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A Brief on Ethanol
The Debate on Ethanol: Prospects and Challenges to California Producers

Rosa Maria Moller, Ph.D.

Prepared at the Request of Senator Richard Alarcón

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INTRODUCTION AND SUMMARY

This paper responds to a request of Senator Richard Alarcón to the California Research Bureau for an overview of issues related to ethanol, the most widely used renewable fuel in the United States.

The request is especially timely given recent developments in the energy markets where high pump prices for gasoline and diesel fuel have raised concerns about oil imports, energy security, and fuel conservation. Experts debate the timeframe in which production of world petroleum will peak. Some believe that this could occur in as little as ten years. Others believe that technological innovations for petroleum extraction and the discovery of additional reserves will prolong the time period before it peaks.

In this context, the increased demand for transportation fuel, driven by population growth and economic development, raises concerns as to whether the U.S. has the ability to meet fuel consumption needs in the future. Increased demand for oil from China, India, and other countries experiencing high growth rates will further tighten the oil market. Political instability in the Middle East is another factor that could exacerbate oil shortages. Limited refining capacity means the petroleum industry will need to increase imports of gasoline well above current levels to meet both U.S. and California demand for fuel. There are also substantial fears that oil price spikes may disrupt the economy.

After several years of attempts to pass a comprehensive energy bill to reduce petroleum dependency, Congress passed the Energy Policy Act of 2005 on July 29, 2005. Among other provisions, the Act incorporated a variety of measures to expand domestic energy production, including alternative and renewable fuels. Since the most widely used alternative fuel is ethanol, it will play a significant role in the effort to reduce our dependence on foreign oil and increase the United States' ability to control its own security and economic future. At the same time, the Act has several important impacts on California and its renewable fuel industry.

Californians consume about 15.5 billion gallons of gasoline per year, with 30 percent of the crude oil processed in the state's refineries coming from foreign sources. Moreover, demand is growing. The California Energy Commission forecasts that the state's total demand for gasoline and diesel fuels could increase by as much as 35 percent over the next 20 years. Given limitations on in-state oil refining capacity, this increase can only be met by higher gasoline imports.

Policy makers have for years sought viable alternative fuels for automobiles, and today ethanol is among the alternative fuels most in use. Today, California is the largest ethanol market, with an estimated demand for ethanol in 2004 of about 950 million gallons. However, much of this demand was for ethanol that was used to meet air quality-related fuel oxygenate requirements – requirements eliminated for California by the national Energy Policy Act of 2005.

As a result, the future of ethanol's use in California is an open question. Although the new federal law also includes a renewable fuels policy that requires blenders, refiners, distributors, and importers to have a certain amount of renewable fuel in gasoline sold or dispensed to consumers for the next ten years and beyond, it is unclear what effect this will have on California. This is because the renewable fuel requirements apply to companies rather than geographic areas. Thus, companies can comply with the requirements by supporting ethanol use in locations with more established fuel distribution systems than are in place in California.

Currently, almost all of the ethanol consumed in California is imported. Of the 950 million gallons consumed in 2004, only seven million gallons were produced in the state. This compares with 3,400 million gallons produced elsewhere in the country – mostly in the Midwest where corn is readily available as feedstock. According to the Renewable Fuels Association, California ranks 16th among the 20 states with production capacity and has the capacity to produce less than one-third of the next highest state, Kentucky.

Thus, elimination of the source of much of California demand for ethanol – the oxygenate requirement – in combination with a renewable fuels standard that the industry may be able to meet with concentrated, Midwest production, places California's nascent ethanol industry at risk.

This is not to say that California should not consider policies that support ethanol production and consumption in the state. Ethanol offers several environmental benefits when it is added to gasoline at levels of 20 percent or more and also could be used to displace large volumes of gasoline.

The air-quality effects of ethanol use in automobiles vary with its concentration. Mixing ethanol with gasoline lowers emissions of carbon monoxide and reduces toxic emissions. However, the use of lower than 20 percent ethanol blends result in increased NO_x emissions. The emissions associated with lower blends of ethanol are still the subject of debate, with test results depending on the analytic methodology. The California Air Resources Board (CARB) argues that the use of reformulated gasoline meeting California specifications without ethanol is better for the environment than reformulated gasoline with ethanol. On the other hand, advocates of ethanol argue that the adverse affects identified by CARB are: (1) exaggerated by CARB's analytic method, and (2) offset by other benefits associated with ethanol, such as reduced emissions of carbon monoxide and toxic compounds that are very harmful to health. Ethanol supporters indicate that as the ethanol content increases in lower blends (for example from E-5.7 to E-10) the net effect on air quality is positive since carbon monoxide and other emissions decrease significantly, while the volume of NO_x emissions only increase slightly.

