SUBCHAPTER 3.2

ENERGY

Regulatory Setting
Energy Trends in General
Alternative Clean Transportation Fuels
Renewable Energy

3.2 ENERGY

3.2.1 REGULATORY SETTING

Federal and state agencies regulate energy use and consumption through various means and programs. On the federal level, the United States Department of Transportation (U.S. DOT), United States Department of Energy (U.S. DOE), and United States Environmental Protection Agency (U.S. EPA) are three agencies with substantial influence over energy policies and programs. Generally, federal agencies influence transportation energy consumption through establishment and enforcement of fuel economy standards for automobiles and light trucks, through funding of energy related research and development projects, and through funding for transportation infrastructure projects. On the state level, the California Public Utilities Commission (CPUC) and California Energy Commission (CEC) are two agencies with authority over different aspects of energy. The CPUC regulates privately-owned utilities in the energy, rail, telecommunications, and water fields. The CEC collects and analyzes energy-related data, prepares state-wide energy policy recommendations and plans, promotes and funds energy efficiency programs, and regulates the power plant siting process. California is preempted under federal law from setting state fuel economy standards for new on-road motor vehicles. Some of the more relevant federal and state transportation-energy-related laws and plans are discussed in the following subsections.

3.2.1.1 Federal Regulations

<u>Energy Policy and Conservation Act</u>

The Energy Policy and Conservation Act of 1975 sought to ensure that all vehicles sold in the U.S. would meet certain fuel economy goals. Through this Act, Congress established the first fuel economy standards for on-road motor vehicles in the U.S. Pursuant to the Act, the National Highway Traffic and Safety Administration, which is part of the U.S. DOT, is responsible for establishing additional vehicle standards and for revising existing standards. Since 1990, the fuel economy standard for new passenger cars has been 27.5 miles per gallon. Since 1996, the fuel economy standard for new light trucks (gross vehicle weight of 8,500 pounds or less) has been 20.7 miles per gallon. Heavy-duty vehicles (i.e., vehicles and trucks over 8,500 pounds gross vehicle weight) are not currently subject to fuel economy standards. Compliance with federal fuel economy standards is not determined for each individual vehicle model, but rather, compliance is determined on the basis of each manufacturer's average fuel economy for the portion of their vehicles produced for sale in the U.S. The Corporate Average Fuel Economy (CAFE) program, which is administered by U.S. EPA, was created to determine vehicle manufacturers' compliance with the fuel economy standards. The U.S. EPA calculates a CAFE value for each manufacturer based on city and highway fuel economy test results and vehicle sales. Based on the information generated under the CAFE program, the U.S. DOT is authorized to assess penalties for noncompliance.

Intermodal Surface Transportation Efficiency Act

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) promoted the development of inter-modal transportation systems to maximize mobility as well as address national and local interests in air quality and energy. ISTEA contained factors that Metropolitan Planning Organizations (MPOs), such as SCAG, were to address in developing transportation plans and programs, including some energy-related factors. To meet the new ISTEA requirements, MPOs adopted explicit policies defining the social, economic, energy, and environmental values that were to guide transportation decisions in that metropolitan area. The planning process for specific projects would then address these policies. Another requirement was to consider the consistency of transportation planning with federal, state, and local energy goals. Through this requirement, energy consumption was expected to become a decision criterion, along with cost and other values that determine the best transportation solution.

Transportation Equity Act for the 21st Century

The Transportation Equity Act for the 21st Century (TEA-21) was signed into law in 1998 and builds upon the initiatives established in the ISTEA legislation, discussed above. TEA-21 authorizes highway, highway safety, transit, and other surface transportation programs for the next six years. TEA-21 continues the program structure established for highways and transit under ISTEA, such as flexibility in the use of funds, emphasis on measures to improve the environment, and focus on a strong planning process as the foundation of good transportation decisions. TEA-21 also provides for investment in research and its application to maximize the performance of the transportation system through, for example, deployment of Intelligent Transportation Systems, to help improve operations and management of transportation systems and vehicle safety.

Clean Cities Program

The U.S. DOE's Clean Cities Program promotes voluntary, locally-based government/industry partnerships for the purpose of expanding the use of alternatives to gasoline and diesel fuel by accelerating the deployment of alternative fuel vehicles (AFVs) and building a local AFV refueling infrastructure. The Clean Cities Program has created more than 70 partnerships in communities throughout the country. Six of these partnerships have been established in the southern California region: Coachella Valley, Lancaster, Long Beach, Los Angeles, Northwest Riverside, and one administered by SCAG (SCAG, 2005).

3.2.1.2 State Regulations

State of California Integrated Energy Policy Report

In 2002, the Legislature reconstituted the State's responsibility to develop an integrated energy plan for electricity, natural gas, and transportation fuels. On November 1, 2003, and every two years thereafter, the CEC, in consultation with other State energy agencies, must provide an overview of the major energy trends and issues facing California, including supply, demand, price, reliability, and efficiency. It must assess the impacts of these trends and issues on public health and safety, the economy, resources, and the environment. Finally, it must make policy recommendations to the Governor and the Legislature that are based on an in-depth and integrated analysis of the most current and pressing energy issues facing the State (SCAG, 2005).

<u>Reducing California's Petroleum Dependence</u>

The CEC and CARB produced a joint report *Reducing California's Petroleum Dependence* to highlight petroleum consumption and to establish a performance based goal to reduce petroleum consumption in California over the next thirty years. The report includes the following recommendations to the Governor and Legislature regarding petroleum:

- Adopt the recommended statewide goal of reducing demand for on-road gasoline and diesel to 15 percent below the 2003 demand level by 2020 and maintaining that level for the foreseeable future.
- Work with the California delegation and other states to establish national fuel economy standards that double the fuel efficiency of new cars, light trucks, and sport utility vehicles.
- Establish a goal to increase the use of non-petroleum fuels to 20 percent of on-road fuel consumption by 2020, and 30 percent by 2030.

The CEC will use these recommendations when developing its series of recommendations to the Governor and Legislature for the integrated energy plan for electricity, natural gas, and transportation fuels (SCAG, 2005).

<u>Renewables Portfolio Standard</u>

California's renewables portfolio standard (RPS) requires retail sellers of electricity to increase their procurement of eligible renewable energy resources by at least one percent per year so that 20 percent of their retail sales are procured from eligible renewable energy resources by 2017. If a seller falls short in a given year, they must procure more renewables in succeeding years to make up the shortfall. Once a retail seller reaches 20 percent, they need not increase their procurement in succeeding years. The CEC and the CPUC are jointly implementing the standard.

<u>California Environmental Quality Act (CEQA)</u>

Appendix F of the CEQA Guidelines describes the types of information and analyses related to energy conservation that are to be included in EIRs that are prepared pursuant to the CEQA. In Appendix F of the CEQA Guidelines, energy conservation is described in terms of decreased per capita energy consumption, decreased reliance on natural gas and oil, and increased reliance on renewable energy sources. To assure that energy implications are considered in project decisions, EIRs must include a discussion of the potentially significant energy impacts of proposed projects, with particular emphasis on avoiding or reducing inefficient, wasteful and unnecessary consumption of energy.

3.2.2 ENERGY TRENDS IN GENERAL (STATEWIDE)

Figure 3.2-1 shows California's major sources of energy. In 2005, 37 percent of the petroleum came from in-state, with 21 percent coming from Alaska, and 42 percent being supplied by foreign sources. Also in 2005, 78 percent of the electricity came from in-state sources, while 22 percent was imported into the state. The electricity imported totaled 62,456 gigawatt hours (gWh), with 20,286 gWh coming from the Pacific Northwest, 42,170 gWh from the Southwest (CEC, 2005). (Note: A gigawatt is equal to one million kilowatts). For natural gas in 2005, 38 percent came from the Southwest, 23 percent from Canada, 15 percent from in-state, and 24 percent from the Rockies (CEC, 2005).

