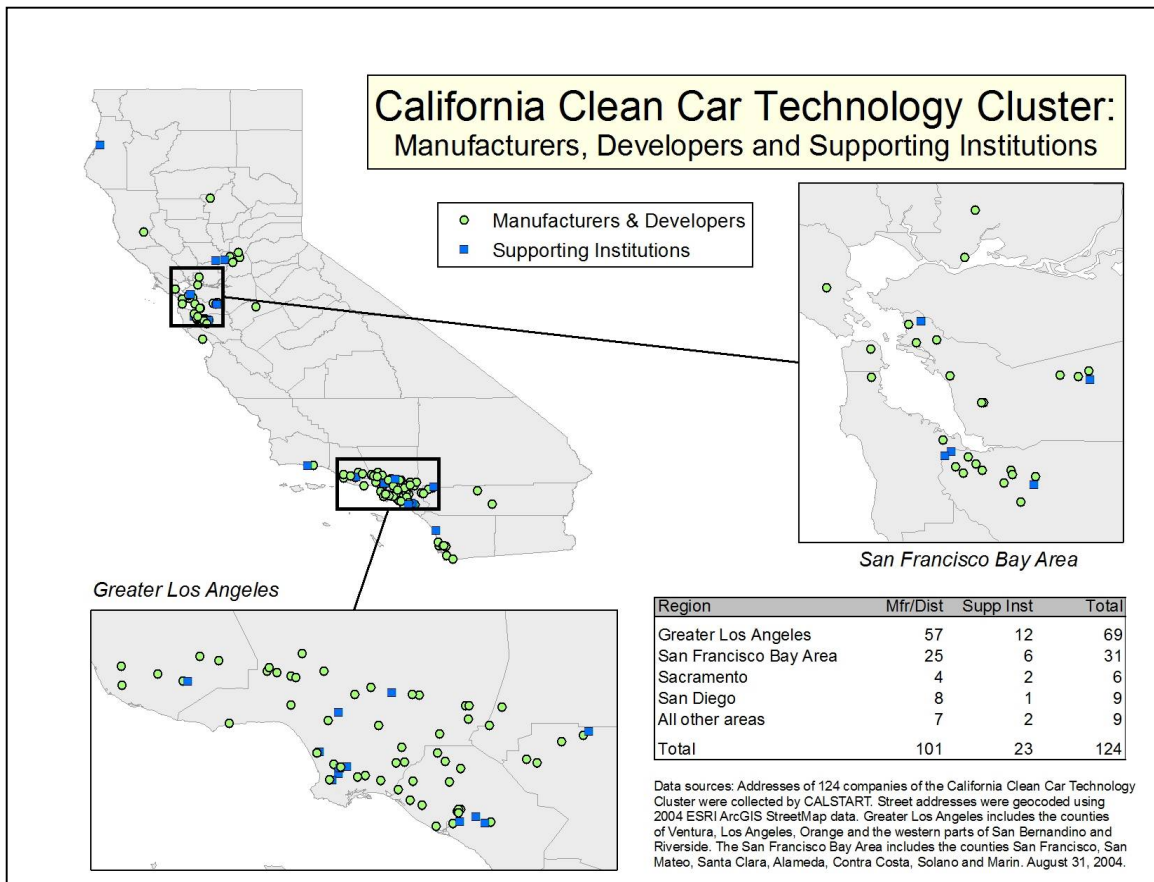
This report finds that California is already an acknowledged world leader in advanced technologies, electronics and software, and engineering and design. These skills and demonstrated strategic strengths align closely with the skill sets needed to create the new technologies and products required for GHG-reducing solutions for vehicles, including electronics and power electronics, advanced propulsion systems, alternative fuels, energy storage, and lightweight materials.



124 clean vehicle technology companies and supporting institutions currently do business in California.

As Figure ES 1 illustrates, this study identifies 101 companies with headquarters and/or major operations in California that have the skills and technologies to be involved in or contribute to the reduction in automotive greenhouse gas emissions. In addition, this study identifies 23 additional supporting institutions, including public and private research laboratories, that provide a critical role in supporting these companies. Many of these companies are already active in this arena, while others have the capabilities to be active, should business opportunities arise.

Figure ES 1: 124 “Clean Car Cluster” Manufacturers, Developers, and Supporting Institutions Identified in this Study



*See Appendix B for a larger version of this map



These companies serve as the foundation for a growing advanced transportation industry, a “clean car cluster” that is comprised of firms with a focus on, or skills applicable to, cleaner vehicle technologies. This California cluster is rooted in the consolidating aerospace industry and Silicon Valley’s high-technology cluster and is comprised of companies and organizations that are involved in the development and production of advanced automotive technologies ranging from innovative propulsion systems to lightweight materials. These companies’ skills sets directly overlap in their skill sets with the segments of California’s economy that ensure the state’s continuing strategic advantage and strength including electronics, engineering, high-technology, and design.

California’s clean car cluster is poised for growth.

In order to better assess the growth potential for California’s clean vehicle technology industry, surveys were sent to 111 clean car cluster companies; a 37 percent response rate was obtained. When asked to assess the effect of requiring greenhouse gas-reducing technologies in vehicles on their business, those surveyed overwhelmingly responded that such a requirement would benefit their company by increasing both job growth and investment. Specifically, the results of the survey are:

- **60 percent** of those organizations that indicated such a requirement would increase employment stated that this **employment increase would be large to very large**, while **46 percent** of those who indicated an investment increase responded that it would result in **a large to very large investment increase**.
- Overall, survey respondents indicated that requiring a significant increase in the use of technologies that reduce greenhouse gas tailpipe emissions could prompt a **37 to 56 percent increase in employment** over current growth forecasts and a **40 to 59 percent increase in investment** over current predictions.
- Furthermore, **74 percent of respondents stated that new greenhouse gas emission standards, such as those required by California AB 1493, would have a positive to very positive effect on their respective organization’s investment and hiring in California.**



Conclusions

In the past, new emission standards created new markets for emission control technologies. For instance, California's LEV II automotive emission standards (adopted in 1998) served as the model for national standards. LEV II spurred innovation that resulted in an estimated \$550 million in additional revenues to the California air pollution control industry from 1999-2002, equaling nearly \$140 million per year. If California's proposed standard to reduce greenhouse gas emissions by 30 percent is adopted nationally, it would create an annual automotive pollution control market of about \$20 billion. Further growth opportunities are created by the increasing interest and involvement of developing countries in solving their pollution and petroleum dependence problems. China has a rapidly growing car market that will equal current U.S. sales by 2015 and the country already has policies in place to promote clean and efficient vehicle technologies. With global market and regulatory trends driving new technologies to market, California's clean car cluster is well positioned to add high quality jobs and investments to California's economy.



1. Introduction

This report assesses the potential for job and economic growth that could be spurred by the creation of a new market for technologies that enable clean, low greenhouse gas emitting vehicles in California. In addition to providing policymakers with a current list of the current companies and organizations in California that are involved both directly and indirectly with advanced automotive and greenhouse gas-reducing technologies in the state, a broad spectrum of these companies and organizations are surveyed. This survey assesses the potential for California economic growth by examining the effect that a requirement to significantly increase the use of greenhouse gas-reducing technologies in vehicles would have on this sector's California employment and investment, with specific regard to the California advanced transportation industry and clean car "cluster". The results of this survey provide a "snapshot" of California's advanced transportation technology industry sector as well as an informed look at the economic value of California industry's ability to contribute to greenhouse gas-reducing technology.

This report and the results of its survey are critically important for they come at a time of mounting concern over the impacts of global warming, growing public demand for clean and efficient vehicles, and increasing governmental initiatives to address automotive greenhouse gas emissions. Europe already has "voluntary" automotive standards for the greenhouse gas carbon dioxide (CO₂). The most significant U.S. initiative is California's automotive global warming pollution program, known as AB 1493 (2002, Pavley). The proposed AB 1493 requirements are designed to reduce CO₂ and other greenhouse gases from new vehicles by 30% by 2016 through the use of existing and emerging motor vehicle pollution control equipment¹, ranging from improved engine valves to hybrid electric drive systems and hydrogen fuel cells. This program is a continuation of long history of the state's successful 40-year leadership in spurring innovations in clean vehicle technologies that led to tremendous reductions in criteria pollutants.

¹ For complete details of the latest proposal, see CARB's web site at <http://www.arb.ca.gov/cc/cc.htm>.



AB 1493 requires the California Air Resources Board (ARB) to evaluate both its environmental and economic impacts, including the creation of jobs within the state, the creation of new businesses within the state, and the expansion of businesses currently operating within the state. In the past, the beneficial impacts of pollution standards extended beyond just pollution reduction. A recent study of the California air pollution control industry by Killion and Ferrier demonstrates that past environmental programs created jobs in California to research, design, and manufacture new air pollution control equipment.²

Regulation aside, it's important to determine the impact on California businesses of the increasing global adoption of clean and efficient vehicle technologies, which is moving forward with or without new regulations. In response to the need to better assess the economic impacts of this trend, this report examines the state's strategic position with regard to matching California's core strengths with the skills required to produce advanced vehicle technologies. It also explores whether the state may experience secondary economic effects, either beneficial or detrimental, from the growing implementation of automotive greenhouse gas reducing technologies and from the enactment of new emission standards.

² Killion and Ferrier, *The Impacts of the Air Pollution Control Industry on the California Economy*, prepared for the California Air Resources Board and the California Environmental Protection Agency, December 2003.



2. California's Emerging Clean Car Cluster

Since the term was coined in 1992, California has been a recognized leader in “advanced transportation technologies” a category that includes energy management, chemical and mechanical energy storage, advanced combustion, lightweight materials, and advanced drivelines. This leadership position essentially created a nascent California “Clean Car Cluster,” which one day could grow into a world-class cluster such as those that currently exist in California, including Silicon Valley, Hollywood, and the California wine industry. A business “cluster” is a term defined by Harvard Business School professor Michael Porter as “a concentration of companies and industries in a geographic region that are inter-connected by the markets they serve and the products they produce.”³

2.1 The Origins and Essential Building Blocks of California's Clean Car Cluster

As Porter points out, successful new clusters often grow out of established ones. In this case, California's clean car cluster grew out of not one, but two established clusters: the consolidating aerospace industry, which refocused some of its resources on the emerging advanced transportation industry, and Silicon Valley's high-technology cluster. This latter example was particularly relevant to the emergence of the clean car cluster as the two share building blocks essential for their respective development including:

- The state's world-class university system necessary to support a highly educated workforce;
- A strong entrepreneurial culture that is willing to take risks;
- An abundance of management talent, particularly in the fast moving world of high technology;
- A vibrant technology base that can create important synergies and cross-pollination of ideas;
- Expertise in advanced technologies;

³ “Clusters and the New Economics of Competition,” Michael E. Porter, Harvard Business Review, November-December 1998



- A huge internal market resulting from the world's sixth largest economy; and
- The presence of significant capital necessary to establish new companies.

As a result of these building blocks and the resulting clean car cluster, California gave and continues to give birth to a number of advanced transportation technology applications, including the first hybrid bus in the nation, the first hybrid Class 8 truck, and the first ultra-high pressure 10,000 pound-per-square-inch (psi) gaseous fuel storage system, among many others.

2.2 California's Strategic Strengths: Recognized Leader in High Tech Investments

While California is currently home to only one vehicle manufacturing plant (NUMMI in Fremont), California is recognized for its automotive research, development, engineering, and design centers. This recognition parallels California's strategic strengths. As The National Science Foundation states in its report *Research and Development in Industry: 1999*⁴, California is not only the leader in industrial research and development investment, but this investment exceeded the next three states' totals combined. This leader status is also true for patents issued and for high tech workers, including engineers, mathematicians, computer scientists, engineering technicians, science technicians, and computer programmers. California also attracted more venture capital funds (\$339 million) for environmentally friendly technologies (the so-called Cleantech industry) than any other state in 2003.⁵ Because of these strengths, California's clean car cluster stands in an enviable position to attract new investments and grow high quality, technology jobs.

These technology and industry capabilities and developments not only represent the next generation of automotive technologies, from gaseous fuels to hybrids, but also have a high degree of correlation with the technologies that will help reduce vehicular greenhouse gas emissions. Therefore, California and its industry stand in an enviable

⁴ National Science Foundation, Division of Science Resources Statistics, *Research and Development in Industry: 1999*, Arlington, VA (NSF 02-312) March 2002.

⁵ Burtis, Patrick, "Creating the California Cleantech Cluster," draft final, Natural Resources Defense Council and Environmental Entrepreneurs, August 2004.



position to provide emerging solutions and products that will have a significant impact on reducing greenhouse gas emissions from vehicles and that also provide and expand the state's high quality technology jobs that the state consistently works to encourage and maintain.



3. Market Drivers for Greenhouse Gas Reduction Technologies

In California and the rest of the world, policymakers are struggling with rising auto ownership and the resulting environmental and oil dependency problems it creates. According to JD Powers and Associates, the global vehicle population will increase by 265 million vehicles over the next 15 years, resulting in a total vehicle population of 1.1 billion.⁶ The vehicle market in Asia, especially in China and India, is fueling this expansion, but markets in Latin America, Eastern Europe and even the U.S. are growing as well. The result of this vehicle population boom is that annual carbon dioxide emissions are predicted to increase by more than 50 percent between 2001 and 2025, from 23.9 to 37.1 billion metric tons.⁷

In most of the world's major auto markets, new policies are being adopted that will have the affect of reducing automobile greenhouse gas emissions and petroleum consumption. As in the past, California is leading the U.S. actions on reducing tailpipe CO₂ emissions with its new GHG pollution law. This program could spread to other states and countries, as even Canada has expressed interest in adopting the California standards. This global policy trend suggests that the market for new, lower greenhouse gas emitting technologies for vehicles could be significant on both domestic and global fronts in the near future.