The energy benefits of ethanol use in automobiles are also the subject of debate and vary with the type of material used to produce the ethanol. Energy benefits are measured by analyzing the "energy balance" – that is, whether the energy required for ethanol production exceeds the energy in the final product. Although this issue continues to be debated, most studies, including a recent study by the California Energy Commission, show a positive energy balance for ethanol fuels. The magnitude of the positive balance is least for ethanol produced from corn and greatest for ethanol produced from other cellulosic materials that require less energy to grow. These include fibrous plant materials such as wood and waste fibrous plant products such as paper and textiles.[*]

As previously mentioned, the Energy Policy Act of 2005 significantly weakens demand for ethanol in California and allows efforts to meet renewable fuel requirements to be concentrated in other parts of the country. Thus, ethanol's future as a viable alternative fuel in California may depend on state policies to encourage its production and consumption. Ethanol production, of course, requires a feedstock, and currently, most ethanol uses corn as that feedstock. In California, the use of other crops to produce ethanol is more profitable. However, according to industry's recent analyses, growing corn and processing it to ethanol and feed in California can be more energy efficient than in the Midwest, resulting in lower costs of production and greater greenhouse gas benefits. For example, about 30 percent of the energy used in corn processing for ethanol is used to dry the feed by-product.[1] In California, corn can be air-dried, and the high protein feed by-products can be fed wet to dairy cows rather than dried and shipped from the Midwest.

With high land prices and crop values, the prospects for a flourishing California ethanol industry heavily depend on using cellulosic materials for feedstock. There are plenty of cellulosic materials in the state. Taking into account the current alternative uses of biomass and the difficulties in collecting it, a 2001 report by the California Energy Commission estimates that about 200 to 400 million gallons a year of cellulosic ethanol could be produced in the state.[2] More recent estimates by the Biomass Collaborative raise this amount to 1.5 billion gallons per year.[3]

Developing a viable cellulosic ethanol industry, however, poses major production challenges, such as those related to feedstock collection and handling. Although California has large amounts of biomass material that could be used for feedstock, the cost of collecting biomass from forests or farmland is high. California also has large volumes of waste cellulosic materials such as paper and cotton products, but again, collecting and sorting the materials is expensive.

Other challenges are associated with the production process itself. New, advanced technologies are being developed for pretreating and converting cellulosic materials to sugar – a necessary step in ethanol production. Recent advances are promising. Iogen, for example, is a Canadian company that has already begun selling the world's first commercial cellulosic-based ethanol. Nevertheless, these technologies are not widely proven, and as a result, investment capital has been unavailable.

Those who support the ethanol industry argue that California should help the industry overcome these challenges with production incentives, such as subsidies and access to low-cost capital, and with funds to support research, development, and demonstration

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[*] California Energy Commission. *Costs and Benefits of a Biomass-to-Ethanol Production Industry in California*. Sacramento: the Commission, March 2001.

projects related to feedstock collection and handling, market development for production byproducts, and use of cellulosic materials.

They note, however, that even more important to the future of a California ethanol industry is whether California will be a market for the fuel. With the elimination of the state's oxygenate requirement for reformulated gasoline, new state policies are critical. Among the options for increasing California ethanol demand are policies that encourage the existing fleet of flexible fuel vehicles to run on high ethanol concentrations, such as E-85, and that expand the network of E-85 fuel stations.

Critics will argue that production and market incentives sufficient to sustain and expand California's ethanol industry would be costly, and the state cannot afford them. Advocates will counter with a list of the potential benefits to the state, including new sources of income and jobs where ethanol production occurs, creation of markets for agricultural waste, avoidance of adverse impacts associated with waste disposal, and environmental benefits resulting from increased use of ethanol as an alternative to gasoline. Other related benefits are reductions in landfill use and reduced risks of forest fire where forest residue is collected for feedstock.

The key question is whether California policy makers believe that the costs associated with increasing the use of renewable transportation fuels are worth the associated environmental and economic benefits.

This paper provides a comprehensive examination of the technical and economic issues related to these issues in an effort to inform the future debate. It integrates information from various reports on ethanol, as well as from conversations with representatives of the ethanol industry and relevant government agencies.