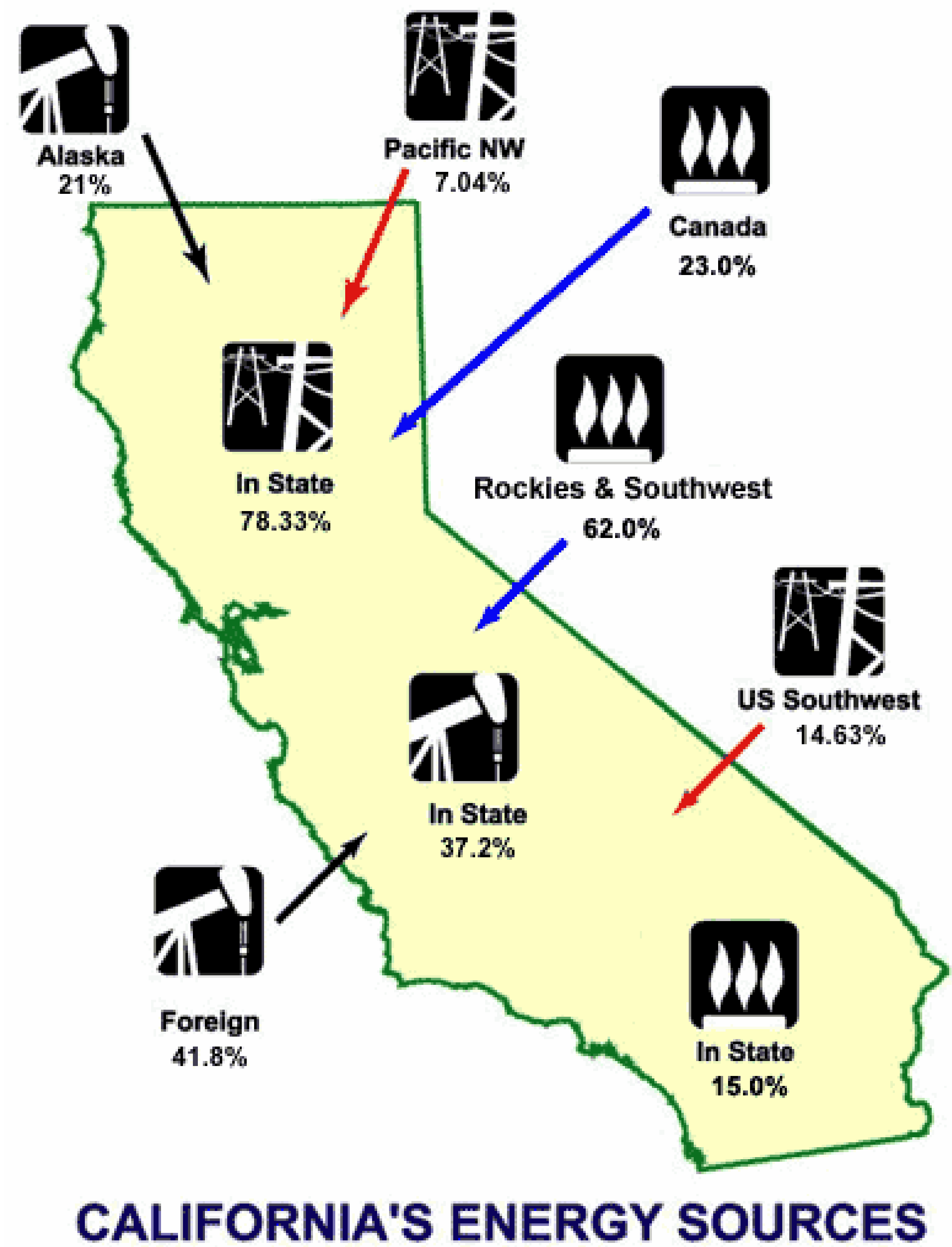
3.2.2.1 Electricity

Assembly Bill 1890, which was signed into law in 1996, attempted to restructure California's electricity market. Flaws in the market design combined with natural gas supply shortages and a number of other factors to produce an energy crisis in the state that resulted in numerous rolling blackouts, huge electricity price spikes, and bankruptcy or near-bankruptcy for two of the state's private utilities. The legislature responded by rescinding much of the deregulation scheme, creating a new state power authority, and enacting emergency energy conservation measures, mostly in the form of rebates and incentives. Currently, it is not clear whether lawmakers will choose to try again with a restructured market, or return to the former regulated market. This uncertainty has deterred many private investors from pursuing energy projects, meaning that the state, and the region's, future energy supply is far from assured.

Power plants in California provide approximately 85 percent of the in-state electricity demand. Hydroelectric power from the Pacific Northwest provides another 2.6 percent, down due to drought conditions in recent years, and power plants in the Southwestern U.S. provide another 13 percent. The relative contribution of in-state and out-of-state power plants depends upon, among other factors, the precipitation that occurred in the previous year and the corresponding amount of hydroelectric power that is available. Two of the largest power plants in California are located in southern California: Alamitos and Redondo Beach. Both of these plants consume natural gas. San Onofre, the state's largest power plant in terms of net capability, is nuclear powered and is located in San Diego County.

Local electricity distribution service is provided to customers within southern California by one of two privately owned utilities – either Southern California Edison Company or San Diego-based Sempra Energy – or by a publicly-owned utility, such as the Los Angeles Department of Water and Power and the Imperial Irrigation District.

Figure 3.2-1
California's Major Sources of Energy



Southern California Edison is the largest electricity utility in southern California with a service area that covers all or nearly all of Orange, San Bernardino, and Ventura counties, and most of Los Angeles and Riverside counties. Southern California Edison Company provides approximately 70 percent of the total electricity demand in southern California. Sempra Energy provides local distribution service to the southern portion of Orange County.

The Los Angeles Department of Water and Power is the largest of the publicly owned electric utilities in southern California. Los Angeles Department of Water and Power provides electricity service to most customers located in the City of Los Angeles and provides approximately 20 percent of the total electricity demand in the Basin. Other cities that operate their own electric utilities in southern California include Burbank, Glendale, Pasadena, Azusa, Vernon, Anaheim, Riverside, Banning, and Colton. Two water districts provide local electric service within the southern California: Imperial Irrigation District and Southern California Water Company. Imperial Irrigation District provides electricity to customers in Imperial County and the Coachella Valley portion of Riverside County. Southern California Water Company provides electric service to the community of Big Bear. Anza Electric Cooperative provides local distribution service to the Anza Valley area of southern Riverside County (SCAG, 2005).

Table 3.2-1 shows the amount of electricity delivered to residential and nonresidential entities in the counties in the Basin (CEC, 2005a).

Table 3.2-1

California Utility Electricity Deliveries for 2000

	Residential		Non-residential		Total	
County	**Number of Accounts**	**kWh[1] (million)**	**Number of Accounts**	**kWh (million)**	**Number of Accounts**	**kWh (million)**
Los Angeles	2,956,616	18,342	356,167	45,577	3,312,783	63,919
Orange	878,934	6,092	120,907	13,612	999,841	19,704
Riverside	500,171	4,396	157,503	6,425	657,674	10,821
San Bernardino	547,654	3,774	67,131	8,093	914,785	11,867

California Energy Commission (CEC, 2005a)

[1] kilowatt-hour (kWh): The most commonly-used unit of measure telling the amount of electricity consumed over time. It means one kilowatt (1000 watts) of electricity supplied for one hour.

Historically truck drivers idle their engines about eight hours a day, or as much as 1,800 hundred hours annually. Under federal law, truckers must rest eight hours for every 10 hours of driving. During this rest period, truck drivers often idle their engines to operate air conditioning or heat in their sleeper cabs or on-board appliances such as a television or microwave. Idling also keeps engines and fuel warm in cold weather.

Truck stop electrification (TSE) is a technology solution with two ways to reduce extended truck idling: on-board and off-board. On-board TSE combines battery storage on the truck with recharging at truck stops to power truck electric appliances. These applications include electric heaters and air conditioning units. Off-board technologies provide heating and air conditioning infrastructure at truck stops. Both on-board and off-board technologies allow the trucks to turn off their engines, thus, saving fuel and reducing air pollution.

TSE reduces petroleum consumption, air pollution, and greenhouse gas emissions. TSE reduces diesel fuel use by 1,800 gallons, NOx emissions by five tons, and carbon dioxide emissions by 21 tons per truck annually. Since June 2003, when the first truck stops along Interstate 5 in California featured Advanced TSE, over 400,000 gallons of diesel fuel have been saved in 500,000 hours of operation (CEC, 2006q).

3.2.2.2 Natural Gas

Four regions supply California with natural gas. Three of them—the Southwestern U.S., the Rocky Mountains, and Canada—supplied 87 percent of all the natural gas consumed in California in 2004. The remainder is produced in California. In 2004, approximately 50 percent of all the natural gas consumed in California was used to generate electricity. Residential consumption represented approximately 22 percent of California's natural gas use with the balance consumed by the industrial, resource extraction, and commercial sectors.

Southern California Gas Company, a privately-owned utility company, provides natural gas service throughout the district, except for the City of Long Beach, the southern portion of Orange County, and portions of San Bernardino County. The service area for the Long Beach Gas & Electric Department, a municipal utility owned and operated by the City of Long Beach, includes the cities of Long Beach and Signal Hill, and sections of surrounding communities, including Lakewood, Bellflower, Compton, Seal Beach, Paramount, and Los Alamitos. San Diego Gas & Electric Company provides natural gas service to the southern portion of Orange County. In San Bernardino County, Southwest Gas Corporation provides natural gas service to Victorville, Big Bear, Barstow, and Needles (SCAG, 2005) (CEC, 2006a).

Table 3.2-2 provides the estimated use of natural gas in California by residential, commercial and industrial sectors. In 2005, about 67 percent of the natural gas consumed in California was for industrial and electric generation purposes.