3.1 Past Market Drivers of California's Air Pollution Control Industry

In the past, as other studies quantified, adopting major new air quality programs, especially at the state level, created new markets that produced direct benefits for the California air pollution control (APC) industry⁸. In a recent report for the California Air Resources Board, researchers found that the California APC industry grew over the past

⁶ Guilford, Dave, "Comment: We're running out of time to replace oil," *Automotive News*, July 19, 2004.

⁷ Ibid.

⁸ As described in the report by Environmental Business International (EBI) and the California Air Resources Board (ARB), the APC industry consists of two main categories: the "Core Air Pollution Control" industry, which directly addresses air quality issues and comprises (primarily equipment manufacturers); and the "Clean Air Products" industry, which makes less emitting products, vehicles, or energy.



three decades from only about \$450 million in revenue and 3,000 California jobs in 1970, to a **\$6.2 billion** industry that now employs **32,000** Californians.⁹ The study estimates that the annual sales of California-based operations of mobile source (both heavy and light duty) emission control systems are **\$670.4 million**.

The study also found that *state and regional laws and programs*, rather than federal regulation, are the primary drivers of local APC economic activity. The report found that “it is clear that [California] Air Resources Board programs are responsible for a considerable portion of the revenues derived by APC companies in the state.” A survey of 130 APC equipment manufacturers found that the most important factors driving sales of their equipment were: 1) enforcement of air quality regulations, 2) local and regional standards in California air districts, and 3) California state air quality standards (tied with economic conditions in their customers’ industries). These local and regional factors ranked well above federal regulation in their importance as APC economic drivers.

3.1.1 Past California Passenger Vehicle Standards

Since California standards are consistently adopted by other states and at the national level, the state’s motor vehicle pollution regulations can also significantly impact market creation at the national level (see Figure 2.1). California consistently leads the nation on new pollution standards, starting in 1961 with the first ever requirement for automotive emission control technology, Positive Crankcase Ventilation (PCV). These standards are regularly emulated by other states and serve as models for national standards.

⁹ Killion and Ferrier 2004.



**Table 3.1 Chronology of California
Automotive Emission Control Leadership**

Year	Event
1961	California adopts regulation to implement the first automotive emissions control technology in the nation, the Positive Crankcase Ventilation (PCV). The regulation goes into effect on new passenger vehicles for sale in California for model year 1963.
1966	California adopts the first ever tailpipe emission standards for hydrocarbons and carbon monoxide.
1971	California adopts the first automobile nitrogen oxides standards in the nation.
1975	First two-way catalytic converters come into use in California.
1980	California requires compliance testing on automobiles as they age to encourage the manufacturing of more durable emissions control equipment.
1984	California Smog Check Program goes into effect.
1990	California adopts the first Cleaner Burning Gasoline Program and the strictest emission standards, the Low and Zero-Emission Vehicles Program.
1992	Phase I California Cleaner Burning Gasoline goes into effect.
1996	Phase II California Cleaner Burning Gasoline goes into effect.
1998	California adopts the Low Emission Vehicle II (LEV II) Program for the strictest new emission standards on vehicles.
2004	LEV II program goes into effect.

Sources: California Air Resources Board, Killion and Ferrier 2004.

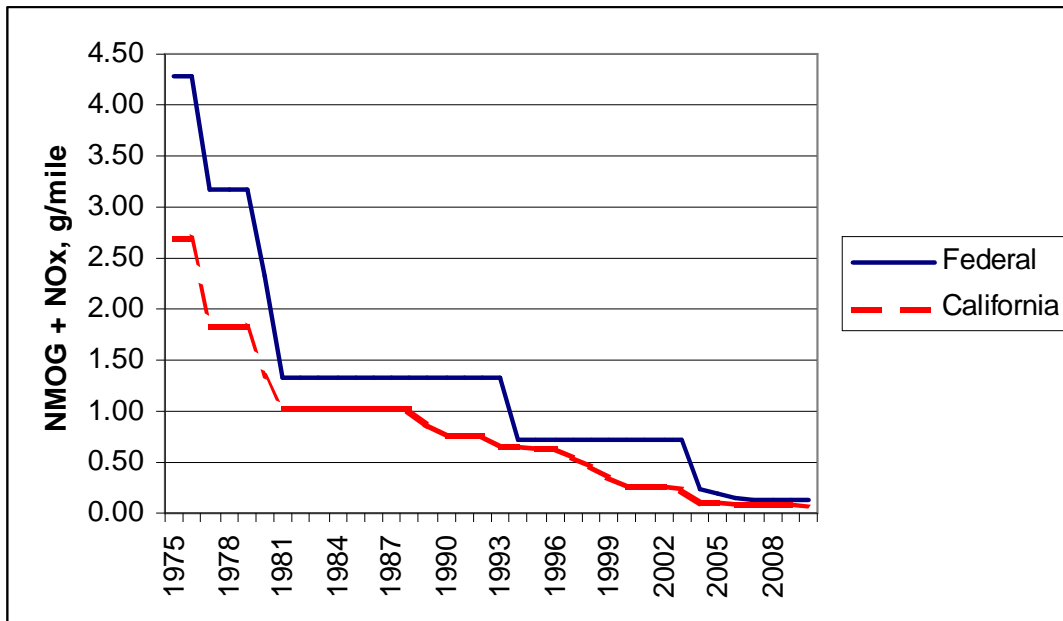
Case Study: California Low Emission Vehicle Program II (LEVII)

The California 1998 LEV II program established stringent new emissions standards for passenger vehicles. Seven states, including California, Connecticut, Maine, Massachusetts, New Jersey, New York, and Vermont, adopted or are in the process of adopting the California LEV II program. Altogether, these states represent about one quarter of total new passenger vehicle sales in the US. The LEV II standards also served as the template for the adoption of a virtually identical program at the national level by the US EPA in 1999 (the "Tier 2" program) thereby bringing the pollution reduction benefits of the current California program to the remaining 43 states. The creation of a national market resulted in an estimated \$550 million dollars in additional revenues from 1999-2002 (nearly \$140 million per year) to the California APC industry.¹⁰

¹⁰ Ibid.



Figure 3.1 California Passenger Vehicle Pollution Standards Consistently Pave the Way For More Stringent Federal Standards



Source: US EPA, CARB.

In addition to increased revenue, the LEV II standards also created a need for more efficient and lower-cost catalysts, spurring research into innovative new material. California scientists and entrepreneurs such as **Catalytic Solutions, Inc.** (based in Oxnard) and **Nanostellar** (based in Menlo Park) are both developing materials to reduce the cost and improve the performance of a new generation of catalysts.

3.2 Future Market Drivers for GHG Technologies

California has a several programs that are spurring development and commercialization of automotive pollution control technologies that can reduce greenhouse gases.

3.2.1 California Zero Emission Vehicle Program

The California Zero Emission Vehicle (ZEV) Program is part of the original California LEV program and was originally adopted by the ARB in 1990. It is still the only program in the nation that requires automakers to produce advanced technology vehicles, with a focus on hybrid and fuel cell vehicles. Since its original adoption, the ARB



amended the program several times; it now begins in 2005 and requires progressive increases in the amount of ultra-clean conventional vehicle, hybrid or natural gas, and fuel cell vehicle production through the year 2017. Five other states in addition to California have the ZEV program as part of their adoption of the overall California LEV program (Maine is the only California LEV state without the ZEV program).

3.2.2 California AB 1493 (Pavley, 2002)

Just like in the past, the adoption of new global warming pollution standards have a high potential to spur new research, development and manufacturing of clean car technologies. The new GHG emission standards will take affect in model year 2009 and will require an approximately 30% reduction over an 8 year period for the combined passenger car and light truck fleet. The ARB estimates that the extra greenhouse gas pollution control equipment required to achieve a 30% reduction in emissions would cost an average of about \$1,260 per vehicle.¹¹ Applying this value to current U.S. fleet sales of 17 million light duty vehicles per year yields an annual market of about **\$20 billion**.

3.2.3 Global Market Drivers

Globally, especially in developing countries, policymakers are struggling with rising levels of auto ownership and the resulting environmental and oil dependency problems it creates. The global vehicle population will increase by 265 million vehicles over the next 15 years, resulting in a total vehicle population of over 1 billion vehicles. The vehicle market in Asia, especially in China and India, is fueling this expansion although markets in Latin America, Eastern Europe and even the U.S. are also growing. Annual carbon dioxide emissions are predicted to increase by more than 50 percent between 2001 and 2025, from 23.9 to 37.1 billion metric tons.¹²

¹¹ Based on CARB's estimate of average cost of control standard of \$1204 for passenger cars and light trucks less than 3750 lbs, and \$1326 for heavy light trucks between 3750 and 8500 lbs. (CARB, "Staff Report: Initial Statement of Reasons for Proposed Rulemaking, Public Hearing to Consider the Adoption of Regulations to Control Greenhouse Gas Emissions from Motor Vehicles, August 6, 2004) Sales shares of the two categories are about 54% for cars and 46% for heavy light trucks.

¹² Guilford, Dave, "We're running out of time to replace oil," *Automotive News* (July 19, 2004), p. 14.



European Voluntary Agreement to Reduce CO₂

In July 1998, the European car industry represented by the European Automobile Manufacturers Association (ACEA)—of which Ford, GM, and DaimlerChrysler are all members—reached an agreement with the European Commission to reduce CO₂ emissions from passenger vehicles. The key commitment pledged by ACEA was to achieve fleet average CO₂ emissions of 140 g/km by 2008. The Japanese and Korean automaker trade organizations also agreed to the same target but delayed their end-date by one year, to 2009.¹³ The European Commission is considering the longer-term goal of 120 g/km for 2012. The European automakers are making substantial progress towards this goal, driving the market for turbochargers, diesels, and other CO₂ reducing technologies in Europe.

China

The Chinese vehicle market is growing at upwards of 80 percent annually and is predicted to match current U.S. sales by 2015, up from roughly two million passenger vehicles today.¹⁴ This means that in about a decade, the Chinese auto market will be one of the largest markets in the world, equaling or exceeding the U.S. To address this growing problem, the Chinese government launched a number of new initiatives to improve the emissions performance and efficiency of their fleet, including new fuel economy standards.¹⁵

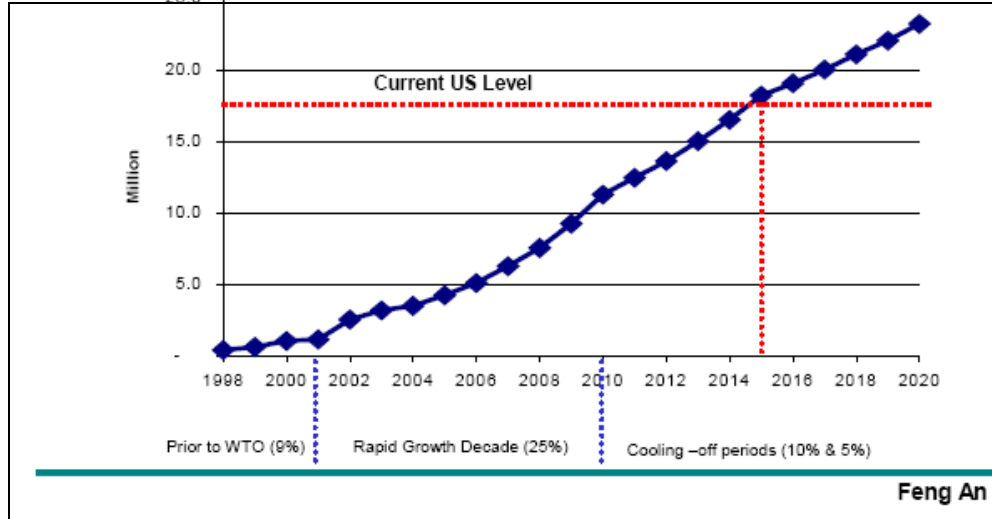
¹³ European Commission, "CO₂ and Cars: Objectives of the Agreements Concluded with the Automobile Industry," http://europa.eu.int/comm/environment/co2/co2_agreements.htm, website accessed April 10, 2002.

¹⁴ Source: An, Feng, "GHG Emissions and Oil Consumption from Transportation Sectors in the US and China," presentation at the Sustainable Multi-Modal Transportation for Chinese Cities International Seminar, October 20-21, 2003, Shanghai, China.

¹⁵ White, Joseph B., "Where the Industry's Future Looks a Lot Like Los Angeles", *The Wall Street Journal*, July 14, 2004.



Figure 3.2 China's Light-Duty Vehicle Sales Will Likely Equal Current US Levels by 2015



Source: An, Feng, "GHG Emissions and Oil Consumption from Transportation Sectors in the U.S. and China," presentation at the Sustainable Multi-Modal Transportation for Chinese Cities International Seminar, October 20-21, 2003, Shanghai, China.

Japan

Japan has new fuel economy requirements that would increase fuel economy of new vehicles by about 23% from 1995 levels by 2010.

Canada

In Canada, the government proposed a voluntary program with automakers that would cut CO₂ by about 20% by 2010 as part of its Climate Change Plan. Alternatively, they proposed adopting California's AB 1493 regulations.



4. Overview of the California Clean Vehicle Technology

Industry

California serves as a unique trailblazer in the area of vehicular greenhouse gas-reducing requirements because it is the largest automotive market in the United States. This market, coupled with a large high technology industry and persistent air pollution problems, resulted in the state becoming home to or well represented by a large number of organizations that, to various degrees, focus on and offer advanced automotive and transportation technologies. These technologies range from components that are incorporated in highly electrified conventional automobiles, such as semiconductors, microchips, and electric motors, to biofuels that can be fed by a large agricultural industry, to fuel cells, which are widely believed to be one of the key low greenhouse gas propulsion and power systems of the future. This section presents an overview of California's Clean Vehicle Industry. Appendix A provides a complete listing of companies and supporting institutions that were identified.