The paper has five sections:

- Section I provides a background on ethanol. It describes ethanol uses; key properties of ethanol; how ethanol is produced and transported; and the ethanol market in the United States and California, including current ethanol projects in the state.
- Section II describes the main factors determining the commercial viability of ethanol plants and challenges posed by these factors to California producers.
- Section III discusses federal, state, and California policies that support production and consumption of ethanol.
- Section IV gives an overview on the controversy surrounding ethanol.
- Section V presents the main conclusions of the study and a menu of potential policies to foster the development of the ethanol industry in California.

SECTION I: BACKGROUND

WHAT IS ETHANOL?

Ethanol (or ethyl alcohol, alcohol, grain spirit, or neutral spirit) is a flammable oxygenated liquid made by fermenting and distilling simple sugars from biological feedstock. The Bureau of Alcohol, Tobacco, Firearms, and Explosives requires that fuel grade ethanol be denatured to avoid payment of the beverage alcohol tax. To prevent its consumption as a beverage, ethanol is denatured by the addition of small quantities of substances that give it an unpleasant taste (the most common is gasoline).

HOW ETHANOL IS PRODUCED

Feedstock

Ethanol can be produced from dedicated biomass energy crops (cultivated and harvested for ethanol production) or from biomass waste-and residue-feedstock. Most world ethanol production is from crops such as sugar cane and corn that can be grown for other markets as well as for ethanol production. Feedstock costs are the largest portion of the total costs of biomass-to-ethanol production. The competitiveness of ethanol largely depends on the development of an ethanol industry based on the use of low-cost cellulosic materials (using waste or agricultural residues as feedstock).

Production Process

Ethanol production includes essentially three main steps: preparing the feedstock, fermenting simple sugars, and recovering the alcohol and residual non-alcohol materials.

Most domestic fuel ethanol is made primarily from corn produced in the United States. There are two processes of traditional corn-to-ethanol production: wet milling and dry milling. These methods differ primarily in the preparation of the material for fermentation (conversion of sugars into alcohol). In wet milling the corn kernel is presoaked and milled to produce germ, fiber, and starch. This process converts corn into corn oil, two animal feed products (corn gluten and corn gluten meal) and starch-based products such as ethanol, corn syrups, and cornstarch. Wet milling is a more costly process used mostly by larger producers.

The dry milling process involves cleaning and breaking down the kernel into fine particles, creating a coarse flour-like consistency for the hydrolysis step (conversion of molecules to sugars). Traditionally the dry milling process generates only two products: ethanol and DDGS (distillers grain, a high value animal feed product). A modern dry-mill ethanol plant produces 2.8 gallons of ethanol and 17 pounds of distiller's grains from one bushel of corn.[4] Both, the wet and dry milling processes generate carbon dioxide, which is expensive to produce in small amounts. Generally only the larger plants market this product.[5]

For biomass-to-ethanol production, various innovative biomass conversion technologies have been developed. Most biomass conversion processes utilize two or three technologies, sometimes in combination.[6]

1. **Pretreatment.** This process separates the four chemical components of biomass (hemicelluloses, cellulose, lignin, and extractives). Separation of extractives in an early pretreatment step is helpful for the manufacture of co-products that increase the revenues of the biomass-to-ethanol operation, as well as the removal of materials that might inhibit the processing of hemicelluloses, cellulose, and lignin. For example there is silica in rice straw and hulls that may be adapted to the demands of rubber and other industries. The percentage of extractives varies with biomass species.
2. **Hydrolysis.** After pretreatment comes hydrolysis by acids or enzymes (cellulases) that cut the hemicellulose and cellulose molecules into their component sugars. Two acid methods are concentrated acid hydrolysis (using concentrated sulfuric acid followed by dilution with water at relatively low temperatures) and dilute acid hydrolysis (dilute solution of sulfuric acid). Most current designs use two stages of hydrolysis, the first at dilute conditions to maximize the yield from hemicelluloses, and the second at higher concentrations and temperatures.
3. **Ethanol Extraction.** The last step is the conversion of carbon sugars to ethanol and other oxygenated chemicals.

State of Art for Ethanol Production

Much progress has been made to develop efficient technologies to produce ethanol commercially from corn. However, this has not been the case for cellulosic ethanol, although there are some producers, such as a company called Iogen that claims to have discovered a technology to produce ethanol efficiently from biomass at a commercial scale.