TABLE 3.2-2

California Natural Gas Demand 2005
(Million Cubic Feet per Day – MMcfd)

Sector	Utility	Non-Utility	Total
Residential	1,286	--	1,286
Commercial	567	--	567
Industrial	844	630	1,474
Electric Generation	1,711	683	2,394
Total	**4,419**	**1,313**	**5,732**

Source: CEC, 2006

3.2.2.3 Liquid Petroleum Fuels

California is currently ranked fourth in the nation among oil producing states, behind Louisiana, Texas, and Alaska, respectively. Crude oil production in California averaged 731,150 barrels per day in 2004, a decline of 4.7 percent from 2003. Statewide oil production has declined to levels not seen since 1943. In 2005, the total receipts to refineries of roughly 674 million barrels came from in-state oil production (39.4 percent), combined with oil from Alaska (20.1 percent), and foreign sources (40.4 percent) (CEC, 2006b).

California is a major refining center for West Coast petroleum markets with combined crude oil distillation capacity totaling more than 1.9 million barrels per day, ranking the state third highest in the nation. California ranks first in the U.S. in gasoline consumption and second in jet fuel consumption (CEC, 2006b).

A large network of crude oil pipelines connect producing areas with refineries that are located in the San Francisco Bay area, Los Angeles area and the Central Valley. Major ports in northern and southern California receive Alaska North Slope and foreign crude oil for processing in many of the state's 21 refineries (CEC, 2006b).

Most gasoline and diesel fuel sold in California for on-road motor vehicles is refined in California to meet state-specific formulations required by CARB. Major petroleum refineries in California are concentrated in three counties: Contra Costa County in northern California, Kern County in central California, and Los Angeles County in southern California. In Los Angeles County, petroleum refineries are located mostly in the southern portion of the county (SCAG, 2005).

In 2001, refineries in California processed approximately 655 million barrels of crude oil. Almost half of the crude oil came from in-state oil production facilities; 21 percent came from Alaska; and the remaining (approximately 29 percent) came from foreign sources. The long-term oil supply outlook for California remains one of declining in-state and Alaska supplies leading to increasing dependence on foreign oil sources (SCAG, 2005).

In the last fifty years, the human population has doubled, and the number of cars has grown tenfold from 50 to 500 million. As Americans continue to consume oil, oil demand could eventually outstrip oil supplies. By 2010, the world may be consuming as much as 90 million barrels per day, 20 percent more than it does now. The analyses of geophysicist M. King Hubbert suggest that one new barrel of oil is being found for every four barrels being consumed. Hubbert predicted that sometime between 2005 and 2025, world oil production would reach a peak and begin a sharp decline. However, a government summary of several world oil price forecasts for 2025 does not indicate a steep increase in petroleum prices (SCAG, 2005).

Californians consume nearly 44 million gallons of gasoline and 10 million gallons of diesel every day. California refineries produce these fuels and other products from crude oil and blending components. Transportation fuel production in California depends on the availability and quality of the crude oils used by refineries in the state. The supply of crude oil to California refineries has changed substantially in the last 10 years. Most notably, receipts of foreign crude oil have increased as production sources from California and Alaska have continued to decline (CEC, 2006c).

Historically, California has been relatively self-reliant in petroleum supplies. However, crude oil production in California has decreased by 23 percent since 1996. This decline of supply in the state has increased reliance on foreign and domestic imports. Starting in 1994, California refineries received more imported crude oil than in-state sources. In 2005, California crude oil accounted for approximately 37 percent of the total receipts. The quality of the crude oil used by the refineries, in conjunction with the complexity of processing units, dictates the percentages of products produced. For example, lower quality crude oil is more difficult to refine into lighter products, such as motor and aviation gasoline. Refineries have minimum crude oil quality requirements that are determined by the processing units in the plant. *It should be noted that most of the refineries in the Basin have been configured to handle lower quality (lower gravity and high sulfur content) crude oils, e.g., by installing desulfurization units*. Crude oil production in California averaged 731,150 barrels per day in 2004, a decline of 4.7 percent from 2003 (CEC, 2006c).

Production peaked in California in 1983. Production has declined at an average rate of 2.4 percent per year in the last 10 years. Offshore crude oil production peaked at 72 million barrels in 1995 and has declined by around 4.3 million barrels per year - or 10.2 percent per year - from 1995 through 2004 (CEC, 2006c).

In the last two decades, California refineries have been running increasingly closer to capacity levels. Southern California refineries also show an increasing level of crude oil imports. Refinery operations must also consider recent diesel regulations by the U.S. EPA and CARB. The U.S. EPA lowered the allowable amount of sulfur in on-road diesel fuel from less than 500 parts per million (ppm) to less than 15 ppm. This requirement became effective in 2006. The sulfur content and API gravity of crude oil input to the refinery in conjunction with the complexity of process units will affect the quantity of ultra-low sulfur diesel produced by the facility. The hydrocracking and hydrotreater units remove sulfur within the refinery. Hydrocracking units break hydrocarbon molecules into lighter compounds in the presence of hydrogen. Refineries throughout the U.S. upgraded their desulfurization processes in order to meet the new diesel sulfur standards. This upgrade typically involves techniques such as changing the catalyst in the hydrotreater or installing booster pumps to force more feedstock through the unit. Both hydrocrackers and hydrotreaters also remove heavy metals and aromatics from the feedstock. This is particularly important in California where lower aromatic standards will be required along with the new ultra low sulfur diesel standards (CEC, 2006c).

3.2.3 ALTERNATIVE CLEAN TRANSPORTATION FUELS

The demand for transportation fuels in California is increasing at a rapid rate. It is projected to grow by almost 35 percent over the next 20 years. Unless habits change, petroleum will be the primary source of California's transportation fuels for the foreseeable future. As demand continues to rise and in-state and Alaskan petroleum supplies diminish, California will rely more and more on foreign imports of crude oil. Most of California's transportation system is fueled currently by fossil fuels.

To reduce future reliance on imported fuels, and reduce combustion emissions from petroleum fuels, alternative fuels are increasingly being used as a replacement for petroleum fuels. Alternative fuels include biodiesel, natural gas (compressed or liquefied), electricity, ethanol and E85, gas-to-liquid fuels, hydrogen, natural gas (compressed or liquefied), methanol (M85), and liquefied petroleum gas (LPG). Assembly Bill 1007 requires the California Energy Commission, in partnership with CARB, to prepare a state alternative energy plan no later than June 30, 2007 to increase the use of alternative fuels in California. These alternative fuels are briefly described in the following subsctions.

3.2.3.1 Biodiesel

Biodiesel is an alternative fuel produced from renewable resources, such as soybeans or used restaurant grease. Biodiesel contains no petroleum, but it can be blended with petroleum diesel to create a biodiesel blend. It can be used in diesel engines with no major modifications. Biodiesel is simple to use, biodegradable, nontoxic, and essentially free of sulfur and aromatics.

Biodiesel is registered as a fuel and fuel additive with the U.S. EPA and meets clean diesel standards established by the CARB. Neat (100 percent) biodiesel has been designated as an alternative fuel by the U.S. DOE and the U.S. DOT.

Biodiesel is the only alternative fuel to have fully completed the health effects testing requirements under the Clean Air Act (CCA). The use of biodiesel in a conventional diesel engine results in substantial reductions of unburned hydrocarbons, carbon monoxide, and particulate matter compared to emissions from diesel fuel (CEC, 2006q).

3.2.3.2 Compressed Natural Gas (CNG)

CNG is natural gas under pressure which remains clear, odorless, and non-corrosive. Although vehicles can use natural gas as either a liquid or a gas, most vehicles use the gaseous form compressed to pressures above 3,100 pounds per square inch.

Natural gas is produced both worldwide and domestically at relatively low cost and is cleaner burning than gasoline or diesel fuel. Natural gas vehicles show an average reduction in ozone-forming emissions of 80 percent compared to gasoline vehicles.

CNG vehicles have been introduced in a wide variety of commercial applications, from light-duty trucks and sedans (e.g., taxi cabs), to heavy-duty vehicles (e.g., transit buses, street sweepers and school buses). In California, transit agency buses are some of the most visible CNG vehicles.

With the consumption of CNG increasing nationwide 145 percent over the past six years, the fueling infrastructure for natural gas vehicles continues to grow. California has over 200 CNG fueling stations. In southern California alone, there are more than 100 public fueling stations in major metropolitan areas from Los Angeles to the Mexican border. Another 50 stations are now under construction (CEC, 2006q).

3.2.3.3 Electricity

Electric vehicles (EVs) have been around for a very long time. In the early 1900s, there were more electric vehicles than gasoline-powered cars. In an EV, batteries are typically used to store the electricity that powers the electric motor(s) in the vehicle. The batteries must be recharged by plugging into a power source. Some EVs have on-board chargers, while others need to be plugged into an external charger. An EV is a zero-emission vehicle because its motor produces no tailpipe exhaust emissions.