4.1 Methodology to Categorize and Identify Clean Vehicle Companies

Modeled after the work of the California Air Resources Board staff and others, CALSTART identified seven broad categories of technologies that can impact greenhouse gas-reductions in automobiles. CALSTART also identified three support categories for companies providing assistance to this industry or its technologies that are critical enablers for a clean car cluster, thereby bringing the total category count to ten:

Greenhouse Gas Reducing Technology Categories:

- **Electronics and power electronics**, encompassing all the components used in the increased electrification of vehicles, ranging from the use of on-board computers to higher voltage electrical systems.



- **Fuels, fuel infrastructure, and additives**, including alternative fuels, such as natural gas, ethanol, and biodiesel, and conventional fuel additives.
- **Advanced propulsion systems** that go beyond the traditional internal combustion engine, including components such as electric motors that can be applied to hybrid or fully electric operations.
- **Engine, combustion, aftertreatment, and alternative fuel systems** that advance fuel or operation in conventional propulsion systems.
- **Energy storage devices** such as advanced automotive batteries and gaseous fuel tanks.
- **Lightweight, high-strength materials**, such as aluminum, carbon fiber, and advanced plastics.
- **Vehicular designs** that increase aerodynamics and reduce wind resistance; made up of automotive monitoring centers and design studios and schools that led to California's leadership in emerging automotive trends and design. While such firms are not directly involved in creating technologies, they add to the strength of the cluster and are often on the front lines of utilizing new technologies (hybrid, lightweight materials, low-rolling resistance tires) and design approaches (increased aerodynamics) in advanced vehicle designs.

Research and Other Supporting Institution Categories:

- **Research** institutions that examine and work to create new, innovative ways to reduce vehicular greenhouse gas emissions. These institutions also serve the critical function of training researchers to work in the companies that are directly involved in developing new technologies. Examples of such institutions include universities, colleges, laboratories, non-governmental organizations, and consortiums.
- **Industry support** comprised of organizations that work to assist, promote, or advocate reduced greenhouse gas-emitting vehicles and assist in the development and deployment of advanced automotive technologies.
- **Automotive Marketing and Support** made up of the North American headquarters of what are often referred to as "California's automakers", including Toyota, Honda



and Nissan, and the headquarters and technical monitoring centers of other major automakers. Although these operations themselves will be less directly involved in greenhouse gas technologies, they provide strong support to the industry cluster in California and show the state's importance to these automakers.

CALSTART then reviewed a diverse cross-section of organizations linked to these categories of technologies and products that were involved in reducing vehicular tailpipe greenhouse gas emissions. The organizations included are either directly involved in researching, developing, demonstrating or manufacturing technologies or serve critical enabling functions to support these organizations.

4.2 Results: 124 Advanced Vehicle Technology Companies in California

CALSTART identified a compelling, though not comprehensive, list of 124 companies and organizations in California that are working on, involved with, and/or supporting the development of technologies that can reduce automotive greenhouse gas emissions. These companies range from those developing fuel cells and advanced hybrid electric vehicle components to those producing lightweight, high-strength materials and turbochargers for gasoline-powered vehicles. A directory of these companies can be found in Appendix A.

4.2.1 Electronics and Power Electronics Organizations

Electronics and power electronics are the most rapidly growing category of automotive components.¹⁶ This trend will likely intensify if new greenhouse gas requirements are adopted. This category includes: semiconductors, electronic control units for more precise engine control, and power inverters and controllers for hybrids.

Hybrid electric vehicles, which combine an internal combustion engine with electric motors, have several key electronic components, including inverters and semiconductors

¹⁶ Armstrong, Julie, "Electronics spark supplier growth," *Automotive News*, June 28, 2004.



to control the electric motors and manage the power. The inverters convert the battery power (DC current) to AC current for the motors. They also convert the motor electricity back to DC current during regenerative braking episodes. They are typically either MOSFETs (for 42-volt or less) or IGBTs (integrated bipolar transistors). **Avatar Engineering** (Oakland) is an example of a company currently building inverters.

Semiconductors are used in control electronics, such as in controlling the electric motors of hybrids, among their many uses in the automotive industry. Experts predict that demand for automotive semiconductors will double to \$24.5 billion by 2008, outpacing the 68% overall growth. The typical car uses 50 to 70 microcontroller units, luxury cars up to 100. That number is expected to double by 2008.¹⁷ The demand could be much higher if hybrid sales increase more rapidly since they use twice as many chips as conventional vehicles.¹⁸ California has obvious strengths in semiconductors, with heavyweights such as **Intel Corporation** (Santa Clara) and **NEC Electronics Inc** (Santa Clara) already supplying the auto industry.

4.2.2 Fuels, Fuel Infrastructure, Additives, and Alternative Fuel Systems

Alternative fuels, or improved conventional fuels, are another important strategy to reduce greenhouse gases. Natural gas, biofuels, and hydrogen are some of the most promising alternatives. Many of the technologies used currently for natural gas are adaptable for hydrogen, as hydrogen becomes more common. Also, biofuels, especially those that use agricultural waste, have a significant potential for growth and GHG reduction in California.

Due to California's existing leadership in vehicle emission control programs, California has tremendous expertise in alternative fuel production, delivery, and distribution, especially with regard to gaseous fuels. In fact, this category has the largest number of

¹⁷ "High-tech vehicles drive auto chip demand," Reuters, Automotive News, July 12, 2004.

¹⁸ "Carmakers race to meet demand for electronics." Reuters, Automotive News, July 12, 2004.



companies listed. Examples of companies working on alternative fuels are **Praxair** (Carson) and **Clean Energy Fuels** (Seal Beach).

4.2.3 Advanced Propulsion Systems

It is widely acknowledged that vehicles using electric drivetrains will become an increasingly important part of the new vehicle market, especially hybrids and fuel cell vehicles. California has a long history of pioneering the development of electric drive vehicles, including developing core components for the General Motors EV-1 prototype (**AeroVironment** of Monrovia) as well as other advanced electric vehicle drivetrains (**AC Propulsion** of San Dimas) and hybrid drivelines (**Enova Systems** of Torrance).

California continues to be on the leading edge of the next wave of electric drive vehicles: those powered by fuel cells. For fuel cells to become practical, advances must be made in reducing the cost and improving the output of the fuel cell stacks. Many California companies are working on solving these challenges, ranging from fuel cell system integrators like **Anuvu Incorporated** (Sacramento) to companies that are working on new lower cost materials like **Catalytica Energy Systems** (Mountain View).

4.2.4 Engine, Combustion, Aftertreatment, and Alternative Fuel Systems

Advanced engine, combustion, aftertreatment, and alternative fuel systems are among the simplest and most cost effective measures for reducing greenhouse gas emissions from vehicles. These technologies are refinements of conventional engine technologies, can be added to existing systems to improve their efficiency, and/or can serve as enablers for more efficient, lower greenhouse gas emitting technologies.

For example, highly-efficient and lower greenhouse gas emitting diesel and lean burn engines emit particulate matter and/or nitrogen oxide at levels that are greater than California law allows. Several California companies, including **Cleaire** (San Leandro), **Extengine** (Fullerton), and **KleenAir Systems** (Irvine), manufacture products that can be



applied to reduce emission levels and therefore enable the use of these more efficient technologies.

California also is home to a number of companies that work on technologies to improve the efficiency and reduce greenhouse gas emissions of conventional vehicles. **Garrett Engine Boosting Systems** (Torrance) and **Turbonetics Inc.** (Simi Valley) manufacture turbochargers that increase engine power and, therefore, allow smaller sized engines that emit less greenhouse gas emissions to be used in vehicles. **IMPCO** (Cerritos) manufactures fuel systems that allow engines to operate on clean, low greenhouse gas emitting alternative fuels.

4.2.5 Energy Storage Devices

California's rich high-technology resources are reflective as the state is home to multiple energy storage companies. The devices that these companies manufacture hold electrical, mechanical, or gaseous energy and are an integral part of enabling systems that reduce greenhouse gas emissions from advanced vehicles.

Implementing higher voltage systems and increasing vehicle electrification allows vehicles to perform tasks that reduce greenhouse gas emissions, including the partial- to full-hybridization of gasoline and fuel cell vehicles. For instance, 42-volt electrical systems can permit passenger vehicles to more easily shut their engines off at stoplights, among other benefits, thereby reducing emissions. Further advantages are experienced with higher voltage systems, such as 144-volt and higher electrical systems. High voltage electrical systems require sophisticated energy storage devices such as batteries, ultracapacitors or flywheels. Examples of electrical energy storage companies in California include **Maxwell Technologies** (San Diego) and **Trojan Battery Company** (Santa Fe Springs), while **Pentadyne** (Chatsworth) is an example of a company that is developing mechanical energy storage systems for vehicles.



The state is also home to manufacturers of gaseous energy storage devices. These devices can hold gaseous fuel at very high pressures, thereby increasing their range and enabling alternative fueled vehicles to more effectively compete with conventional vehicles. Examples of such manufacturers include **Hydrospin Inc.** (Huntington Beach) and **Luxfer Gas Cylinder** (Riverside), both of which manufacture high-pressure cylinders for this and other purposes.

4.2.6 Lightweight, High-strength Materials

The use of lightweight, high-strength materials, such as aluminum and composites, can reduce vehicular greenhouse gas emissions by lowering the energy needed to accelerate the vehicle and climb grades. In California, **Hexcel Composites** (Livermore) and **Superform USA** (Riverside) are two of several companies manufacturing these materials for automotive use.

4.2.7 Vehicular Designs

Reducing vehicular aerodynamic resistance also reduces the required engine load, thereby reducing greenhouse gas emissions. Typical methods of reducing aerodynamic friction include reshaping the front end of the vehicle, lowering its profile, covering underbody components, and implementing air skirt and dams. There are a multitude of design centers in California, including the **Art Center College of Design** (Pasadena), **Power Design International** (Newport Beach), **BMW DesignWorks** (Newbury Park), and **Volvo Cars of North America** (Camarillo), that are working on these and other advanced, aerodynamic vehicular designs.

4.2.8 Research Institutions

The state's numerous, top-tier research institutions play a vital role in the development of California's clean car industry by training researchers and working to identify and develop currently available and advanced automotive greenhouse gas reducing methods.



These institutions conduct vital research into traditional and non-traditional technologies and techniques that serve as pathways to the future. California's institutions, such as the **University of California Davis, Institute of Transportation Studies** (Davis) and **San Jose State University Institute for Transportation Studies** (San Jose), are recognized around the country and the world as leaders in the clean car industry.

4.2.9 Industry Support

Institutions that provide support to the industry serve to further its success. This support can come in the form of consulting, consortium organization, business development assistance, and technology development assistance. California has several organizations that provide industry support, including partnerships focused on single technology pathways, the **California Fuel Cell Partnership** (Sacramento), and multiple-technology industry consortium, **WestStart-CALSTART** (Pasadena).

4.2.10 Automotive Marketing and Support

Adding significantly to California's automotive status and to the growth of its industry cluster, the state is home to the North American sales and marketing operations of several of the world's major automakers, including **Honda, Toyota** and **Nissan** (Torrance), as well as the headquarters of Ford's **Lincoln Mercury Division** (Irvine). These operations do not normally involve themselves directly in technology development, but are integral components for assessing the market applicability of new designs.

4.3 Company Profiles

This section profiles three companies that are listed above and are representative of the California advanced automotive industry. While these companies are growing on their own merits based on the applicability of the technologies and products they sell, they are particularly relevant industry examples that stand to benefit from the enactment of strong automotive greenhouse gas standards.



4.3.1 Quantum Technologies – Manufacturer of Fuel Systems for Hydrogen and Compressed Natural Gas Vehicles

Headquartered in Irvine, California, Quantum Technologies develops advanced, greenhouse gas reducing fuel systems and supplies these systems to Original Equipment Manufacturers. Quantum's fuel storage products are applied to a variety of alternative fuels including compressed natural gas, liquid propane gas, and hydrogen. In fact, the company was the first to develop and offer a high-pressure gaseous storage tank that can hold up to 10,000 psi (700 bar) and significantly extend the range of hydrogen and natural gas-powered vehicles. Quantum also produces a high-flow alternative fuel injector as well as a variety of electronic engine control units that are coupled with proprietary software to optimize vehicle fuel pressure and flow management of gaseous fuels, among other attributes. Quantum integrates these three technologies into alternative and fuel cell vehicles and performs other services, such as upfitting and prototyping, for its automotive original equipment manufacturer (OEM) customers. Quantum is particularly successful in securing OEM contracts to install its high-pressure tanks and fuel systems in fuel cell vehicle prototypes, as well as securing contracts for providing natural gas fuel systems for major automakers.

In California, Quantum employs over 140 scientists, engineers, and other professionals at two separate locations. Over the past seven years Quantum invested more than \$85 million in new technologies and products and established the largest development center in the world that is focused on advancing gaseous fuel system technology. With such a key role in the development and implementation of multiple greenhouse gas reducing technologies, these employment and investment numbers are poised to grow should regulation prompt increased demand by OEMs for greenhouse gas reducing automotive technologies.



4.3.2 Maxwell Technologies – Energy Storage Devices for Hybrid Applications

To date, batteries have been the primary energy storage technology applied to hybrid electric drive systems because of their widespread availability. However, from a technology perspective, ultracapacitors may be more appropriate for certain hybrid electric applications, especially those requiring high power throughput, as they capture and release energy faster than batteries and may have a far longer service life. This characteristic is optimal for hybrid electric operation, as vehicles need greater assist upon acceleration and often regenerate electricity rapidly upon deceleration. In this regard, Maxwell Technologies is well positioned because its BOOSTCAP® ultracapacitors, which are suitable for a variety of applications including hybrid electric vehicles, deliver up to 10 times the power, last up to 10 times as long, operate more reliably in high- and low-temperature conditions, and require far less maintenance, as compared to batteries. Maxwell ultracapacitor systems are already found in hybrid bus platforms and are being explored in fuel cell hybrid vehicle designs.