The major challenge has been adapting the process to convert a wide variety of biomass feedstock to sugars and then ethanol (grass wastes, paper wastes, wood wastes). A problem is that technologies designed to treat some feedstock are not adequate for other types of feedstock. For example, technologies used to treat cellulosic feedstock may not be appropriate for processing cull fruits because of the fundamental differences in the composition of these materials. Furthermore, some feedstock may be contaminated. For example, papers may contain inks that would make them difficult to pre-treat and convert to ethanol. Yard waste can be contaminated with dirt or rocks.

USES OF ETHANOL

As an Additive

Most ethanol fuel in the United States is used as an additive, either as an oxygenate or an octane booster in gasoline. Oxygenates are chemical compounds that contain oxygen and improve combustion, reducing carbon monoxide and hydrocarbon* emissions in motor vehicle exhaust. As an oxygenate, ethanol is used to prevent air pollution. As an octane booster, ethanol prevents early ignition, or "engine knock."

The majority of fuel ethanol is used in blends of gasoline and low-percentages of ethanol (gasoline and either 5.7, 7.7, or 10 percent of ethanol). These ratios yield the following approximate oxygen contents:

Table 1

Percent Blend	Percent Oxygen Content Provided
5.7	2.0
7.7	2.7
10.0	3.5

All vehicles, including older vehicles, can use blends of gasoline and up to 10 percent ethanol without any mechanical adjustments.[7] In California, most ethanol is used in blends of 5.7 percent.

As an Alternative Fuel

Ethanol is also used as an alternative fuel to replace gasoline in automobiles especially designed for its use. Blends of 85 percent ethanol with 15 percent gasoline (E-85) and 95 percent ethanol with 5 percent gasoline (E-95) are currently considered alternative fuels by the U.S. Department of Energy. The small amount of gasoline added to the alcohol helps the fuel vaporize.

Flexible fuel vehicles (FFVs) are vehicles capable of running on both ethanol (E-85 or E-95) and gasoline. The car industry manufactures various car and light truck FFV models.† In the U.S., there are over four million vehicles capable of running on E-85. More than 230,000 E-85 FFVs are registered in California. The population of FFVs is expected to exceed 300,000 by the end of the year.‡

As a Component in E-Diesel

Another use of ethanol is as a component in E-diesel. The use of oxydiesel is in an experimental stage.[8] Established under the Renewable Fuels Foundation in early 2002,

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* Hydrocarbons are also referred as volatile organic compounds (VOCs).

† GM is the largest producer of FFVs; most have been pickup and SUV models. Last year, Saab, (owned by GM) announced the development of a sedan to offer E-85 FFV option. Daimler Chrysler has manufactured about one million FFVs. There are also some flexible fuel vehicles that can run using more than one alternative fuel. For example, GM and Bosh in Brazil have developed the Astra sedan Multipower that can run on gasoline, ethanol, or natural gas.

‡ According to data in the California Department of Motor Vehicles Registration Database, about 234,000 E-85 FFVs were registered in California as of October 22, 2004. Source. California Energy Commission.

the E-Diesel Consortium includes participants from the government and industry who are working to facilitate the use of E-diesel.* There have been positive demonstrations in trucks, farm equipment, and buses that have encouraged continued work with stakeholders to identify and address issues related to the potential commercialization of E-diesel. Issues include engine warranties, materials compatibility, emissions, storage and handling requirements, fuel economy, the application of ASTM fuel standards, and health effects testing (EPA).† So far, a blend of 80 percent diesel fuel, 10 percent ethanol and 10 percent additives and blending agents has been demonstrated in fleets of buses with unmodified engines. Demonstration fleets of heavy-duty buses and trucks with diesel engines especially designed for using pure ethanol (E-100, with or without additives) have also been operated.

As a Feedstock for Biodiesel

Some representatives of the car industry propose ethanol as a feedstock for producing biodiesel.[9] Biodiesel is an alternative diesel fuel made from renewable sources such as new and recycled vegetable oils and animal fats. It is a biodegradable oxygenate that reduces toxics associated with petroleum diesel exhaust and the amount of carbon dioxide being released in the atmosphere.

Fats and oils can be chemically reacted with ethanol and a catalyst to produce fatty acid ethyl esters that meet the ASTM standard specifications for biodiesel. Although ethanol is more expensive, ester derived from ethanol is renewable and more environmentally benign than methyl ester derived from using methanol.[10] Blends of up to 20 percent volume biodiesel and 80 percent petroleum diesel fuels (B20) can be used in nearly all diesel equipment and are compatible with most storage and distribution equipment. Higher blends can be used in many engines built since 1994 with little or no modification.