Well-designed EVs can travel at the same speeds as conventional vehicles and provide the same safety and performance capabilities. In some instances, the EVs have better acceleration because of the characteristics of motors at low speeds. The range for EVs, however, is more limited than conventional vehicle ranges and spans from 50 to 130 miles. Variables include the vehicle's weight, engineering, design, type of battery, weather extremes, and the use of heating and air conditioning.

In 1990, CARB passed a rule to reduce the pollution from cars. CARB mandated that beginning in 1998, two percent of all vehicles sold in California would have to be zero emission vehicles (ZEVs), increasing to five percent in 2001 and 10 percent in 2003. The regulation was revised in 1996 to eliminate the "ramp up" but left in the 10 percent mandate in 2003. The new regulation also allowed partial ZEV (PZEV) for extremely clean emission vehicles that were not ZEV. As the deadline approached, CARB further amended is regulation in 2001 to allow extremely low-emission vehicles to get partial ZEV credits but required that auto companies still sell two percent pure-ZEVS (battery

EVs or hydrogen fuel cell vehicles). Additional changes to the ZEV regulations were made in 2003 by CARB in response to lawsuits.

One of the first modern EVs produced by a major auto company was the General Motors Impact. GM changed its name and started leasing the GM "EV1" in 1997. The company, however, decided to end its lease program and not pursue future production and operation of battery electric vehicles.

Beginning in 1999, nearly all of the major auto companies -- Ford, General Motors, Toyota, Chrysler and Honda offered at least one model electric car. That number dropped by 2002, with many auto companies working on hybrid and/or fuel cell vehicles. The largest group of EVs being sold today are called Neighborhood Electric Vehicles - NEVs. These are smaller vehicles that normally can't exceed 35 miles per hour. There are other types of electric vehicles. Many cities use electric-powered buses, trolleys, subways or light-rail (CEC, 2006q).

3.2.3.4 Ethanol and E85

Ethanol, or ethyl alcohol, has the chemical formula C2H5OH. Ethanol makes an effective motor fuel, with decades of motor fuel application experience in the United States and other countries.

Most ethanol used for fuel is being blended into gasoline at concentrations of five to 10 percent. Ethanol has replaced methyl tertiary butyl ether (MTBE) as a gasoline component in California's reformulated gasline. More than 95 percent of the gasoline supplied in the state today contains six percent ethanol. There is a small but growing market for E85 fuel (85 percent ethanol and 15 percent gasoline) for use in flexible fuel vehicles (FFVs), several million of which have been produced by U.S. automakers. Ethanol is also being used to formulate a blend with diesel fuel, known as "E-Diesel" and as a replacement for leaded aviation gasoline in small aircraft.

The cost of producing ethanol remains significantly higher than the cost of producing fuels from petroleum. The U.S. Government, since 1978, has applied tax incentives intended to make ethanol competitive with gasoline in the motor fuel marketplace. Continued progress with both conventional and advanced ethanol production technologies could someday result in ethanol production costs competitive with petroleum fuels.

Produced renewably from agricultural crops or from recycled wastes and residues, ethanol used as motor fuel offers a way to reduce greenhouse gas emissions from transportation sources. With respect to other motor vehicle emissions, differences between ethanol and gasoline are becoming less significant as new motor vehicles are produced with extremely low emission levels on all fuels. California's replacement of MTBE with ethanol was based on a determination that ethanol presents less of a pollution risk to drinking water sources (CEC, 2006q).

3.2.3.5 Gas-to-Liquid (GTL) Fuels

Gas-to-liquid (GTL) fuels are fuels that can be produced from natural gas, coal and biomass using a Fischer-Tropsch chemical reaction process. The liquids produced include naphtha, diesel, and chemical feedstocks. The resulting GTL diesel can be used neat (100 percent) or blended with today's diesel fuel and used in existing diesel engines and infrastructure. These fuels provide an opportunity to reduce dependence on petroleum-based fuels and reduce tailpipe emissions.

The GTL process needs large volumes of low-cost natural gas, less than $1.00 per million British Thermal Units (BTUs) (10 cents/therm), to compete with diesel fuel. Natural gas at this price and in these volumes does not currently exist in or near California. GTL produced from pipeline-supplied natural gas would not be competitive due to the higher alternative value of pipeline natural gas (today's value is 70-90 cents/therm). In the long term, technology is expected to develop fuels that can be produced from nearby U.S. coal reserves, biomass or waste.

California's nearest GTL supplier is the Shell GTL plant at Bintulu, Malaysia. The plant which began operation in 1993, was shutdown December 25, 1997, and restarted on May 20, 2000. This plant can produce up to 4,000 barrels/day of GTL fuel for worldwide sales. This is equivalent to two percent of California's diesel demand. In 2002, GTL fuel was used in Caltrans heavy-duty vehicles for one month. This trial confirmed that there were no fuel-related performance or maintenance problems. Furthermore, Yosemite water trucks used GLT fuel in a 12-month trial beginning in 2004. The results of this trial showed a significant reduction in vehicle emissions.

Availability of GTL fuel will continue to be limited, as fuel from the planned world scale Qatar plant will be spread across world markets. In the near-term, GTL fuel can be blended with conventional diesel to reduce existing diesel vehicle exhaust and toxic emissions. Furthermore, it could improve the prospects of new engines meeting the national 2007 and 2010 heavy-duty diesel engine emission standards.

Unmodified diesel engines, fueled with neat GTL, show the following average emission reductions compared to typical California diesel;

- Hydrocarbons (40 percent reductions)
- CO (39 percent reductions)
- NOx (eight percent reductions)
- PM (30 percent reductions)

While the cost of producing GTL fuel has been declining as a result of better catalysts, scale up and plant design, the transport and distribution costs to market are slightly higher than for locally produced refinery fuels. Research and development is focused on reducing costs further, as well as economies of scale from the new generation of world scale plants in Qatar. With limited GTL fuel available for some years, GTL fuel will be attracted to those markets prepared to pay these additional costs (CEC, 2006q).

3.2.3.6 Hydrogen as a Transportation Fuel

Hydrogen is the simplest, lightest and most plentiful element in the universe. It is made up of one proton and one electron revolving around the proton. In its normal gaseous state, hydrogen is colorless, ordorless, tasteless, non-toxic and burns invisibly. Hydrogen holds more energy per unit mass than other fuels. One kilogram of hydrogen contains as much energy (114,000 Btu, LHV) as a gallon of gasoline, which weighs 2,7 kilogram. However, hydrogen is stored as a compressed gas at 5,000 psi on most vehicles. Space considerations limit how much fuel can be stored on a vehicle.

Currently, most hydrogen is made from natural gas through a process known as reforming. Reforming separates hydrogen from hydrocarbons by adding heat. Hydrogen can also be produced from a variety of sources including water and biomass.

Hydrogen is not more dangerous than any other fuels. Hydrogen's hazards are usually managed easier than hydrocarbon fuels because hydrogen is lighter than air and it burns upward and disperses. Hydrogen can, however, cause brittleness in some materials, including metals, and can generate electrostatic charges and sparks through flow or agitation.

From 2000 to 2005, 65 light-duty fuel cell vehicles operating on hydrogen were placed in California and traveled more than 220,000 miles on California's roads and highways. These cars are still being tested and are available to a few fleets and consumers. Fuel cell buses are being tested at SunLine Transit in Thousand Palms, Alameda-Contra Costa Transit (AC Transit), and Santa Clara Valley Transportation Authority (Santa Clara VTA). The buses began operation in 2005. In addition, buses are being tested at Sacramento Municipal Utility District and University of California at Davis.

The U.S. DOE tested four internal combustion vehicles using hydrogen: a Dodge Ram van and a Ford F-150 with engines designed for compressed natural gas, a Ford F-150 with a gasoline engine that was modified to run on a hydrogen/natural gas blend, and a Mercedes van with a gasoline engine modified to run on pure hydrogen. The tests showed the hydrogen lowered emissions and increased fuel economy (as compared to the engine on natural gas or gasoline alone). Ford Motor Company has developed an internal combustion engine optimized to burn hydrogen instead of gasoline. The engine can reach an overall efficiency of about 38 percent, about 25 percent more fuel-efficient than a typical gasoline engine with nearly zero emissions. The engine is based on Ford's 2.3 liter engine used in the Ford Ranger. Supercharging allows the engine to deliver the same power as its gasoline counterpart (CEC, 2006q).

The California Fuel Cell Partnership is a collaboration of 31 member companies who are working together to promote the commercialization of hydrogen fuel cell vehicles.