Maxwell Technologies is headquartered in San Diego and employs 185 people worldwide, with the majority of those employees in California, and as of June 30, 2004, the company had a market capitalization of more than \$150 million. Originally a government contractor, Maxwell Technologies began converting to commercial applications for its technologies and products in the early 1990s and now generates all of its revenue from commercial sources. Indeed, this conversion is not surprising seeing the vast potential of their ultracapacitors to combine with advanced propulsion systems to improve vehicular operability and efficiency, thereby reducing operating costs and greenhouse gas emissions.

4.3.3 Garrett Engine Boosting Systems – Turbochargers for Conventional Vehicles

With its world headquarters as well as its North American Technical Center in two separate locations in Torrance, California, Garrett Engine Boosting Systems produces turbochargers that improve engine performance and efficiency, thereby reducing criteria



and greenhouse gas emissions. While turbochargers are primarily associated with racing applications where the maximization of speed is the priority, turbochargers are also applied to smaller engines to obtain the horsepower of larger engines, which enables these lower greenhouse gas emitting smaller engines to drive larger applications without compromising performance. Turbocharging is particularly common in Europe, where the average size engine is 1.9 liters compared with the U.S. average of 3.2 liters. The California Air Resources Board estimates that this inexpensive technology that is easily adaptable to conventional engines can reduce carbon dioxide emissions by between six and eight percent from 2002 level small and large cars.¹⁹

Garrett is a recognized world leader of turbocharging technologies. Many of the world's top engine and car manufacturers employ Garrett turbochargers to boost their engines, including Audi, BMW, DaimlerChrysler, Fiat, Ford, Peugeot, Renault, Saab, and Volkswagen. Garrett earned \$1.2 billion in revenue in 2002 and Honeywell, its parent company, has a market capitalization of \$30.8 billion.

¹⁹ California Environmental Protection Agency, Air Resources Board, *Staff Proposal Regarding the Maximum Feasible and Cost-Effective Reduction of Greenhouse Gas Emissions from Motor Vehicles*, Draft: June 14, 2004.



5. Survey Results: Projected Economic and Employment Impacts of Automotive Greenhouse Gas Emission Requirements

To gain better insight into the clean vehicle industry, CALSTART administered a confidential survey to 111 companies and organizations that comprise part of California's clean car cluster and received replies from 41, greater than a one-third response. The survey methodology is listed in Appendix B, a list of the organizations sent surveys is in Appendix C, and the actual survey instrument is shown in Appendix D. The first three questions established the current status of the organization including employment, recent annual revenue, and recent employment growth. The next three questions established baseline forecasts including predicted employment, revenue, and investment growth over the next three to five years. The final four questions probed the effect that a requirement to significantly increase the use of technologies that reduce greenhouse gas tailpipe emissions would cause on near-term California employment and investment, with the final question specifically referring to the effect regulation such as AB 1493 would have on investment and employment. Complete confidentiality of all answers was promised to each participant.

The responses included representatives from eight of the identified categories. The breakdown of these responses and the corresponding percentages each one represents is as follows:

Table 5.1 Respondent Category Breakdown

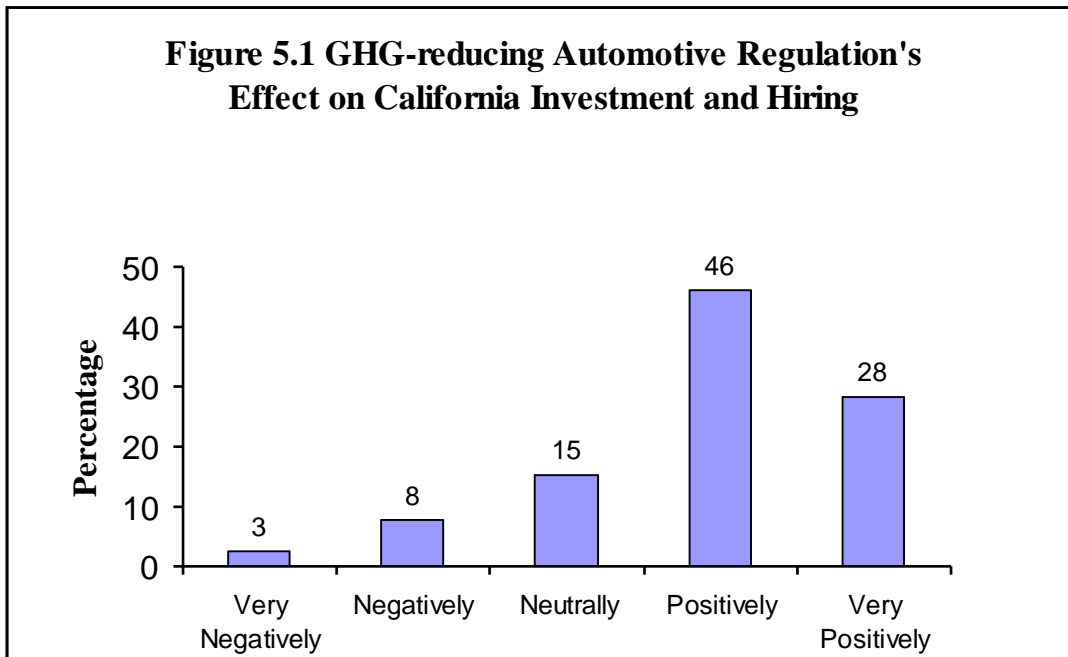
Category	Number of Respondents	Percentage of Respondents
Fuels, Fuel Infrastructure, Additives	12	29%
Energy Storage Devices	8	20%
Advanced Propulsion Systems	7	17%
Engines, Combustion, Aftertreatment, and Alternative Fuel Systems	5	12%
Research Institutions	4	10%
Electronics and Power Electronics	3	7%
Lightweight, High-strength Materials	1	2%
Vehicular Design	1	2%
Industry Support	0	0%
Automotive Design	0	0%



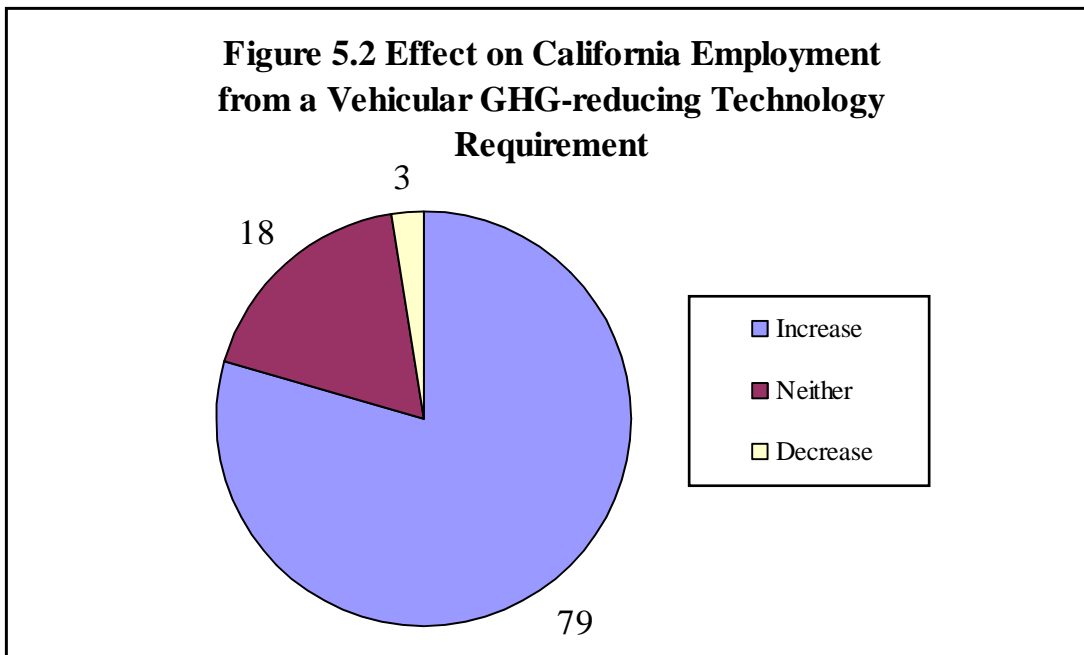
While a straightforward approach cannot be applied that extrapolates the economic results of those 41 respondents to the other 70 identified organizations and beyond, it is important to note that this survey obtained an impressive 37% response rate, which is over one-third of the targeted industry organizations CALSTART identified. Therefore, it legitimately presents a snapshot of and provides insight into an industry that clearly represents a significant number of California jobs and revenue.

5.1 The Effects of Automotive Greenhouse Gas Reducing Technology Requirements on California Employment and Investment

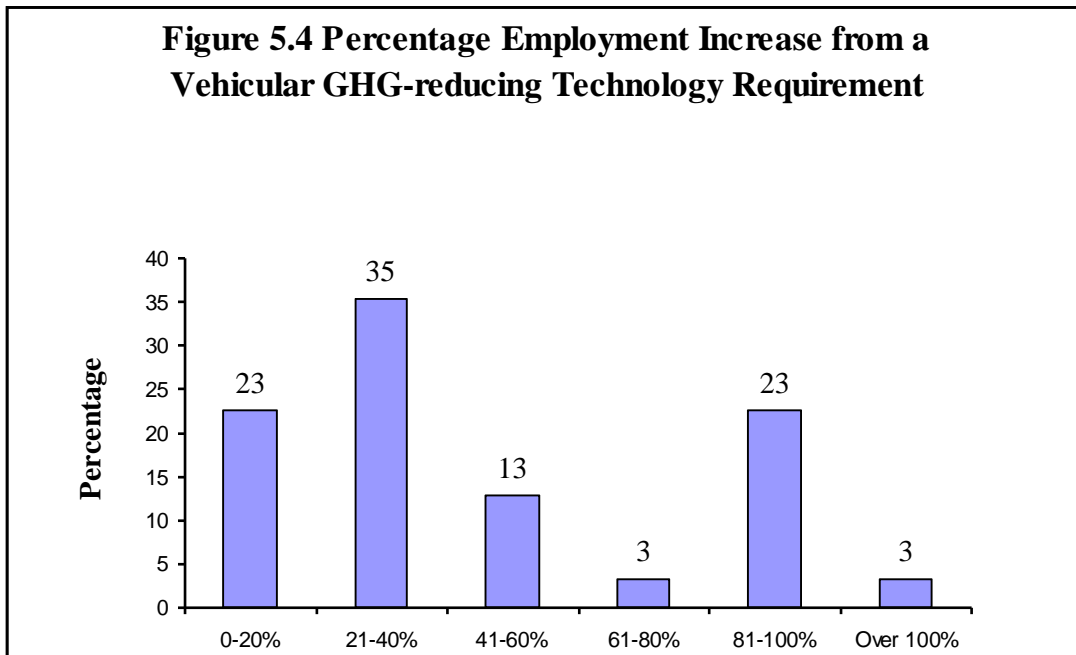
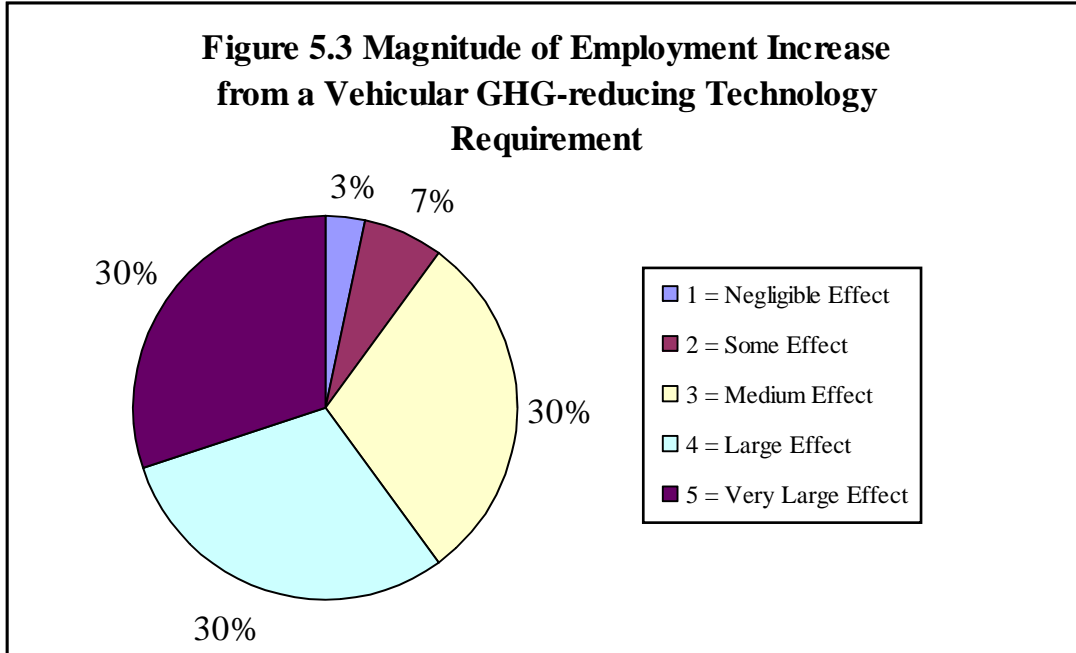
A vast majority of the respondents to this survey indicated a strong belief that *regulation limiting greenhouse gas tailpipe emissions could increase or significantly increase their organization's California employment and investment*. Survey participants were asked to relate how the imposition of regulations that stringently limit California greenhouse gas automotive tailpipe emissions would likely affect investment and hiring plans. A solid 74 percent of respondents stated that such regulation would have a positive to very positive effect on their respective organization's investment and hiring.