As a Hydrogen Carrier

Ethanol can also be used as a hydrogen carrier for fuel cells and it is the most cost effective renewable source of hydrogen.‡ Fuel cells are electrochemical devices that

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* Some Participants include additive suppliers such as AAE Technologies/Octel Starreon, Pure Energy Corp.); engine manufacturers (John Deere), the U.S. Department of Energy (NREL, Argonne National Laboratory; Renewable Fuels Association (U.S. and Canada); National Corn Growers Association, and state and local, public, and private groups such as Nebraska Ethanol Board.

† ASTM International (formerly American Society for Testing and Materials) sets consensus specifications on transportation fuels.

‡ Biomass is often referred to as cellulosic or lignocellulosic biomass to differentiate it from grain-based, starch-containing feedstocks and sugars. Biomass (or cellulosic materials) is defined as matter produced through photosynthesis. It includes plant materials; agricultural, industrial, and municipal wastes, and residues derived from there (such as switch grass, rice straw, sugar cane (bagasse), trees, paper waste, plastics, plant and tree clippings cardboard). Biomass contains three primary constituents: cellulose, hemicellulose and lignin, and can contain other compounds (for example, extractives). Cellulose and hemicellulose are carbohydrates that can be broken down by enzymes, acids, or other compounds to simple sugars, and then fermented to produce ethanol.

combine hydrogen and oxygen to generate electricity more efficiently with less noise and pollution than internal combustion engines. All fuel cells are essentially fueled with hydrogen. According to a report from the University of Kansas, "University of Minnesota researchers have produced hydrogen from ethanol in a reactor small enough to heat homes and power cars."[11] For many, ethanol should be the fuel of choice for fuel cells because, compared to other alternatives, ethanol: (1) is more environmentally friendly, (2) is renewable, (3) is readily available, (4) is more efficient, and (5) has better performance.[12]

ETHANOL PROPERTIES

The review of some properties of ethanol is important for understanding some environmental and policy issues discussed later in this paper.

1. Ethanol is a renewable fuel, and readily biodegradable.* It contains 35 percent oxygen by weight, twice the oxygen content of MTBE (methyl tertiary butyl ether, another oxygenate).
2. Ethanol's energy content (measured in British thermal units (BTU)) is lower than that of gasoline. It takes about 1.3 gallons of ethanol to deliver the same mileage as one gallon of gasoline. At the 10 percent level blend (E10) this would equate to about 3 percent less energy.
3. Most studies, including analyses by the California Energy Commission, have shown that ethanol has a positive *energy balance* in that the amount of energy required to produce a given amount of ethanol is less than the amount generated by it. Many studies conducted since the late 1970s estimating the net energy value of corn ethanol have reported a wide range (some even negative). These variations are due to the use of different data and assumptions. A recent United States Department of Agriculture (USDA) study identified the factors causing this wide variation and developed a more consistent estimate. This study reported that the energy ratio of corn ethanol is estimated at 1.34; that is, for every BTU dedicated to producing ethanol there is a 34 percent energy gain. Furthermore, only about 17 percent of the energy used to produce ethanol comes from fuels, such as gasoline and diesel fuel.† For every 1 BTU of petroleum-based fuel used to produce ethanol, there is a 6.34 BTU gain.[13]

   The ethanol energy balance depends on the feedstock used and the technologies used in ethanol production. Estimates of the energy balance of corn ethanol have been rising over time.[14] The most recent report from the USDA Economic Research Service Office of Energy on this issue shows an even higher positive

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* As noted in an earlier footnote, renewable fuels are fuels derived from resources that are generally not depleted by human use, such as the sun, wind, and water movement. A "biodegradable" product is a product that can break down, safely and relatively quickly, by biological means, into the raw materials of nature and disappear into the environment.

† Other sources of energy are coal and natural gas.

energy balance, with a positive ratio of 1.67 due to technological advances in ethanol conversion and increased efficiency in farm production.[15]

Research indicates that ethanol production from cellulosic wastes and residues offers a better energy balance and associated carbon emission result than conventional ethanol production using corn. The net energy ratio for ethanol from cellulosic materials is 2.62, compared to .81 for gasoline.[16]

4. Another property of ethanol is that it raises the *volatility* (measured by *vapor pressure*) of the blended fuel. A fuel's ability to vaporize (or change from liquid to vapor) is referred to as its *volatility*, a very important fuel characteristic that can affect several areas of vehicle performance. For example, high volatility may reduce fuel economy.[*] To control volatility, refiners adjust gasoline seasonally, increasing its volatility in winter (to provide good cold start and warm up), and decreasing it in summer (to minimize vapor lock and to comply with environmental standards). From the viewpoint of the environment, higher volatility is not good because it leads to more evaporative emissions of ozone forming compounds.