Members include automobile manufacturers; energy providers; government agencies including SCAQMD; fuel cell technology companies and transit authorities. Since 2000, 149 light duty vehicles were placed in California and traveled more than 786,000 miles on California's roads and highways. Over the next few years, the California Fuel Cell Partnership hopes to place fuel cell vehicles in independent, fleet demonstration projects throughout California. One of the main goals of the California Fuel Cell Partnership is to facilitate members' placement of up to 300 fuel cell cars and buses into fleets and to promote hydrogen fueling stations to support them. There are currently 23 hydrogen fueling stations in operation, primarily in the San Francisco and Los Angeles urban areas. An additional 14 stations are planned through the central portion of the state (with a focus on Interstate 5 highway) so that hydrogen can be available and used throughout California (California Fuel Cell Partnership, 2006).

3.2.3.7 Liquified Natural Gas (LNG)

LNG is natural gas in a liquid form that is clear, colorless, odorless, non-corrosive, and non-toxic. LNG is produced when natural gas is cooled to minus 259 degrees Fahrenheit, through a process known as liquefaction. During this process, the natural gas, which is primarily methane, is cooled below its boiling point, whereby certain concentrations of hydrocarbons, water, carbon dioxide, oxygen, and some sulfur compounds are either reduced or removed. LNG is also less than half the weight of water, so it will float if spilled on water.

A majority of the world's supply of LNG comes from countries with the largest natural gas reserves: Algeria, Australia, Brunei, Indonesia, Libya, Malaysia, Nigeria, Oman, Qatar, Trinidad, and Tabago. LNG is transported in double-hulled ships specifically designed to handle the low temperature of LNG. These carriers are insulated to limit the amount of LNG that evaporates. LNG carriers are up to 1000 feet long and require a minimum water depth of 40 feet when fully loaded. Currently, there are approximately 140 LNG ships world-wide.

LNG terminals in the United States are located in Everett, Massachusetts; Cove Point, Maryland; Elba Island, Georgia; Lake Charles, Louisiana; and Puenelas, Puerto Rico. There are also plans to construct LNG terminals along the west coast of the United States. When LNG is received at most terminals, it is transferred to insulated storage tanks specifically built to hold LNG. There have been several proposed LNG terminals on the West Coast, including the Port of Long Beach. These tanks can be found above or below ground and keep the liquid at low temperature to avoid evaporation.

When cold LNG comes in contact with warmer air, it creates a visible vapor cloud from condensed moisture in the air. As it continues to get warmer, the vapor cloud becomes lighter than air and rises. When the vapor mixes with air, it is only flammable when the mixture is between five to 15 percent natural gas. When the mixture is less than five percent natural gas it doesn't burn (lower explosive level). When the mixture is more than 15 percent natural gas in air, there is not enough oxygen for it to burn (upper explosive level). As a liquid, LNG is not explosive. LNG vapor will only explode in an enclosed space within the flammable range of five to 15 percent.

Benefits of LNG in transportation applications:

- LNG is produced both world-wide and domestically at a relatively low cost and is cleaner burning than diesel fuel. Since LNG has a higher storage density, it is a more viable alternative to diesel fuel than compressed natural gas for heavy-duty vehicle applications.

- In addition, LNG in heavy-duty natural gas engines achieves substantailly lower NOx and particulate emission levels than diesel.

California's LNG fuel infrastructure is expanding rapidly. By the end of 2005, there will be more than 40 locations strategically located near major highways and thoroughfares throughout the state. To further enhance the supply and distribution, there are plans to construct one or more fueling terminals in southern California and/or Mexico (CEC, 2006q).

3.2.3.8 Methanol and M85

Methanol (methyl alcohol), often referred to as "wood alcohol", is a clean-burning liquid alternative transportation fuel. Methanol is normally produced from natural gas but also can be produced from coal or biomass crops, such as bagasse, the pulp residue left over from sugar cane.

According to the American Methanol Institute, methanol has been used for more than 100 years as a solvent and a chemical building block to make consumer products such as plastics, plywood and paint. It was first discovered in 1823 by condensing gases from burning wood into a liquid. Consumers use methanol directly in windshield washer fluid, gas-line antifreeze and as model airplane fuel. Methanol's power, performance, and safety have also made it the fuel of choice for Indianapolis 500 race cars since 1965.

M85 (85 percent methanol and 15 percent unleaded gasoline) has an octane rating of 102, compared to 92 for premium unleaded and 87 for regular unleaded gasoline. M85 showed a 50 percent reduction in total toxic air pollutants suspected or known to cause cancer (including acetaldehyde; benzene; 1,3 butadiene), when compared to gasoline.

Methanol was sold in California as part of a public-private partnership between the state of California and oil companies. It was actually a blend of 85 percent methanol and 15 percent unleaded gasoline, which enhanced starting ability in cold weather and safety. Known as M85, this blend was originally seen as an interim step to the use of M100, or neat methanol, which offers greater air quality benefits. After the demonstration program ended, however, the oil companies discontinued selling M85. M85 is no longer available.

The CEC worked with several oil companies to sponsor more than 60 methanol fueling facilities throughout California. These stations supplied M85 to a number of private and government fleet vehicles, as well as privately-owned vehicles. There are also about 50 private methanol fueling sites operated by Caltrans, public and private fleets, and school and transit districts. The ten-year program actually lasted about 15 years from 1988 through 2003.

The CEC began testing alcohol-powered vehicles in 1978. It was only in the mid-1980s when the fuel-flexible vehicle (FFV) technology was created, first by Ford and followed closely behind by GM, that the number of vehicles began to increase dramatically. It was not until the 1990s, however, that the vehicles were available for sale to fleets and the general public. A few auto companies continue to sell FFVs, but they are set up for ethanol - E85. By 1996, approximately 13,000 FFVs, along with about 500 buses (including school buses) and trucks, were running on methanol in California (more than the rest of the country combined).

Methanol was, at one time, a very promising alternative transportation fuel, but has been eclipsed by support for ethanol - mostly outside of California from corn-producing states - and compressed natural gas - supported by natural gas utility companies. There has been little effort in the last five years to pursue methanol. However, the fuel has been considered as a source of hydrogen for fuel cell vehicles.

The state's demonstration program proved that methanol could be a viable fuel but required government assistance to bring it into the marketplace. Methanol and M85 and California's programs did spur the oil industry into creating cleaner-burning gasoline formulations and helped create technical innovations in alternative transportation fuels and vehicles (CEC, 2006q).

3.2.3.9 Propane (LPG)

Motor Fuel Propane, otherwise known as Liquefied Petroleum Gas (LPG), is produced as part of natural gas processing and crude oil refining. In natural gas processing, the heavier hydrocarbons that naturally accompany natural gas, such as LPG, butane, ethane, and pentane, are removed prior to the natural gas entering the pipeline distribution system. In crude oil refining, LPG is the first product that results at the start of the refining process and is therefore always produced when crude oil is refined.

Propane is a gas that can be turned into a liquid at a moderate pressure, 160 pounds per square inch (psi), and is stored in pressure tanks at about 200 psi at 100 degrees Fahrenheit. When propane is drawn from a tank, it changes to a gas before it is burned in an engine. Propane has been used as a transportation fuel since 1912, and is the third most commonly used fuel in the United States, behind gasoline and diesel. More than four million vehicles fueled by propane are in use around the world in light-, medium-, and heavy-duty applications. Propane holds approximately 86 percent of the energy of gasoline and so requires more storage volume to drive a range equivalent to gasoline, but it is price competitive on a cents-per-mile-driven basis. LPG has a long and varied history in transportation applications. It has been used in rural and farming settings since its inception as a motor vehicle fuel.

Over time, propane has been used in several niche applications such as for fork-lifts, both inside and outside warehouses, and at construction sites. Use of propane can result in lower vehicle maintenance costs, lower emissions, and fuel costs savings when compared to conventional gasoline and diesel. Presently, domestic auto makers have reduced their offerings of vehicles that can operate using propane and other gaseous fuels; this has placed renewed emphasis for the conversion or "upfitting" of new vehicles to operate on propane and compressed natural gas now, and possibly hydrogen in the future.

Vehicle conversions in the 1970s started a very large upswing in the numbers of vehicles capable of using propane, as rising gasoline prices compelled drivers to find more economical fuel sources. The propane industry is once again focused on the conversion or upfitting of vehicles, to maintain the fuel as a viable motor fuel alternative that can provide both emission and petroleum displacement benefits, in the absence of original engine manufacturer (OEM) offerings.

Approximately 1,200 facilities in California dispense propane. Nearly all of these facilities are used primarily to fuel residential and commercial applications such as heaters, recreational vehicles, and barbecues. About half of all these facilities are capable of providing propane as a motor fuel, though only about three percent of all the fuel dispensed is used for transportation applications. Since 2000, the California state fleet has purchased, and is now operating in daily use, nearly 1,600 bi-fuel Propane Ford F-150 pickup trucks. The potential use of propane in those vehicles constitutes the largest petroleum displacement for the state fleet; it could displace approximately 4.4 percent of the total fleet fuel use, if these vehicles were exclusively operated on propane.