The first survey question asked respondents to rate the effect that a “requirement to significantly increase the use of technologies that reduce greenhouse-gas tailpipe emissions in vehicles” would have on their organization’s California employment over the next 5 years. The results indicate that, for a broad spectrum of representative organizations involved in the California automotive greenhouse gas-reducing technology industry, this requirement could provide *significant California employment and investment benefits*. Altogether, thirty-three respondents, representing 80 percent of the total, indicated such a requirement would increase employment, and eight, representing 20 percent, indicated that it would have no effect. Only one organization indicated it would decrease employment.



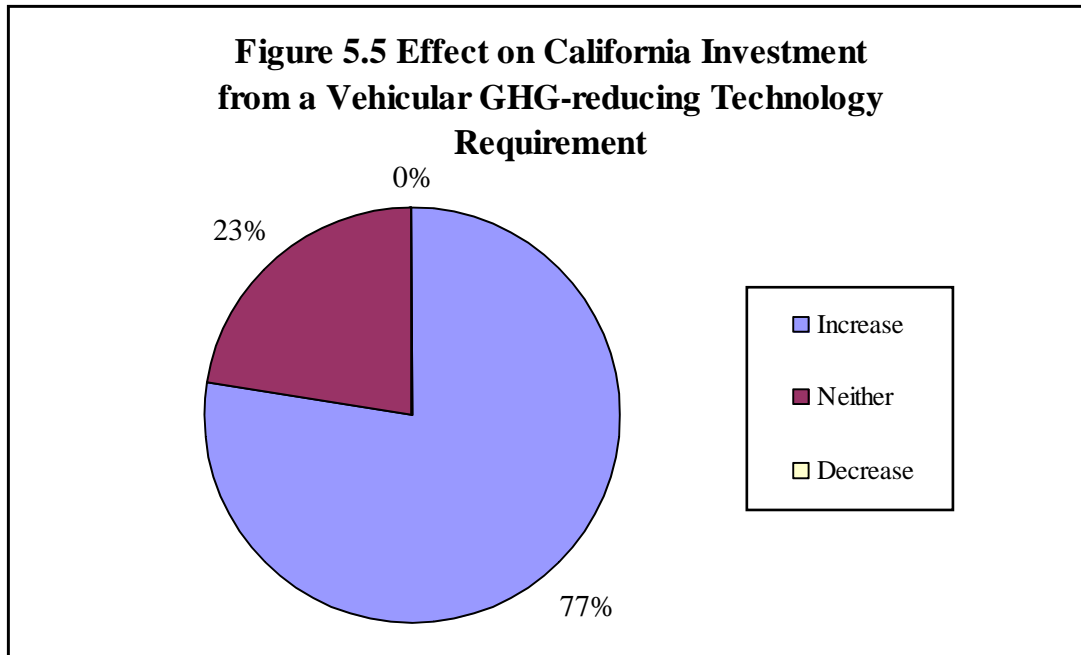
60 percent of the respondents stated that the employment increase from new pollution requirements could be “large” to “very large.” Furthermore, the respondents were asked to project the percentage increase or decrease such a requirement could cause on their organization’s California employment. 29 percent of respondents indicated that such a requirement could increase their respective organization’s employment by 61 percent or higher.



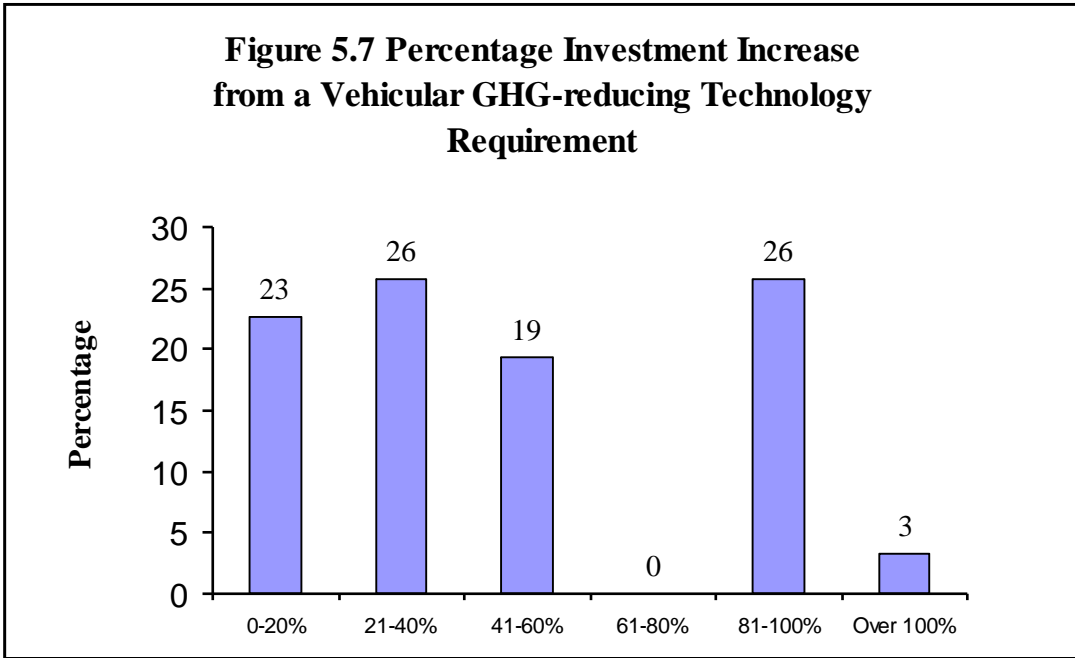
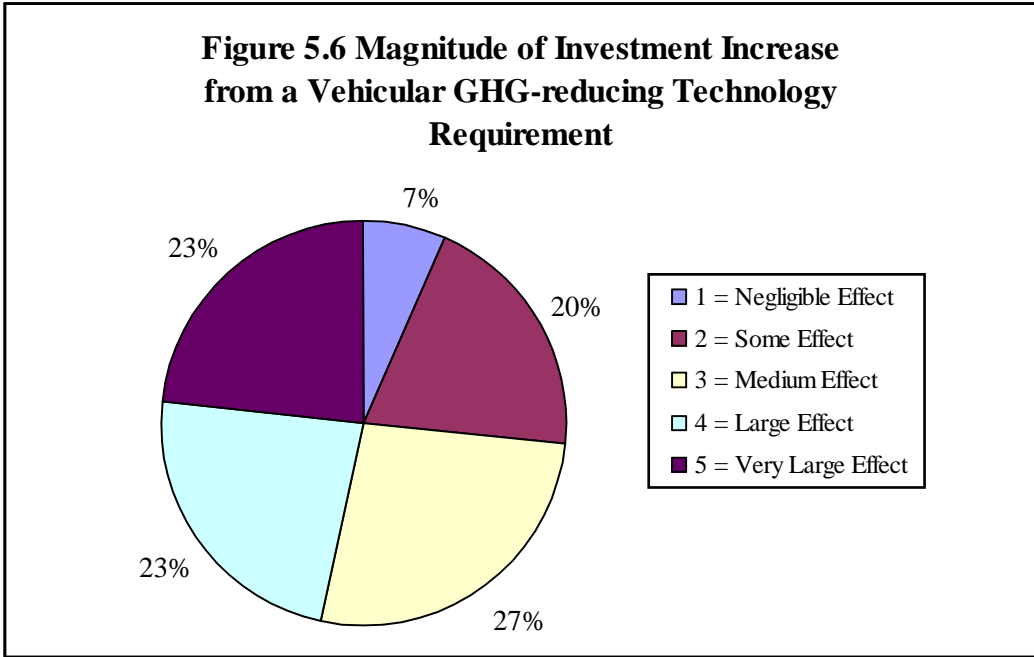
The same questions were asked regarding investment status and forecasts that were asked for employment. In response, a vast majority indicated new pollution requirements could increase investments. Regarding a “requirement to significantly increase the use of technologies that reduce greenhouse-gas tailpipe emissions in vehicles”, 31 survey respondents, representing 76 percent of the total, indicated this could prompt an increase



in California investment over the next 5 years while 9 respondents indicated it would have no effect.



As with employment, respondents were asked to rate the magnitude of the indicated increase or decrease based on a scale of 1 through 5. While two respondents indicated the magnitude of the increase would be negligible, 46 percent indicated a large to very large increase in investment. Along these same lines, the respondents were asked to speculate on the percentage increase or decrease such a requirement could cause on the organizations' planned California investment. 29 percent indicated that a greenhouse gas-reducing requirement could cause their California investment to increase by at least 81 percent over current predictions.



23 of the companies also provided confidential internal current investment plans *along with* projected investment changes associated with a greenhouse gas technology requirement. These respondents currently plan to invest \$306M in California operations over the next five years. A requirement to significantly increase the use of technologies



that reduce greenhouse gas tailpipe emissions could prompt this snapshot to increase California investment above current predictions by between \$123 million and \$181 million over the next five years. This represents an increase of between 40 and 59 percent over current predictions.



Appendix A: California Clean Vehicle Technology Companies

Electronics and Power Electronics Organizations

Organization	Description
Avatar Engineering 4332 Fruitvale Ave Oakland, Ca 94602	Major manufacturer of inverters supplied to automotive companies.
BI Technologies/TT Group 4200 Bonita Place Fullerton, CA 92835	Global manufacturer of electronic resistive and potentiometer products for automotive applications.
Calsonic North America 9 Holland Irvine, CA 92618-2506	Major supplier of electronic modules to automotive companies.
Curtis PMC 235 East Airway Blvd. Livermore, CA 9455	Produces integrated systems for electric and hybrid electric vehicles including motor speed control, battery measurement technology, power conversion technology, and instrumentation.
DENSO 3900 Via Oro Ave. Long Beach, Ca 90810	One of the world's largest automotive suppliers; product lines include original equipment, aftermarket and re-manufactured automotive parts, heavy-duty diesel, and electrical components. California operations are involved in sales and distribution, but they do take part in technology scanning and their presence supports the strong industry cluster in California.
Intel Corporation 2200 Mission College Blvd. Santa Clara, CA 95052	Produces semiconductors and microprocessors that can be used in advanced automotive components, including hybrids.
International Rectifier 233 Kansas St. El Segundo, CA 90245	Manufacturer of 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, Inc. 8611 Balboa Ave San Diego, CA 92123-1501	The company is North America's largest producer of ceramic semiconductor packages. California operations focus on producing multilayer ceramic substrates for automotive engine control unit (ECU) applications.
NEC Electronics Inc. 2880 Scott Blvd. Santa Clara, CA 95050-2554	Manufacturers and supplies semiconductors used in advanced automotive components, including hybrids.



Tri-Circuit America, Inc. 2105 S Bascom Ave Ste 336 Campbell, CA 95008-3295	Supplies multi-chip module (MCM) substrates to one of the Big Three automobile manufacturers.
ZF Micro Devices, Inc. 1000 Elwell Court Palo Alto, CA 94303	Automotive supplier of circuit boards and semiconductors.

Fuels, Fuel Infrastructure, and Additives

A.E. Schmidt Environmental 8100 Balboa Place Van Nuys, CA 91406	Construction professionals focusing on retail/hypermarket gasoline stations, alternative fueling facilities (CNG/LNG) and fleet fuel management systems.
Air Products 858 Third Avenue 455 Chula Vista, CA 91911-1305	Manufacturers hydrogen refueling and infrastructure equipment.
Altenergy 2330 Gold Meadow Way Gold River, CA 95670	Suppliers of portable and stationary fuel cells, hydrogen hydride cartridges and refilling
Bio-Energy Systems, LLC 862 Sir Francis Drake Blvd San Anselmo, CA 94960	Produces biodiesel in Vallejo.
Biodiesel Industries, Inc. 435 1/2 El Sueno Road Santa Barbara, CA 93110	Dedicated to advancing the technology and principles needed to establish biodiesel as a practical and affordable alternative fuel.
The BOC Group 2700 Maxwell Way, P.O. Box 2529 Fairfield, CA 94533-0252	Hydrogen producer and supplier.
Clean Energy Fuels 3020 Old Ranch Pkwy Seal Beach, CA 90740-2751	Designs, builds, and operates natural gas fueling stations.
Clean Fuel Connection, Inc. 127 La Porte Avenue, Unit M Arcadia, CA 91006	Installs and services electric vehicle chargers.
Cryogenic Experts Inc. 531 Sandy Circle, Oxnard, California 93036	Manufactures vaporizers and systems for the industrial gas marketplace for all types of cryogenic fluids, including hydrogen.
Down Stream Systems, Inc. (Omnifuel) 8421 Auburn Blvd. Suite 258 Citrus Heights, Ca 95610	Biomass processing and bio-fuel production.
DynaMotive Corporation 134 N Van Ness Ave Los Angeles, CA 90004-3906	Development and commercialization of environmentally friendly energy systems, based on fuels produced from biomass.