   Since one test procedure to measure volatility is vapor pressure using the Reid test method, the term Reid Vapor Pressure (RVP) has become synonymous with vapor pressure. When ethanol is added to gasoline at low levels (E-10 or less), the resulting fuel has higher vapor pressure than the gasoline.[†] California specifications (and federal Environmental Protection Agency (EPA) specifications) include RVP caps to reduce ethanol's impact on volatility (which would otherwise increase VOCs (volatile organic compounds emissions). Hence, refiners must adjust the base fuel (gasoline) to accommodate the vapor pressure increase resulting from the addition of ethanol. California gasoline specifications require a 7.2-psi cap. A base fuel with a targeted vapor pressure of 7.2 psi needs to be below 6.0 psi to accommodate the ethanol addition. Consequently, to comply with RVP specifications, refiners need to remove butane and/or pentane.[17] This operation increases the cost of the blended fuel and reduces refinery output.[‡] The control of VOC emissions under California reformulated gasoline regulations leads refiners to use no more than 5.7 percent ethanol in their blends.[§]

   Evaporative emissions of ozone-forming compounds due to increased RVP peak with a mixture that contains between 5 and 10 percent ethanol and then start to decline at 20 percent blends or more, reaching a level equal to pure gasoline once there is about 40 percent ethanol. Above 40 percent, the blended fuel results in fewer evaporative VOC emissions than does gasoline. A mixture of 85 percent ethanol and 15 percent gasoline (E-85) results in nearly the same four- or five-fold reduction in emissions that pure ethanol would produce.[18]

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[*] If too much vapor is formed, the fuel flow to the engine may decrease, resulting in loss of power, rough engine operation, or complete stoppage (symptoms of vapor lock).

[†] The volatility of the blend due to ethanol drops at higher than 25 percent concentrations of ethanol.

[‡] This is one of the reasons why refiners are not keen about ethanol.

[§] VOCs are also referred as reactive organic gases or hydrocarbons.

5. Ethanol has an affinity for moisture and is completely soluble in water. This presents a problem for transporting blends of gasoline and ethanol via pipelines. If the ethanol and gasoline blend picks up water in the pipeline it could "phase separate," resulting in off-specification product and potential contamination of other products interfaced with the ethanol shipment. The "phase separation point" depends on the proportion of gasoline and the temperature. Studies indicate that blends with larger amounts of ethanol resist separation longer than those with lower percentages of ethanol. They also indicate that blends are more likely to separate in colder temperatures.[19]