Accordingly, the CEC and the U. S. DOE have provided funding to establish 25 motor fuel propane stations across the state. These stations are situated for convenient use by CalTrans and the Department of Water Resources fleets, and for use by the public. The stations, operated by CleanFuel USA and Delta Liquid Energy, are unique from other propane filling stations. They have dispensers on the fueling island at a gasoline station, use fleet fueling cards or credit cards, and offer fuel that is priced competitively with gasoline or diesel on a fuel equivalency basis.

Propane is a low-emission, economic and easily used fuel that can play an important role as an alternative, non-petroleum fuel for our state and the nation. Given the right conditions and incentives, propane can steadily displace a growing volume of petroleum fuels in California, and therefore help provide a broader, more competitive transportation fuel market in the state (CEC, 2006q).

3.2.3.10 Fuel Cells

Fuel cell technology dates back to the 1800s, but it was not until the end of the 20th century that it was used successfully in spacecraft to provide electricity and water. The technology can be used to make electricity to power vehicles, homes, and businesses. In

California, fuel cell electricity systems using renewable resources are eligible for funding under the state's Emerging Renewables Rebate Program.

Unlike conventional technologies, fuel is not "burned" but is combined in a chemical process. A fuel cell consists of two electrodes sandwiched around an electrolyte. Oxygen passes over one electrode and hydrogen over the other, generating electricity, water, and heat.

Hydrogen fuel is fed into the "anode" of the fuel cell. Oxygen (or air) enters the fuel cell through the cathode. Encouraged by a catalyst, the hydrogen atom splits into a proton and an electron, which take different paths to the cathode. The proton passes through the electrolyte. The electrons create a separate current that can be utilized before they return to the cathode, to be reunited with the hydrogen and oxygen in a molecule of water.

A fuel cell system that includes a "fuel reformer" can obtain hydrogen from any hydrocarbon fuel - from natural gas, methanol, and even gasoline. Other possible fuels include propane, hydrogen, anaerobic digester gas from wastewater treatment facilities, and landfill gas.

Fuel cells are being designed for use in stationary electric power plants to provide reliable, clean, high quality electricity for distributed power generation. These small systems can provide primary or backup power to commercial and industrial customers such as hotels, hospitals, manufacturing facilities, and retail shopping centers. Eventually, smaller fuel cells will be sold for use in homes, most of which will connect to the existing residential natural gas supplies.

For industries that require high quality uninterruptable power, such as the computer technology industry, fuel cells can provide power without disruptions or voltage distortions.

In addition to electricity, customers can take advantage of the heat from the fuel cell and use it for hot water, space heating and cooling, and industrial processes.

<u>Fuel Cell Types</u>

Fuel cells are categorized according to the type of electrolyte used. Some of the these include:

- Proton exchange membrane (PEM) fuel cells were used in the "Gemini" space craft missions and designed by DuPont. A solid polymer ion exchange membrane is used as an electrolyte. Platinum ruthenium is used as the catalyst. PEM fuel cells are being tested in mobile sources such as buses and smaller vehicles.

- Platinum is used as the catalyst in phosphoric acid fuel cells, one of the most mature fuel cells (and which relies upon aqueous phosphoric acid as an electrolyte).

- Alkaline fuel cells are one of the oldest types of fuel cells. They too rely upon platinum (or palladium) as the catalyst for a potassium hydroxide electrolyte.

All three of the above fuel cell types operate at temperatures that require that conversion of fuel to hydrogen, which occurs outside of the fuel cell. This approach introduces a level of complexity avoided by the following two fuel cell designs:

- Molten carbonate fuel cells rely upon nickel-based catalysts (and molten carbonates as electrolytes) and can operate at higher temperatures. Reforming the fuel into hydrogen can occur inside the fuel cell. Most of the larger fuel cells on the market today rely upon this approach.

- The Solid Oxide fuel cell relies upon a coated zirconia ceramic as the electrolyte, which translates into the ability to operate at even higher temperatures that can support fuel formulation within the fuel cell. No catalyst at all is required. This technology is the least mature of the fuel cell types currently on the market. Nevertheless, it offers the promise of reduced cost and greater quantities of thermal heat for use at the installation site (CEC, 2006m).

3.2.4 RENEWABLE ENERGY

Renewable energy has been used for thousands of years. From the heat of the sun to dry clothes, fruit and vegetables, to wind energy to grind corn or to power sail boats, renewable energy sources can be harnessed to do work.

Homes have been built to use the sun's rays to warm them in the winter. People and companies have used solar water-heating systems. Others have installed photovoltaic panels to make electricity. Still others have tapped the heat below ground in geothermal electricity systems, direct-use geothermal, or ground-source heat pumps (CEC, 2006e).

Public Resources Code § 25748 requires the CEC report annually to the Legislature on the Renewable Energy Program and the report shall include the following:

(1) A description of the allocation of funds among existing, new, and emerging technologies, the allocation of funds among programs, including consumer-side incentives, and the need for the reallocation of money among those technologies;

(2) The status of account transfers and repayments;

(3) A description of the cumulative commitment of claims by account, the relative demand for funds by account, and a forecast of future awards;

(4) An itemized list, including project descriptions, award amounts, and outcomes for projects awarded funding in the prior year.

The 2006 Annual Report must also address the allocation of interest earned on the funds deposited into the Renewable Resource Trust Fund (RRTF) and the voluntary contributions made by utility customers.

In addition, the 2006 Annual Report must include a discussion of the progress being made toward achieving Renewables Portfolio Standard (RPS), which requires retail sellers to procure at least one percent more renewable energy each year so that 20 percent of their total electric supply portfolio is made up of renewable energy generation by 2017. In 2003, the state's energy agencies accelerated this 20 percent goal to be met by 2010 and the Governor expanded the goal to 33 percent by 2020 for both investor-owned and municipal utilities. Integral to the RPS, production incentives referred to as supplemental energy payments (SEPs) will cover the appropriate above-market cost of renewable resources selected by retail sellers to fulfill their RPS obligations. Accordingly, the 2006 Annual Report must also identify the biomass fuels used by facilities receiving SEPs and their impacts on improving air quality (CEC, 2006o).

The Renewable Energy Program, which began in 1998, was reauthorized through 2006, however its approach for supporting renewable energy development was impacted by the energy crisis of 2000 and 2001. California's move to a restructured electricity market and the resultant energy crisis prompted policy makers to pursue a new method to encourage the development of renewable power: the RPS. Under the RPS, the Renewable Energy Program's focus is twofold:

- To increase, in the near term, the quantity of California's electricity generated by renewable energy resources, while protecting system reliability, fostering resource diversity, and obtaining the greatest environmental benefits for California residents; and

- To identify and support emerging renewable energy technologies with the greatest near-term commercial promise that merit targeted assistance.

The program continues to build a market for renewable energy by offering production incentives for new and existing utility-scale facilities powered by renewable energy; consumer rebates for on-site renewable energy systems; and consumer information on the purchase, installation, and available incentives for renewable energy (CEC, 2006o).

3.2.4.1 Hydroelectric Power

Hydro power is a significant source of California's and the nation's electricity. In 2004, about 16.5 percent of the total electricity in California is from hydro -- 14.9 percent from large hydroelectric plants, and about 1.6 percent is from small hydro facilities, which are 30 megawatts or smaller in size. Nationally, according to the U.S. DOE, hydro accounts for about 10 percent of the country's total electricity production - about 95,000 megawatts (CEC, 2006g).

The larger hydro plants on dams in California (such as Shasta, Folsom, Oroville, etc.) are operated by the U.S. Bureau of Reclamation and the state's Department of Water Resources. Smaller plants are operated by utilities, mainly Pacific Gas and Electric Company and Sacramento Municipal Utility District. Licensing of hydro plants is done by the Federal Energy Regulatory Commission with input from state and federal energy, environmental protection, fish and wildlife, and water quality agencies.

Hydroelectric power, a renewable resource, is generated when hydraulic turbines are turned by the force of moving water as it flows through a turbine. The water typically flows from a higher to a lower elevation. These turbines are connected to electrical generators, which produce the power. The efficiency of such systems can be close to 90 percent. Hydroelectric power is generated in the district, but is a smaller percentage of overall generation as compared to the rest of the state. Hydroelectric power is supplied to the district by investor-owned utilities, water districts, and municipalities (CEC, 2006d).

3.2.4.2 Geothermal Energy

Geothermal energy is produced by the heat of the earth and is often associated with volcanic and seismically active regions. California has 25 known geothermal resource areas, 14 of which have underground water temperatures of 300 degrees Fahrenheit (149 degrees Celsius) or greater.

Hot water and, in some instances, steam can be used to make electricity in large power plants. Hot water can also be put to direct use, such as heating greenhouses or other buildings. The constant temperature below ground can also be tapped to warm and cool residences through a ground-source heat pump.