FuelSell Technologies 601 Van Ness Ave Ste 2018 San Francisco, CA 94102-6310	Development of hydrogen compression and distribution technology. The company licenses its technology, patents and other intellectual property on a nonexclusive worldwide basis.
General Atomics 3550 General Atomics CT San Diego, CA 92121-1122	Developer of power systems to produce hydrogen using hydrothermal processing.
Golden Cheese Company 1138 W. Rincon Street Corona, California 92880	Ethanol production facility in Corona, CA.
Green Star Products 858 Third Avenue #455 Chula Vista, CA 91911-1305	Manufacturers of lubricant and anti-friction metal treatments; development of greenhouse gas reducing, power improvement, and emission reduction technologies for internal combustion engines and hybrid electric drive systems; 35% owner of American Biofuels, which produces biodiesel in Bakersfield
Harvest Energy Technology 9253 Glenoaks Blvd Sun Valley, CA 91352-2614	Develops hydrogen generators for refueling stations, small industrial markets and PEM fuel cells in the 50-250 kW range.
Imperial Western Products 86-600 Avenu 54 Coachella, CA 92236	Biodiesel production in Coachella.
Lubrizol 2400 E Katella Ave Anaheim, CA 92806-5945	Manufacturer of lubricants and fuel additives that reduce greenhouse gas emissions, among others.
Makel Engineering Inc. 1585 Marauder St. Chico, CA 95973	Designs and manufactures hydrocarbon reformers for fuel cells as well as systems for leak detection.
Parallel Products 1431 W 9th St Upland, CA 91786-5672	Ethanol production facility in Rancho Cucamonga.
Praxair 2006 E 223rd St Carson, CA 90810-1609	Produces and supplies hydrogen and hydrogen refueling capabilities for use in vehicles and for the creation of cleaner fuels.
Procter and Gamble 8201 Fruitridge Rd Sacramento, CA 95826-4716	Produces biodiesel in Sacramento.
RIX Industries 4900 Industrial Way Benicia CA 94510	Manufactures a wide range of reciprocating piston compressors for industrial gases, including natural gas and hydrogen.
RKI Instruments, Inc. 1855 Whipple Rd Hayward, CA 94544	Manufactures gas detection units for hydrogen and natural gas that are critical safety equipment for vehicles and refueling stations.
Yokayo Biofuels 150 Perry Street Ukiah, CA 95482	Biodiesel production in northern California



Advanced Propulsion Systems

AC Propulsion 441 Borrego Court San Dimas, CA 91773	Development of advanced electric components for electric and hybrid electric vehicles including power and battery management systems.
AeroVironment, Inc. 825 S. Myrtle Dr. Monrovia, California 91016	Develops and manufactures electric and hybrid electric vehicle systems including power processing systems, fast chargers and stations, battery management systems, and integrated drivetrain development.
Anuvu Incorporated 3980 Research Drive Sacramento, CA 95838	Designs and manufactures fuel cell stacks and fuel cell engines and systems.
Asia Pacific Fuel Cell Technologies, Ltd. 3812 E. La Palma Ave Anaheim, CA 92807	Designs and manufactures PEM fuel cell stacks, storage, and distribution systems for mobile and other applications.
CalNetix 12880 Moore St Cerritos, CA 90703	Develops and manufactures highly efficient motors and generators for different automotive subsystems including starter/alternators, hybrid electric systems, and air management systems for automotive fuel cells.
Capstone Turbine 21211 Nordhoff Street Chatsworth, CA 91311	Manufacturers microturbines for hybrid-vehicle and other applications.
Catalytica Energy Systems 430 Ferguson Drive, Bldg. 3 Mountain View, CA 94043	Developing advanced emission control systems for diesel engines and fuel processing systems for fuel cells used in automotive applications.
Coval H2 Partners LLC 69-391 Dillion Road Desert Hot Springs, CA. 92241	Developed battery-powered and fuel cell hybrid-electric vehicles and stationary power systems
DTI Energy, Inc. 5325 Venice Blvd. Los Angeles, CA 90019	Worldwide licensing rights to patented Direct Methanol Fuel Cell (DMFC) technology that can be used in vehicle applications.
General Motors Advanced Technology Center 3050 Lomita Blvd. Torrance, CA 90505-5103	The Torrance facility is one of GM's premier technology facilities worldwide and was directly involved in developing core components for the company's advanced vehicles, including the electric EV1 and its inductive charging system.
H2 ECOnomy 220 S. Kenwood St., Suite 305 Glendale, CA 91205-1671	Develops, manufactures, and sells fuel cell stacks, components and related products.



Honeywell Engines and Systems 2525 West 190th Street Torrance, CA 90504	Manufactures turbochargers and provides research and development on a device suitable for CO remediation in an automotive PEM fuel cell power plant as well as a turbocompressor for PEM fuel cells.
Hyundai America Technical Center 81 Bunsen Irvine, CA 92618-4218	The Irvine facility is one of Hyundai's leading worldwide technical centers; It led the efforts to test Hyundai's prototype fuel cell vehicles and electric vehicles.
Intelligent Energy 2955 Redondo Ave Long Beach, CA 90806	Leaders in applying fuel cell technology to distributive power solutions and to motive and portable power delivery.
ISE Research 7345 Mission Gorge Rd San Diego, CA 92120-1270	Develops and manufactures electric, hybrid-electric, and fuel cell vehicle components and subsystems
Maxdem Inc. 140 E Arrow Hwy San Dimas, CA 91773-3336	Research and development of proton exchange membranes for use in hydrogen and methanol fuel cells.
NEOMAX America, Inc. 23326 Hawthorne Blvd. Suite 360 Skypark 10 Torrance, CA 90505	Manufacturer of magnets and special metals for automobile electric motors and other applications.
Parker Hannifin Corporation 3400 Finch Rd Modesto, CA 95354-4125	Developing advanced fuel cell components and products. Also is a world leader in hydraulic systems that have applications to hydraulic hybrids.
Polyfuel, Inc. 1245 Terra Bella Ave Mountain View, CA 94043-1833	Developer and manufacturer of key enabling membrane technology for direct methanol fuel cell power systems
Powerzinc Electric, Inc. 17800 Castleton St City Of Industry, CA 91748	Develops and manufactures zinc air fuel cell technology for vehicle propulsion.
Soligen Technologies, Inc. 19408 Londelius St Northridge, CA 91324	Produces complex cast metal prototypes for automotive powertrain applications.
Symyx Technologies, Inc. 3100 Central Expressway Santa Clara, CA 95051	Focused on the discovery of advanced materials that enable emissions reduction, the development of next-generation fuel cells, fuel processing, and polymers.



<p>Toyota Technical Center 1630 West 186th Street Gardena, CA 90248</p>	<p>Comprehensive Toyota research and development arm that conducts automotive R&D work in everything from the testing and evaluation of U.S. parts and materials to emissions certification and technical research. The organization is playing an increasingly important role in the design-engineering and development of Toyota products, particularly those developed for the North American market</p>
<p>TUV America Inc. 17011 Beach Blvd. Huntington Beach, CA 92647</p>	<p>Fuel cell related activities such as testing, analysis, safety consulting, and homologation of fuel cell vehicles; works with hydrogen related systems used in the production, distribution and application of hydrogen fuel cell technology.</p>
<p>Wesgo Metals (Morgan PLC) 2425 Whipple Road Hayward, CA 94544</p>	<p>Noble and non-precious metals and alloys for the automotive and other markets.</p>

Engine, Combustion, Aftertreatment, and Alternative Fuel Systems

<p>BAYTECH Corporation P.O. Box 1148 Los Altos, CA 94023</p>	<p>EPA and CARB certified low- and ultra-low emission CNG systems (NGV LINK™ Performance Kit) for General Motors vehicles and engines.</p>
<p>Catalytic Solutions 1640 Fiske Place Oxnard, California 93033</p>	<p>Manufactures and delivers a proprietary technology that significantly improves the performance and reduces the cost of catalytic converters.</p>
<p>Cleaire 14775 Wicks Blvd. San Leandro, CA 94577</p>	<p>Cleaire's emission control products cover a wide range of engine types, duty cycles, and pollutant reduction needs, including NOx and PM.</p>
<p>Clean Air Power 5066 Santa Fe Street San Diego, CA 92109</p>	<p>Manufacturers "dual fuel" engines, which operate primarily on natural gas, and other vehicle components.</p>
<p>Corning APT 6300 Gateway Drive Cypress, CA 90630</p>	<p>Manufacturer of APC equipment including advanced ceramic substrates and diesel particulate filters.</p>
<p>Engelhard Corporation 12874 Bradley Avenue Sylmar, CA 91342</p>	<p>Manufacturer of automotive APC equipment including conventional automotive and alternative fuel vehicle catalyst technologies that reduce methane and nitrous oxide.</p>



Extengine 1370 South Acacia Avenue Fullerton, CA 92831	Design, engineer, prototype, test, develop, market and commercialize products and services that substantially reduce emissions and enhance engine performance.
Garrett Engine Boosting Systems 23326 Hawthorne Blvd., Suite 200 Torrance, CA 90505	Manufacturer of turbochargers that increase power and reduce greenhouse gas emissions.
Horiba Instruments, Inc. 17671 Armstrong Avenue Irvine, CA 92614	Manufacturer of 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 16804 Gridley Pl Cerritos, CA 90703	Manufacturer and supplier of fuel storage, fuel delivery, and electronic control systems that allow internal combustion and fuel cell engines to operate using clean fuels.
Johnson Matthey 1070 Commercial Street, Suite 110 San Jose, CA 95112	Works with precious metals for use in catalytic technologies for the reduction of greenhouse gas and criteria pollutants.
Kavlico Corporation 14501 Los Angeles Avenue Moorpark, CA 93021	Produces highly integrated engine sensors for engine misfire, fuel tank, active suspension, air conditioning, high-pressure fuel injection, fuel rail, and other applications.
KleenAir Systems Inc. 1711 Langley Ave., Suite B Irvine, CA 92614	Manufacturers NOx and PM reduction technologies for diesel engines.
Nanostellar 3603 Haven Avenue, Suite A Menlo Park, CA 94025	Nanostellar develops highly efficient Platinum Nano-Composite Catalyst for the automobile emission control, fuel cell, and chemical industries.
Quantum Technologies 17872 Cartwright Rd Irvine, CA 92614	Manufacturer of advanced fuel storage, fuel metering, electronic control systems, and system integration for manufacturers of fuel cell engines and internal combustion engines.
Turbonetics Inc. 2255 Agate Ct. Simi Valley, CA 93065	Turbocharger and turbocharging accessory manufacturer.
VCAP Technologies 211 South Hill Drive, Ste C Brisbane, CA 94005	Manufacturer of "Variable Compression Axial Piston" technology that increases engine efficiency.

Energy Storage Devices

AFS Trinity Power Corporation 6724 Preston Ave Ste D Livermore, CA 94551-9429	Developing flywheels for various stationary and mobile applications.
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Hawker Energy Products, Inc. 9163 Siempre Viva Rd San Diego, CA 92154-7608	Battery manufacturer for hybrid and electric vehicles (among other things).
Hydrospin Inc. 5281 Research Dr Huntington Beach, CA 92649-1540	Manufacturers lightweight, composite reinforced gas cylinders for use in numerous high-pressure storage applications, such as CNG fuel tanks.
Luxfer Gas Cylinder 3016 Kansas Ave Riverside, CA 92507-3478	Development, production and supply of seamless, extruded aluminum and composite high-pressure cylinders for the storage of compressed natural gas, among other gases.
Maxwell Technologies 9244 Balboa Ave. San Diego, CA 92123	Produces ultracapacitors for use in hybrid electric vehicular applications.
Pentadyne 20750 Lassen St Chatsworth, CA 91311-4507	Designs, manufactures, and markets advanced flywheel energy storage systems that provide ride-through power and voltage stabilization for power quality, power recycling applications, and power/energy storage for hybrid vehicle applications.
PolyPlus Battery Company 2431 5th St Ste B Berkeley, CA 94710-2409	Developing technology for lithium and lithium sulfur batteries for applications including electric and hybrid electric vehicles
Structural Composites 325 Enterprise Place Pomona, CA 91768	Designs and manufactures lightweight, aluminum-lined, composite-wrapped, high-pressure cylinders for natural gas and hydrogen, among other applications.
Trojan Battery Company 12380 Clark Street Santa Fe Springs, CA 90670	Deep cycle batteries used in neighborhood electric vehicle applications, among others.
U.S. Battery Company 1675 Sampson Ave. Corona, CA 92879	Manufacturer of deep cycle batteries for use in electric and hybrid electric vehicle applications, among others.

Lightweight, High-strength Materials

Alcoa 16680 Armstrong Ave. Irvine, CA 92606	The world's leading producer of primary aluminum, fabricated aluminum, and alumina that are used in advanced automotive components and assemblies. The California facility is primarily focused on lightweight, bonded materials for aerospace applications, but represents leading-edge technical capability.
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Hexcel Composites 75 N Mines Rd Livermore, CA 94550-2256	Manufacturers carbon fibers, prepregs, adhesives, honeycombs, special process and sandwich panels, RTM systems, laminates, thermoplastics and polyurethane systems for automotive applications.
Kaiser Aluminum & Chemical Corporation 6250 E. Bandini Blvd. P.O. Box 22100 Los Angeles, CA 90022-0100	A leading producer and marketer of fabricated aluminum products, alumina, and primary aluminum.
Superform USA 6825 Jurupa Ave Riverside, CA 92504-1039	The world's leading suppliers of aluminum and composite superplastically formed components.
Superior Industries International, Inc. 7800 Woodley Ave. Van Nuys, CA 91406-1788	Designs and manufactures aluminum wheels, suspension, and underbody components for the automotive industry. Top 100 supplier to Big 3 automotive companies.
XCORP Box 2761 Malibu, CA 90265	Automotive supply company that specializes in ways to reduce greenhouse gas emissions through the use of advanced composites.

Vehicular Designs

Art Center College of Design 1700 Lida St Pasadena, CA 91103-1999	Leading design center that works on advanced automotive and other concepts.
BMW Designworks 2201 Corporate Center Dr Newbury Park, CA 91320	Design center working on advanced styles and concepts.
Calty Design Research, Inc. 2810 Jamboree Road Newport Beach, CA 92660	Provides innovative design solutions for Toyota, Lexus and Scion vehicles (including Toyota's hybrid electric Prius) and supports North American production with color, trim and wheel design. Project activities include research, experimental concepts, advanced design, competition design, and production design.
Hyundai Kia Design and Technical Center 12610 East End Avenue Chino, CA 91710	Design and math modeling of new vehicle designs. More than 100 auto designers, engineers, model makers and technicians.
Powers Design International 828 Production Place Newport Beach, CA 92663	One of largest independent automotive design firms.