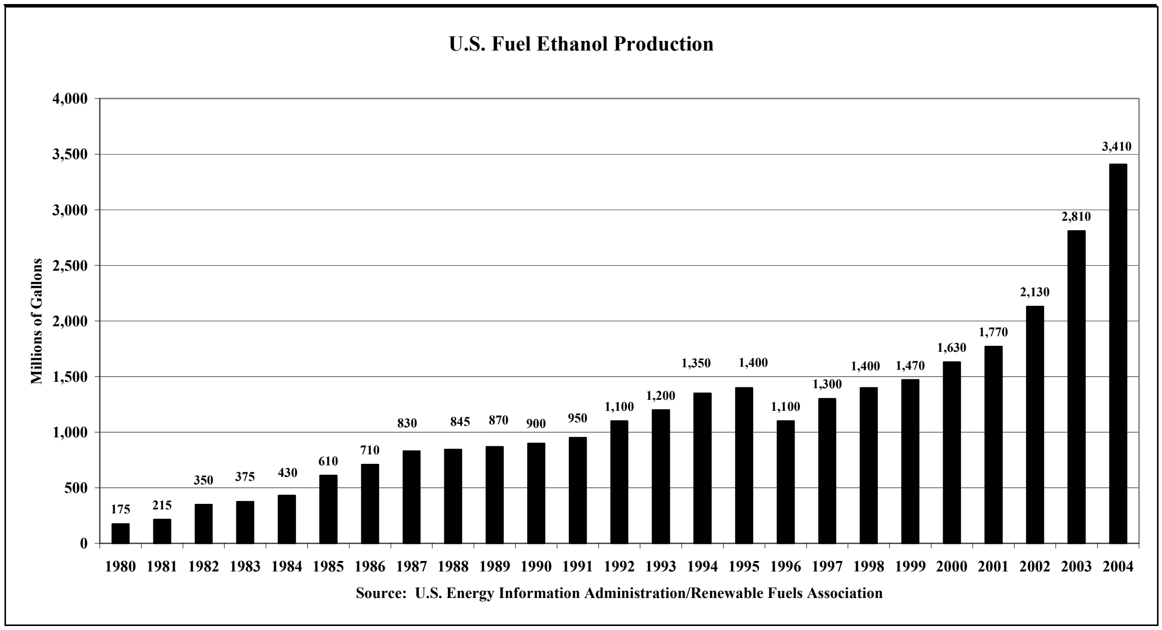
HOW ETHANOL IS TRANSPORTED

Because of phase separation resulting from ethanol's solubility in water, pipeline operators have been reluctant to ship ethanol, or gasoline-ethanol blends, on a commercial scale. Ethanol blends are shipped to finished product terminals by trucks or railroad and blended with the gasoline as it is loaded into the transport truck for delivery to retail. However, at higher ethanol blends and lower temperatures the process of separation is less likely to occur in pipelines, and pipelines can be used for transporting ethanol.

ETHANOL PRODUCTION IN THE UNITED STATES

According to data from the Renewable Fuels Association,[20] the U.S. ethanol industry comprised 81 production facilities in 20 states, capable of producing more than 4.3 billon gallons of ethanol per year. Ethanol production has been significantly expanding during the last five years (see chart 1). Actual production in 2004 reached 3.41 billion gallons, a 21 percent increase over 2003. Twelve new ethanol plants were built in 2004. These new plants and expansions of existing plants increased annual ethanol production by more than 500 million gallons in 2004.

Chart 1



In 2005, the U.S. was the leading world producer of fuel grade ethanol. Table 2 shows ethanol production capacity by state. The majority of the ethanol industry is located in the Midwest states. More than 98 percent of ethanol made in the United States is derived from corn. Production is concentrated among a few large producers. In 2004 the top five companies accounted for approximately 40 percent of production capacity, while the top ten accounted for about 50 percent.[21] However, a large number of smaller producers and cooperatives have entered the market in recent years. California consumes more than one quarter of total ethanol produced in the nation, but it produces less than 1 percent [22] of the amount it consumes.

Table 2

State Ethanol Production Capacity State	Million gallons/Year
Iowa	1,262.5
Illinois	816.0
Minnesota	523.6
Nebraska	523.0
South Dakota	456.0
Wisconsin	210.0
Kansas	149.5
Indiana	102.0
Missouri	100.0
Tennessee	67.0
Michigan	50.0
North Dakota	33.5
New Mexico	30.0
Texas	30.0
Kentucky	25.4
California	8.0
Wyoming	5.0
Ohio	4.0
Colorado	1.5
Washington	0.7
Total	4,397.7

Includes plants currently under construction
Source: Renewable Fuels Association, January 2005

ETHANOL PRODUCERS IN CALIFORNIA

Most ethanol used as fuel in California is produced from corn-based facilities in the Midwest. While there have been some ventures to produce ethanol in California, this industry has not grown significantly. In 2004, California production capacity was eight million gallons of ethanol, and actual production was less than seven million.

Operating Facilities

There have been several feasibility studies, demonstration projects, and small commercial ventures for ethanol production in California. Currently, there are two plants that are actually producing ethanol in the state, and one that just opened.

- *The Golden Cheese Company of California*, a division of Dairy Farmers of America is located in Corona. It derives ethanol from cheese whey. It can produce up to five million gallons of ethanol annually.

- In 1991, a low interest loan program administered by the Department of Food and Agriculture provided initial financial assistance to start *Parallel Products*, a Southern California company that produces about three million gallons of fuel-grade ethanol from food and beverage industry residuals such as expired or mislabeled alcoholic beverages, beverage syrups, and other sugar products.
- *Phoenix Bio Industries* (partnered with Western Milling) recently completed construction of an approximate 25 million gallon per year ethanol production plant in Goshen (San Joaquin Valley). The facility is currently undergoing initial start-up testing. The ribbon cutting ceremony of this plant was August 2005. Pacific Ethanol has an agreement to market the products of Phoenix Bio-Industries, LLC.