Forty-six of California's 58 counties have lower temperature resources for direct-use geothermal. In fact, the City of San Bernardino has developed the largest geothermal direct-use projects in North America, heating at least three dozen buildings - including a 15-story high-rise and government facilities - with fluids distributed through 15 miles of pipelines. Environmentally benign fluids are discharged to surface water channels after heat is used.

When added together, California's geothermal power plants have a dependable installed capacity of about 2,030 megawatts. They produced 4.8 percent of California's total electricity in 2004 (about 14,000 gigawatt/hours) (CEC, 2006h).

The most developed of the high-temperature resource areas of the state is the Geysers. North of San Francisco, the Geysers was first tapped as a geothermal resource to generate electricity in 1960. It is one of only two locations in the world where a high-temperature, dry steam is found that can be directly used to turn turbines and generate electricity.

Other major geothermal locations in the state include the Imperial Valley area east of San Diego and the Coso Hot Springs area near Bakersfield. It is estimated that the state has a potential of more than 4,000 megawatts of additional power from geothermal energy, using current technologies.

Additionally, two forms of geothermal energy - Hot Dry Rock and Magma - have the potential to provide thousands of megawatts in California. Recent investigations in Hot Dry Rock were focused in the Clear Lake area of Lake County and magma research occurred in the Long Valley Caldera of Mono County (CEC, 2006h).

3.2.4.3 Biomass Electricity

Wood Heat

Biomass consists of organic residues from plants and animals that are obtained primarily from harvesting and processing of agricultural and forestry crops. These are used as fuels in direct combustion power plants. The biomass is burned, producing heat that is used to create steam to turn turbines to produce electricity. The steam can often be used for another process -- such as drying vegetables or using in a factory. This is called cogeneration.

Examples of some of the biomass residues that are utilized in direct combustion power plants are: forest slash, urban wood waste, lumber waste, agricultural wastes, etc. The components of biomass include cellulose, hemicelluloses, lignin, lipids, proteins, simple sugars, starches, water, hydrocarbons, ash and other compounds. The total estimated biomass resource potential of California is approximately 47 million tons.

Biomass energy is also the term used for the use of wood products to heat homes and businesses (CEC, 2006i).

Landfill Gas

When trash is buried at a landfill, an oxygen-free environment is created under the capping soil layer. With relatively dry conditions, landfill waste produces significant amounts of gas as it decomposes -- mostly methane. With Californians dumping nearly 50 percent of the state's annual waste collected in state landfills, the total amount of landfill gases produced in California is tremendous (CEC, 2006i).

If these gases (e.g., methane) were just released to the atmosphere, they could add to global climate change problems. They could also be potentially a fire or explosion hazard if not collected and removed properly. A good solution to the landfill gas problem is to collect it and burn it to produce electricity.

The gas can be collected by a collection system, which typically consists of a series of wells drilled into the landfill and connected by a plastic piping system. The gas entering the gas collection system is saturated with water, that water must be removed prior to further processing.

The typical dry composition of the low-energy content gas is 57 percent methane (natural gas), 42 percent carbon dioxide, 0.5 percent nitrogen, 0.2 percent hydrogen, and 0.2 percent oxygen. In addition, a significant number of other compounds are found in trace quantities. These include alkanes, aromatics, chlorocarbons, oxygenated compounds, other hydrocarbons, and sulfur dioxide (CEC, 2006i).

After the water is removed, the landfill gas can be used directly in reciprocating engines. The carbon dioxide can be removed with further refining, so purer methane can be used for electricity generation applications such as gas turbines and fuel cells. For example, Southern California Edison and Los Angeles Department of Water and Power operate a 40 kilowatt phosphoric acid fuel cell using processed landfill gas at a hotel/convention center complex in the City of Industry (CEC, 2006i).

<u>Digester Gas</u>

Anaerobic digestion is a biological process that produces a gas principally composed of methane and carbon dioxide otherwise known as biogas. These gases are produced from organic wastes such as livestock manure and food processing waste.

Anaerobic processes could either occur naturally or in a controlled environment such as a biogas plant. Organic waste such as livestock manure and various types of bacteria are put in an airtight container called digester so the process could occur. Depending on the waste feedstock and the system design, biogas is typically 55 to 75 percent pure methane. State-of-the-art systems report producing biogas that is more than 95 percent pure methane (CEC, 2006i).

The process of anaerobic digestion consists of three steps. The first step is the decomposition (hydrolysis) of plant or animal matter. This step breaks down the organic material to usable-sized molecules such as sugar. The second step is the conversion of decomposed matter to organic acids. And finally, the acids are converted to methane gas.

At Royal Farms No. 1 in Tulare, Calif., hog manure is slurried and sent to a covered lagoon for biogas generation. The collected biogas fuels a 70-kilowatt (kW) engine-generator and a 100 kW engine-generator. The electricity generated on the farm is able to meet monthly electric and heat energy demand.

Given the success of this project, three other swine farms (Sharp Ranch, Fresno, and Prison Farm) have also installed floating covers on lagoons. The Knudsen and Sons project in Chico, California, treated wastewater which contained organic matter from fruit crushing and wash-down in a covered and lined lagoon. The biogas produce is burned in a boiler. At Langerwerf Dairy in Durham, California, cow manure is scraped and fed into a plug-flow digester. The biogas produced is used to fire an 85-kW gas engine. The engine operates at 35-kW capacity level and drives a generator to produce electricity. Electricity and heat generated is able to offset all dairy energy demand. That system has operated since 1982. Another similar project is the renewable energy digester operated by the Inland Empire Utilities Agency that digests 225 tons of manure a day from local dairies to generate abou 500 kW of electricity (used to power a desalter, which purifies drinking water) (CEC, 2006s)

Many anaerobic digestion technologies are commercially available and have been demonstrated for use with agricultural wastes and for treating municipal and industrial wastewater. Where unprocessed wastes cause odor and water pollution such as in large dairies, anaerobic digestion reduces the odor and liquid waste disposal problems and produces a biogas fuel that can be used for process heating and/or electricity generation (CEC, 2006i).

Municipal Solid Waste

Waste-to-Energy Introduction: Californians create nearly 2,900 pounds of household garbage and industrial waste every second; a total of 45 million tons of waste per year (according to the California Integrated Waste Management Board) (CEC, 2006i).

Prior to the adoption of AB939 in 1989, most waste in California was disposed of in landfills. Today, however, because of the waste reduction requirements of AB939, nearly 50 percent of waste and its by-products are being recycled into more useful products. Some waste materials can also be used as a fuel in power plants to create electricity or other forms of energy.

These waste-to-energy power plants are defined by the type of fuel source they use: biomass, digester gas, industrial waste, landfill gas, and municipal solid waste. All together there are 103 waste-to-energy plants in California with a total installed capacity of 1,070 megawatts, about two percent of the state's total electrical capacity. These plants produced 5,701 million kilowatt-hours of electricity in 1997 (CEC, 2006i).

Municipal Solid Waste Power Plants: Municipal solid waste (MSW), can be directly combusted in waste-to-energy facilities as a fuel with minimal processing, known as "mass burn"; it can undergo moderate to extensive processing before being directly combusted as refuse-derived fuel; or it can be gasified using pyrolysis or thermal gasification techniques.

Each of these technologies can produce electricity as well as an alternative to landfilling or composting the MSW. In contrast with many other energy technologies that require fuel to be purchased, MSW facilities are paid by the fuel suppliers to take the fuel (known as a "tipping fee"). The tipping fee is comparable to the fee charged to dispose of garbage at a landfill (CEC, 2006i).

Mass Burn: Incoming trucks deposit the refuse into pits, where cranes then mix the refuse and remove any bulky or large non-combustible items (such as large appliances). The refuse storage area can be maintained under lower-than-atmospheric pressure to prevent odors from escaping. The cranes move the refuse to the combustor charging hopper to feed the boiler.

Heat from the combustion process is used to turn water into steam, with the steam then routed to a steam turbine-generator for power generation. The steam is then condensed via traditional methods (such as wet cooling towers or once-through cooling) and routed back to the boiler. Residues produced include bottom ash (which falls to the bottom of the combustion chamber), fly ash (which exits the combustion chamber with the flue gas [hot combustion products]), and residue (including fly ash) from the flue gas cleaning system.

The combined ash and air pollution control residue typically ranges from 20 percent to 25 percent by weight of the incoming refuse processed. This ash residue may or may not be considered a hazardous material, depending on the makeup of the municipal waste.

It may be possible to avoid the production of hazardous ash by preventing the sources that create hazardous waste from entering the system. It is also possible to treat the ash. Both of these methods avoid the costs of disposal at a limited number of landfills classified as able to handle hazardous materials. Non-hazardous ash can be mixed with soils for use as landfill cover or can be sold (or given away) for such beneficial uses as pavement aggregate or for cinder block production (CEC, 2006i).

Refuse-Driven Fuel: Refuse-derived fuel (RDF) typically consists of pelletized or "fluff" MSW that is the by-product of a resource recovery operation. Processing removes iron materials, glass, grit, and other materials that are not combustible. The remaining material is then sold as RDF. Both the RDF processing facility and the RDF combustion facility are usually located near each other, if not on the same site (CEC, 2006i).