Volvo Cars of North America, Inc. 700 Via Alondra Camarillo, CA 93012	Works on advanced automotive and mobility designs and concepts.
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Research Institutions

The Bourns College of Engineering - Center for Environmental Research and Technology (CE-CERT) 1084 Columbia Ave Riverside, CA 92507	Partnerships among industry, government, and academia that researches emissions, fuels, transportation systems, and vehicle technology research.
DaimlerChrysler Research and Technology North America Inc. 1510 Page Mill Road Palo Alto, CA 94304	The Research and Technology Center in Palo Alto, California is focusing on new technologies and trends including market development for alternative fuels and drivetrains.
EPRI Electric Power Research Institute 3412 Hillview Avenue Palo Alto, CA 94303	Non-profit energy research consortium for utility members, their customers, and society. Performs scientific research, technology development, and product implementation.
Lawrence Berkeley National Laboratory 1 Cyclotron Road Berkeley CA 94720	Conducts research across a wide range of scientific disciplines with key efforts including new energy systems and environmental solutions
Lawrence Livermore National Laboratory 7000 East Ave Livermore, CA 94550-9234	Research laboratory involved in energy storage, flywheels, and zinc, among others.
Mitsubishi Chemical Corp. 7127 Hollister Ave Goleta, CA 93117	High tech research and development company focusing on environmentally benign energy systems, "green" environmentally sustainable polymers, functional polymers, and biomaterials, among others.
Rockwell Scientific Company LLC 1049 Camino Dos Rios Thousand Oaks, CA 91360-2362	Conducts research on projects ranging from disruptive technologies intended to catalyze new business opportunities to technology application and transition.
San Jose State University Institute for Transportation Studies 210 N. 4th Street, 4th Floor San Jose, CA 95112	Sustainable transportation research.
Schatz Energy Research Center 1 Harpst St Arcata, CA 95521-8222	Working to establish clean and renewable energy technologies in our society by designing and building prototype proton exchange membrane (PEM) fuel cells and integrate them into complete power systems.



University of California Berkeley Institute of Transportation Studies 109 McLaughlin Hall, MC 1720 University of California Berkeley, CA 94720	Transportation research, education and scholarship.
University of California Davis, Institute of Transportation Studies Davis, CA 95616	One of the world's leading university programs on travel behavior, advanced environmental vehicle technology, and environmental impacts of transportation.
University of California Irvine Combustion Laboratory / Advanced Power and Energy Program Irvine, California 92697-3550	Promotes and supports the development and adoption of advanced power and energy systems by providing technological leadership with a vigorous program of research and beta testing, coupled with education and technology transfer to and from the market place.

Industry Support

Alternative Energy Systems Consulting, Inc. 1945 Camino Vida Roble, Suite A Carlsbad, CA 92008	Engineering and project development firm specializing in fuel cells and distributed generation (among other things); Fuel cell related tech assessment, performance testing, integration studies, market evaluations, etc.
Apollo Power P.O. Box 4142 Santa Cruz, CA 95063	Provides consulting, sales, and transitional assistance for biodiesel, fuel cell power, and hydrogen.
California Fuel Cell Partnership 3300 Industrial Boulevard Suite 1000 West Sacramento, CA 95691	A collaboration, unique to California, of auto manufacturers (including DaimlerChrysler, Ford Motor Company, General Motors, Honda, Hyundai Motor Company, Nissan, Toyota, Volkswagen), energy companies, fuel cell technology companies, and government agencies to advance automotive fuel cells.
Clean Air Vehicle Technology Center 1000 Broadway, Suite 410 Oakland, CA 94607	Nationally recognized company that provides advanced vehicle emissions testing and research. Extensive experience with both gasoline-powered vehicles and vehicles that run on alternative fuels.
Hydrogen Ventures, LLC 400 Continental Blvd FL 6 El Segundo, CA 90245-5074	Provides independent market research, assists with building business plans and financing strategies, and assists with technology development and demonstration.
Hygen Industries P.O. Box 955 Topanga, Ca, 90290	Consulting contracting for renewable hydrogen energy technologies involving project development and deployment, media, public relations, event planning, fundraising, marketing, and promotions.



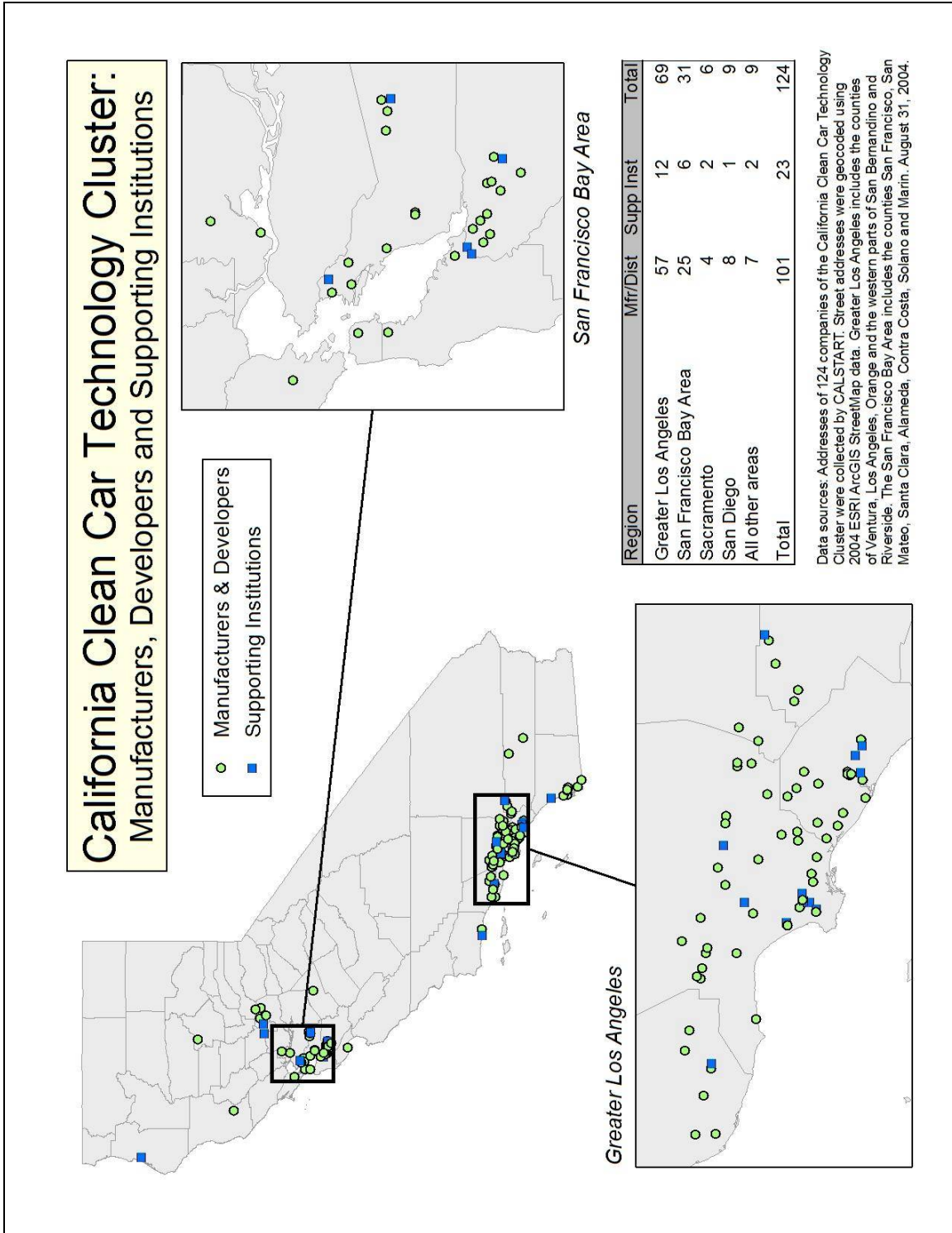
<p>WestStart-CALSTART 2181 East Foothill Blvd. Pasadena, CA 91107</p>	<p>Non-profit organization that works with the public and private sectors to develop advanced transportation technologies and foster companies that help clean the air, lessen our dependence on foreign oil, reduce global warming, and create jobs.</p>
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Automotive Marketing and Support

<p>American Honda Motor Co. 1919 Torrance Blvd. Torrance, CA 90501</p>	<p>Automobile manufacturer producing low greenhouse gas emitting vehicles and developing advanced internal combustion engine, hybrid, and fuel cell technologies.</p>
<p>BMW Technology Office 555 Hamilton Avenue, Ste. 300 Palo Alto, CA 94301</p>	<p>Engineers specializing in chemistry, information science experts, and logistics specialists working on advanced vehicle technologies.</p>
<p>Lincoln Mercury World Headquarters 1 Premier Irvine, CA 92618</p>	<p>Corporate headquarters for the Lincoln Mercury Division that, due to new trends and customer demands, Ford relocated to California to keep pace with change and be closer to customers needs.</p>
<p>Nissan North America 18501 S Figueroa St Gardena, CA 90248-4504</p>	<p>North American headquarters for the company that marketed the first gasoline SULEV vehicle.</p>
<p>Toyota Motor Corporation 19001 South Western Ave Torrance, CA 90501-1106</p>	<p>Automobile manufacturer working with advanced internal combustion engine, hybrid, and fuel cell technologies.</p>



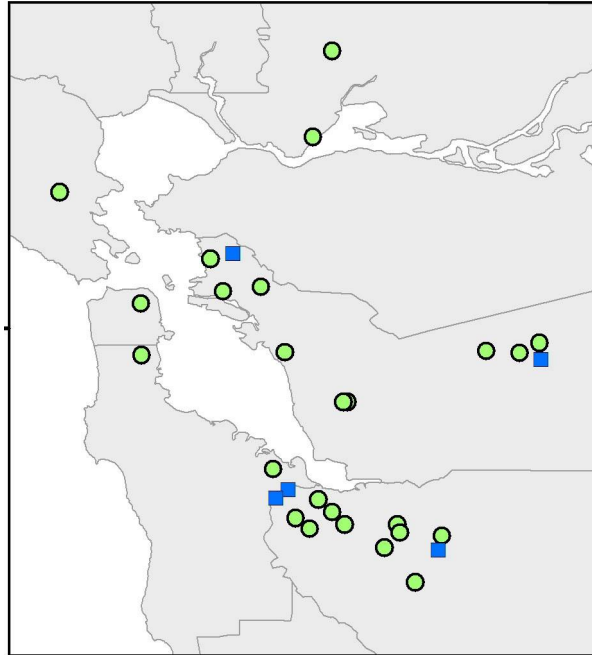
Appendix B: California Clean Car Technology Cluster Map





Appendix C: Company Breakdown by Region

San Francisco Bay Area



Manufacturers and Developers

AFS Trinity Power Corp.	Livermore
Avatar Engineering	Oakland
BAYTECH Corporation	Los Altos
Bio-Energy Systems, LLC	San Anselmo
Calytica Energy Systems	Mountain View
Cleaire	San Leandro
Clean Air Vehicle Technology Center	Oakland
Curtis PMC	Livermore
EPRI Electric Power Research Institute	Palo Alto
FuelSell Technologies	San Francisco
Hexcel Composites	Livermore
Intel Corporation	Santa Clara
Johnson Matthey	San Jose
Nanostellar	Menlo Park
NEC Electronics Inc.	Santa Clara
Polyfuel, Inc.	Mountain View
PolyPlus Battery Company	Berkeley
RIX Industries	Benicia
RKI Instruments, Inc.	Hayward
Symyx Technologies, Inc.	Santa Clara
The BOC Group	Fairfield
Tri-Circuit America, Inc.	Campbell



VCAP Technologies	Brisbane
Wesgo Metals (Morgan PLC)	Hayward
ZF Micro Devices, Inc.	Palo Alto

Supporting Institutions

BMW Technology Office	Palo Alto
DaimlerChrysler Research and Technology North America Inc.	Palo Alto
Lawrence Berkeley National Laboratory	Berkeley
Lawrence Livermore National Laboratory	Livermore
San Jose State University Institute for Transportation Studies	San Jose
UC Berkeley Institute of Transportation Studies	Berkeley

Sacramento

Manufacturers and Developers

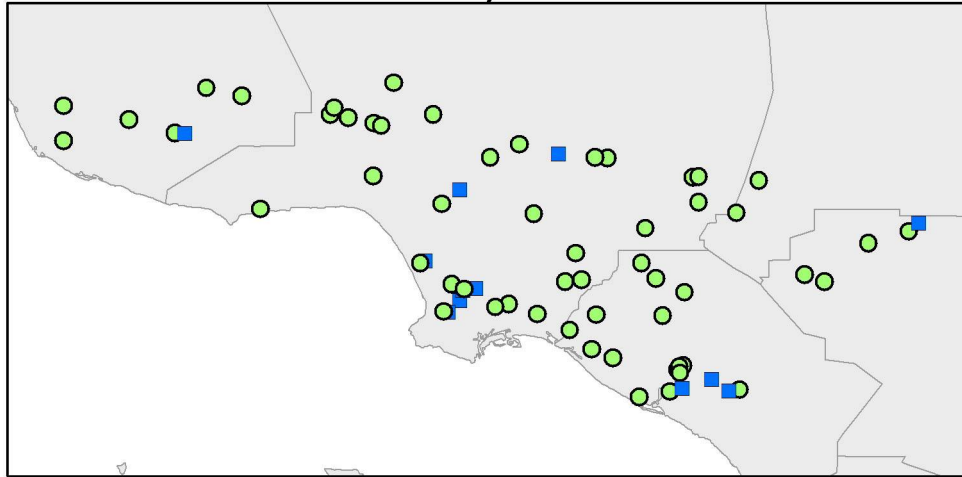
Altenergy	Gold River
Anuvu Incorporated	Sacramento
Down Stream Systems, Inc. (Omnifuel)	Citrus Heights
Procter and Gamble	Sacramento

Supporting Institutions

California Fuel Cell Partnership	West Sacramento
UC Davis, Institute of Transportation Studies	Davis