Pyrolysis/Thermal Gasification: Pyrolysis and thermal gasification are related technologies. Pyrolysis heats organic material to high temperatures in the absence of gases such as air or oxygen. The process produces a mixture of combustible gases (primarily methane, complex hydrocarbons, hydrogen, and carbon monoxide), liquids and solid residues. Thermal gasification of MSW is different from pyrolysis in that the thermal decomposition takes place in the presence of a limited amount of oxygen or air.

The producer gas that is generated in either process can then be used in boilers or cleaned up and used in combustion turbine/generators. The primary area of research for this technology is the scrubbing of the producer gas of tars and particulates at high temperatures in order to protect combustion equipment downstream of the gasifier and still maintain high thermal efficiency.

Both of these technologies are in the development stage with a limited number of units in operation. The Hyperion Energy Recovery System operated by the city of Los Angeles has a system designed to fire dried sewage sludge in a staged fluidized bed combustor. The resulting gas was then combusted in stages, and the heat was used to turn water into steam, driving a 10-MW steam turbine-generator (CEC, 2006i).

3.2.4.4 Wind Power

The kinetic energy of the wind can be changed into other forms of energy, either mechanical energy or electrical energy. When wind fills a sail, its kinetic energy is being used to push a sailboat through the water. Farmers have been using wind energy for many years to pump water from wells using windmills. Wind has also been used to turn large grinding stones to mill or grind wheat or corn, just like a water wheel is turned by water power. The wind is also used by a wind turbine to generate electricity.

There are many windy areas in California. Problems with using wind to generate power are that it is not windy all year long nor is the wind speed constant. It is usually windier during the summer months when wind rushes inland from cooler areas, such as near the ocean, to replace hot rising air in California's warm central valleys and deserts. By placing mechanical wind turbines in these windy areas, the wind can be used to generate electricity.

A wind turbine is very similar to a child's pinwheel or the propeller of an airplane. The blade of a turbine is tilted an angle. The movement of the air is channeled creating low and high pressures on the blade that force it to move. The blade is connected to a shaft, which in turn is connected to an electrical generator. The mechanical energy of the turning blades is changed into electricity.

Wind speeds typically must be sustained to at least 10 miles per hour to turn larger turbines fast enough to generate electricity. The turbines usually produce about 50 to 300 kilowatts of electricity each. A kilowatt is 1,000 watts (kilo means 1,000). Ten 100 watt light bulbs can be lit with 1,000 watts for one hour. So, a 300 kilowatt (300,000 watts) wind turbine could light up 3,000 lights for one hour using 100 watt bulbs (CEC, 2006j).

There are more than 14,000 wind turbines in California grouped together in what are called wind "farms." The farms have roughly 1,800 megawatts of installed capacity. These wind farms are located mostly in the three windiest areas of the state:

- Altamont Pass east of San Francisco (outside the district)
- San Gorgonio Pass near Palm Springs (within the district)
- Tehachapi south of Bakersfield (outside the district)

Together these three places make enough electricity to supply an entire city the size of San Francisco with electrical power. All together the wind turbines in California produce about one percent of California's total electricity.

California's share of the world's wind-produced electricity dropped from about 90 percent in the early 1980s to about 10 percent today. Other countries, especially in Europe, have been adding thousands of new turbines each year, while California went through a relatively slow period of wind development. But California is adding new wind production. In 1998, an auction under the CEC's New Renewable Resources Account auctioned off funding support for 300 megawatts of new wind capacity. In December 2000, an additional 439 MW was added via a second auction (CEC, 2006j).

3.2.4.5 Solar (Photovoltaic Cells)

Almost all energy used can be traced back to the sun. Fossil fuels are plant and animal matter that decayed tens of millions of years ago and have been compressed and heated, turning them into coal, oil, and gases. Plants get energy from the sun and convert it through photosynthesis. Animals in turn eat plants, converting the stored energy into energy to keep themselves alive. Similarly, wind is created because of differential heating of land and water areas by the sun, creating movement of air from one area to another.

The Sun's energy can also be used directly. Modern-day devices that convert sunlight into energy are referred to as photovoltaic cells (PVs). They're also known as solar cells. Solar PV panels register efficiencies ranging from nine to 15 percent.

Solar photovoltaic cells are small, square shaped panel semiconductors manufactured in thin film layers from silicon and other conductive materials. When sunlight strikes the PV cell, chemical reactions release electrons, generating electric current. The small current from individual PV cells, which are installed in modules, power individual homes and businesses, or can be plugged into the bulk electricity grid.

When large collections of PV panels or modules are put together, they can be tied into the electricity grid system. These can supply additional power to areas that need electricity, but costs for new transmission lines and substations are prohibitive. These types of systems are basically Utility-Scale Applications of Photovoltaics. PV systems can also be used in homes, whether they are connected to the electricity grid or are in rural or remote locations (CEC, 2006p).

There are two primary PV markets. Off-grid systems are used where the cost of a PV system is cheaper than stringing electrical power lines long distances from the local utility. Grid-connected PV systems usually cannot compete directly with the cost of utility-produced power. However, with the changing deregulated marketplace, many people are now considering grid-connected PV systems. If the PV system provides more power than the home or business uses, additional electricity is fed back into the grid for general use. This effectively spins an electricity meter backward in what is known as "net metering."

Incentives are being offered to homeowners and small businesses by some states to help develop a more robust PV industry. In California, incentives from the Emerging Renewables Rebate Program can reduce the cost of a grid-connected system by up to 50 percent. Nationally, the Million Solar Roofs program begun in 1997 seeks to install solar energy systems on one million homes by 2010. With more than 350,000 systems installed by 2002, Million Solar Roofs is succeeding beyond expectations. (DOE, 2007)

Photovoltaics or solar cells can be purchased in two formats: 1) as a stand-alone module that is attached to the roof or on a separate system; or 2) using integrated roofing materials with dual functions -- as a regular roofing shingle and as a solar cell making electricity.

Because they do not produce polluting air emissions or water effluents, solar PV systems are prime candidates for supplying electricity at locations where such environmental impacts are unacceptable; for example, in parks and places where preserving high levels of environmental quality are important (CEC, 2006p).

3.2.4.6 Solar Thermal Energy

Solar Thermal Heating: The intense energy of the sun has long been used to heat liquids. Among the first mechanical uses of the sun was a 20-square-meter, parabolic concentrating reflector that boiled water and produced steam. This steam was used in a steam-driven printing press at the 1878 World's Fair in Paris.

In the late 1800s, relying upon the sun to heat water was common practice in the southwestern United States. Photos can be found showing pioneer families proudly showing off new homes equipped with solar water heaters. At one point, almost a quarter of the residents of Los Angeles relied upon the sun to heat their water with rooftop solar thermal systems.

The sun's heat can be used in two ways with homes and businesses. The sun is used to heat water for domestic hot water systems or the sun's light can be concentrated and water temperatures increased to make steam and electricity. Solar hot water systems use sunlight to heat water. They may be used to heat domestic hot water or for space heating. These systems are basically composed of solar thermal collectors and a storage tank. The three basic classifications of solar water heaters are:

- Active systems which use pumps to circulate water of a heat transfer fluid.
- Passive systems which circulate water or a heat transfer fluid by natural circulation.
- Batch systems using a tank directly heated by sunlight.

Solar Thermal Electricity: Solar energy can also generate electricity. Over the past 20 years, solar electricity generation technologies have grown by leaps and bounds, registering annual growth rates between 25 and 41 percent. Costs have also fallen by 80 percent. Global solar electric generation technologies contribute roughly 2,000 MW of electricity today. That figure is less than a tenth of the world's global electricity supply (CEC, 2006).

While solar photovoltaics (PV) are better known, California actually gets far more of its electricity from a solar thermal power plants. Nine distinct solar thermal power plants located in the Mojave Desert total 360 megawatts, by far the largest central solar power station in the world, producing enough electricity to supply 360,000 homes.

These solar thermal power plants rely upon curved mirrored troughs that concentrate sunlight. The sun heats a liquid that creates steam to turn a traditional turbine. A more efficient technology is called the "stirling dish," which is powered by an entirely new kind of engine. Instead of the internal combustion engine, which relies upon an explosion inside the engine walls to turn pistons, the stirling dish engine relies upon the sun to heat tubes filled with hydrogen that turn the crankshaft.

The solar thermal trough rankine cycle facilities are approximately 22 percent efficient. Stirling solar dishes have been measured at efficiencies as high as 30 percent. (These efficiency numbers are based on calculations that convert the sun's energy into the equivalent of British Thermal Units, a universally recognized measuring unit of energy commonly referred to as "Btu's". One Btu is the same quantity of heat required to raise the temperature of one pound of water one degree Fahrenheit.)