Greater Los Angeles



Manufacturers and Developers

- | | |
|---|------------------|
| A. E. Schmidt Environmental | Van Nuys |
| AC Propulsion | San Dimas |
| AeroVironment, Inc. | Monrovia |
| Alcoa | Irvine |
| Art Center College of Design | Pasadena |
| Asia Pacific Fuel Cell Technologies, Ltd. | Anaheim |
| BI Technologies/TT Group | Fullerton |
| BMW Designworks | Newbury Park |
| CalNetix | Cerritos |
| Calsonic North America | Irvine |
| Calty Design Research, Inc. | Newport Beach |
| Capstone Turbine | Chatsworth |
| Catalytic Solutions | Oxnard |
| Clean Energy Fuels | Seal Beach |
| Clean Fuel Connection, Inc. | Arcadia |
| Corning APT | Cypress |
| Cryogenic Experts Inc. | Oxnard |
| DENSO | Long Beach |
| DTI Energy, Inc. | Los Angeles |
| Engelhard | Sylmar |
| Extengine | Fullerton |
| Garrett Engine Boosting Systems | Torrance |
| Golden Cheese Company | Corona |
| H2 ECONOMY | Glendale |
| Harvest Energy Technology | Sun Valley |
| Honeywell Engines and Systems | Torrance |
| Horiba Instruments, Inc. | Irvine |
| Hydrospin Inc. | Huntington Beach |
| Hygen Industries | Los Angeles |



Hyundai Kia Design and Technical Center	Chino
IMPCO	Cerritos
Intelligent Energy	Long Beach
International Rectifier	El Segundo
Kaiser Aluminum & Chemical Corp.	Los Angeles
Kavlico Corporation	Moorpark
KleenAir Sys. Inc	Irvine
Lubrizol	Anaheim
Luxfer Gas Cylinder	Riverside
Maxdem Inc.	San Dimas
NEOMAX America, Inc.	Torrance
Parallel Products	Upland
Pentadyne	Chatsworth
Powers Design International	Newport Beach
Powerzinc Electric, Inc.	City Of Industry
Praxair	Carson
Quantum Technologies	Irvine
Soligen Technologies, Inc.	Northridge
Structural Composites	Pomona
Superform USA	Riverside
Superior Industries International, Inc.	Van Nuys
Toyota Technical Center	Gardena
Trojan Battery Company	Santa Fe Springs
Turbonetics	Simi Valley
TUV America Inc.	Huntington Beach
U.S. Battery Company	Corona
Volvo Cars of North America, Inc.	Camarillo
XCORP	Malibu

Supporting Institutions

American Honda Motor Co.	Torrance
DynaMotive Corporation	Los Angeles
General Motors ATC	Torrance
Hydrogen Ventures, LLC	El Segundo
Hyundai America Technical Center	Irvine
Lincoln Mercury World Headquarters	Irvine
Nissan North America	Gardena
Rockwell Scientific Company LLC	Thousand Oaks
The Bourns College of Engineering - Center for Environmental Research and Technology (CE-CERT)	Riverside
Toyota Motor Corporation	Torrance
University of California Irvine	Irvine
Combustion Laboratory / Advanced Power and Energy Program	
WestStart-CALSTART	Pasadena



San Diego

Manufacturers and Developers

Air Products	Chula Vista
Clean Air Power	San Diego
General Atomics	San Diego
Green Star Products	Chula Vista
Hawker Energy Products, Inc.	San Diego
ISE Research	San Diego
Kyocera America, Inc.	San Diego
Maxwell Technologies	San Diego

Supporting Institutions

Alternative Energy Systems Consulting, Inc.	Carlsbad
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All other areas

Manufacturers and Developers

Apollo Power	Santa Cruz
Biodiesel Industries Inc.	Santa Barbara
Coval H2 Partners LLC	Desert Hot Springs
Imperial Western Products	Coachella
Makel Engineering Inc.	Chico
Parker Hannifin Corp. Racor Div.	Modesto
Yokayo Biofuels	Ukiah

Supporting Institutions

Mitsubishi Chemical Corp.	Goleta
Schatz Energy Research Center	Arcata



Appendix D: Survey Methodology

Initially, 327 companies and organizations were identified by CALSTART as potentially relevant to this assessment. However, subjecting these organizations to various criteria narrowed this group. First, organizations were included only if research suggested they had operations in California related to aspects of automotive greenhouse gas reduction. In particular, those organizations with a major and/or long-term California presence that were related to the advanced automotive, component, and technology industries were targeted for participation. While some organizations that didn't have California operations and/or weren't involved in automotive greenhouse gas reduction were sent surveys, these organizations either indicated they wouldn't participate and/or that the survey wasn't relevant to them.

Second, in all but a few instances, CALSTART only included those organizations that it believed employed at least ten people in California. Exceptions to this rule were made in a few instances where the greenhouse gas-reducing aspects of the organization's operations were particularly direct and/or relevant to an automotive greenhouse gas-reducing requirement.

Subjecting the organizations to these criteria reduced the list to 125 companies and organizations, which is printed in Section 3.2. Further examination that identified companies and organizations that were not able to answer the survey in time for inclusion in the analysis and/or whose structure prevented proper identification of an appropriate contact to receive the survey reduced the list to a final of 111 who were then targeted to receive the survey.

Description of Surveying Process

After identification, each company was contacted in order to determine the appropriate person to receive the survey. Since the survey questions involved speculating on changes in the operation's California investment and employment pending the increased use of



GHG-reducing technologies in vehicles, it was essential to determine a person with sufficient seniority and knowledge of the organization's California operations. In many cases this led to sending the survey to a vice president, chief operating officer, or business development manager. Discussions were held with the identified person so that he or she was aware that the survey would be sent in the near future.

After the survey was administered, follow-up phone calls were made to the recipients to make sure they received the survey, understood the questions, and were in fact the appropriate persons to receive and answer the questions. Unless an organization indicated that it didn't wish to participate in the survey, more follow-up phone calls were made periodically until a completed survey was received by CALSTART.

Possible Errors and Biases

A key challenge of this assessment that prevented larger participation was the *reluctance that organizations felt in revealing proprietary information*, even with the strict assurance of confidentiality stated by CALSTART. This reluctance is understandable as several of the companies sought for participation are privately held and, in this situation, business plans are closely guarded. However, even larger and/or publicly held companies were reluctant to speculate on hypothetical planning, which in some cases resulted in partially completed survey responses.

Another possible bias lies in the inherent nature of gathering information based on a vague hypothetical situation. Since this assessment seeks to measure employment and investment decisions based on a "requirement to significantly increase the use of technologies that reduce GHG tailpipe emissions in vehicles" rather than specifically base the questions on the proposed structure and requirements of AB 1493, *the questions were subject to interpretation*. Despite the emphasis both in writing and over the phone that, except for the last question, this survey should not be interpreted as being entirely based on regulation or AB 1493 but was merely based on a "requirement", several companies



were unable to make this distinction, expressed discomfort at having to speculate on regulation structure, and therefore withdrew from survey participation.

Constricted schedules also factor in to the survey response rate. On several occasions, an appropriate person who was willing to participate and be supportive of the surveying effort was identified within a targeted organization, but was *unable to find time in a hectic schedule to complete the survey*. Efforts made to combat this situation included making the survey only one page long and phrasing many of the questions in multiple-choice format. Still, respondents were often required to locate information that they were not familiar with and/or seek input from others in order to provide thoughtful and accurate answers.

Finally, in some cases, respondents were *unable to see the connection between their company's product(s) and vehicular GHG-reduction*. This was especially true for organizations working with technologies and products indirectly involved in GHG-reduction, such as manufacturers of electrical components specifically designed for 42-volt and higher automotive systems. However, this occurred with organizations more directly related to automotive GHG-reducing technologies and products as well. For example, in a couple of instances, manufacturers of technologies that are associated with a high level of potential for reducing tailpipe automotive GHG emissions, such as fuel cells, factored in variables of upstream fuel production and/or product lifecycle emissions in their responses, an issue outside the scope of this survey's focus on tailpipe emissions. While in some cases this may have lead to biased responses, in other cases it prevented participation in the assessment altogether.



Appendix E: Surveyed Companies and Organizations

AC Propulsion	AeroVironment, Inc.
AFS Trinity Power Corp.	Air Products
Alcoa	American Biofuels LLC
American Honda Motor Co.	Anuvu Incorporated
Art Center College of Design	Asia Pacific Fuel Cell Technologies, Ltd.
Avatar Engineering	Bio-Energy Systems, LLC
BMW Designworks	BMW Technology Office
California Council Science & Technology	California Fuel Cell Partnership
CalNetix	Calsonic North America
Capstone Turbine	Catalytica Energy Systems
CE-CERT	Chevron-Texaco
Clean Air Power	Clean Energy Fuels
Combustion Laboratory (UCI) / National Fuel Cell Research Center	Coval H2 Partners LLC
Cryogenic Experts Inc.	Curtis PMC
DaimlerChrysler Research and Technology North America Inc.	DENSO
Down Stream Systems, Inc. (Omnifuel)	DTI Energy, Inc.
DynaMotive Corporation	Enova Systems
Electric Power Research Institute (EPRI)	Extengine
Fluor Daniel	Ford Motor Company
Fuel Cell Energy, Inc.	FuelSell Technologies
General Atomics	General Motors
Golden Cheese Company	Golden Gate Petroleum
H2 ECONOMY	Harvest Energy Technology
Hawker Energy Products, Inc.	Hexcel Composites
Honeywell Engines and Systems / Garrett Engine Boosting Systems	Hydrogen Ventures, LLC
Hydrospin Inc.	Hygen Industries
Hyundai America Technical Center	Hyundai Kia Design and Technical Center
IMPCO	Imperial Western Products
Intel Corporation	International Rectifier
ISE Research	Kyocera America, Inc.
Lam Research Corp.	Lawrence Berkeley National Laboratory
Lawrence Livermore National Laboratory	Lee Escher Oil Company, Inc.
Lubrizol	Luxfer Gas Cylinder
Maxdem Inc.	Maxwell Technologies
Mitsubishi Chemical Corp.	NEC Electronics Inc.
Nissan North America	NUMMI
Ovonics Battery, ECD	Panasonic Industrial Company
Parallel Products	Parker Hannifin Corp
Pentadyne	Pi Technology



Pinnacle CNG Company	Polyfuel, Inc.
PolyPlus Battery Company	Powers Design International
Powerzinc Electric, Inc.	Praxair
Procter and Gamble	Quantum Technologies
Ricardo, Inc.	RIX Industries
RKI Instruments, Inc.	Robert Bosch Corporation Research and Technology Center
Rockwell Scientific Company LLC	Rose Batteries
Schatz Energy Research Center	Siemens Transportation Systems, Inc.
Soligen Technologies, Inc.	Structural Composites
Superform USA	Symyx Technologies, Inc.
Toyota Motor Corporation	Tri-Circuit America, Inc.
Trojan Battery Company	TUV America Inc.
U.S. Battery Company	UC Berkeley Institute of Transportation Studies
UC Davis, Institute of Transportation Studies	UTC Fuel Cells
VCAP Technologies	Volvo Cars of North America, Inc.
Wesgo Metals	XCORP



Appendix F: Survey Form

CONFIDENTIAL

Dear Company Representative,

WestStart-CALSTART, a non-profit organization focused on **advanced transportation technologies**, is conducting a study to assess the **economic impact** over the next 3 to 5 years of requiring a significant increase in the use of onboard greenhouse-gas-reducing technologies in vehicles. Because your company is identified as a leader in new transportation technologies and/or services, WestStart-CALSTART would appreciate your participation in this study by responding to this short survey. Please take a few moments of your time to answer, to the best of your ability, the questions listed below. All the information that you provide will be treated as **strictly confidential** and used only as part of an aggregate to assist with economic analysis.

Thank you for taking the time to assist us in this study.

Company Name:

Current Status

1) How many full time employees does your organization currently employ in:
 California? Outside California?

2) What was your organization's total revenue in 2003? \$

3) How many net employees have you added to California operations over the last 2 years?

Current Forecasts

4) How many employees do you plan to add (through acquisitions or internal additions) in the next 3 to 5 years in:
 California? Outside California?

5) How much revenue growth (%) do you expect over the next 3 to 5 years? %

6) How much investment in operations do you plan to make over the next 3 to 5 years in:
 California? \$ Outside California? \$

Hypothetical Forecasts

7) Would a requirement to significantly increase the use of technologies that reduce greenhouse-gas tailpipe emissions in vehicles:

a) Increase or decrease the number of employees your organization plans to hire for employment in California over the next 5 years? Increase <input type="checkbox"/> Decrease <input type="checkbox"/> Neither <input type="checkbox"/>	Based on your answer to 7a, please rate (1-5) the effect a requirement would have on the increase or decrease on hiring: (1=Negligible Effect, 5=Very Large Effect) <input type="text"/>
b) Increase or decrease the amount of money your organization plans to invest in California over the next 5 years? Increase <input type="checkbox"/> Decrease <input type="checkbox"/> Neither <input type="checkbox"/>	Based on your answer to 7b, please rate (1-5) the effect a requirement would have on the increase or decrease on investment: (1=Negligible Effect, 5=Very Large Effect) <input type="text"/>

8) Asking question 7a another way, requiring a significant increase in the use of technologies that reduce greenhouse-gas tailpipe emissions in vehicles could cause my company to increase or decrease employment (over current predictions) in California operations by as much as:

0% 20% 40% 60% 80% 100% other %

9) Asking question 7b another way, requiring a significant increase in the use of technologies that reduce greenhouse-gas tailpipe emissions in vehicles could cause my company to increase or decrease investment (over current predictions) in California operations by as much as:

0% 20% 40% 60% 80% 100% other %

10) The imposition of regulations that stringently limit California GHG automotive tailpipe emissions (such as California AB 1493) would likely affect your investment and hiring plans:

Very Negatively Negatively Neutrally Positively Very Positively