Planned Ethanol Projects

Other planned ethanol projects in California include:

- *Pacific Ethanol* is a publicly traded company. In 2003, it bought a new, state-of-the-art grain receiving, processing and storage facility on 137 acres in Madera, California. Positioned on the mainline of the Burlington Northern Santa Fe Railroad and 4 miles east of one of California's main north-south highways, the plant is ideally situated for shipping materials and product either by truck or rail. The facilities on the property will include the grain mill, the ethanol plant, and a 10-megawatt natural gas cogeneration facility, which will provide all the electricity and steam needed onsite. The firm plans to partner with another company that will purchase all the CO_2. The Madera plant is in the center of the greatest concentration of dairy cows in the world (half a million head in a 50-mile radius). A by-product from the process is corn mash that will be turned into wet distillers grain, one of the most nutrient-rich cattle feeds available. This feed can be shipped to local dairies at a lower cost since imported feed from Midwest producers is dried first and then transported. Upon completion, the plant will have the capacity to produce 35 million gallons of ethanol as well as its byproducts: 290,000 tons of wet distillers grain and 100,000 tons of CO_2. Their production plant will also be set up to make ethanol from cellulose in the future.
- *Imperial Bioresources LLC*. Located in the Imperial Valley, this is an example of an effort to produce ethanol from dedicated energy crops while integrating various activities to produce an array of products. This effort plans to integrate cultivation of sugar cane, processing plants for sugar production using beets and sugarcane, and an ethanol plant. Energy for this combined-process facility would be provided through the combustion of bagasse (the spent fiber fraction following the extraction of sugar juice) and other available biomass materials to generate power and process steam. The company has not begun to produce ethanol and is still in the development stage. The project has been underway for six years with plans to initiate 300 acres of cane trials. Several million dollars have already been spent in this effort. The venture continues to seek funding from a variety of sources, particularly the USDA/DOE based on the renewable fuel aspect of their company. The company expects to operate commercially by the end of 2008.

- *Calgren Renewable Fuels* has purchased a 60-acre plant to produce ethanol in Pixley. The company has also renewed an option on 60 acres in the Hanford industrial park and will shortly file a plan with the City of Hanford to start the environmental report for a similar ethanol plant that could be built as soon as in two years. Both the Pixley and Hanford plants are $80 million projects each. The company expects the Pixley plant to begin operating in June 2006.[23]
- *BC International Corporation*, of Dedham, Massachusetts, has been pursuing ethanol production from rice straw in Gridley, Butte County, and from thinnings and wood wastes in Plumas County at an existing biomass electric power plant. Currently these projects have been suspended due to lack of funds but the firm plans to proceed once the financial conditions are more favorable. The production plant will cost between 68 and 80 million dollars and is difficult to finance since it uses a new technological process. BC International Corporation is currently producing ethanol from sugar bagasse in its Louisiana plant.
- *Arkenol* had proposed two plants for cellulosic ethanol (using straw and wood wastes) in California, but these projects have not been built due to lack of financing. The company needs a minimum of $15 million to finance its new technological process. Arkenol is currently producing ethanol from wood waste in Japan, with government funding for this operation.

ETHANOL IMPORTS

Ethanol consumed in California comes from the Midwest by rail, or by ship from Gulf Coast storage terminals (via the Panama Canal route). Domestic refiners producing ethanol from American corn supply most of the U.S. ethanol market. Foreign imports play a small role because a 54-cent-per-gallon tariff on imported ethanol offsets the economic incentive of 52 cents per gallon for the use of ethanol in gasoline.* However, the Caribbean Basin Initiative (CBI), enacted in 1984, allows most imports from the Caribbean Region and Central America, including ethanol, duty-free. In 2004, about 10 percent of the ethanol used in California reformulated gasoline under Phase 3 was delivered by ship from CBI countries and Brazil.

The CBI permits up to 7 percent of the previous year's U.S. ethanol output to be imported duty free. Ethanol entering the United States under the CBI is generally produced elsewhere (mostly from Brazil feedstock) and reprocessed in CBI countries for export to the United States.[24] Brazil is the second largest world producer of ethanol (3.6 billion gallons from sugar cane at much lower cost than the ethanol produced in the U.S.) The U.S.- Central America Free Trade Agreement (CAFTA) will maintain the CBI duty-free treatment.

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* Policy incentives for the use of ethanol in gasoline are discussed in Section III.

ETHANOL CONSUMPTION

Ethanol accounts for only about 2 percent of the total gasoline consumed in the United States.[25] Historically, ethanol has been utilized to improve the gross margin (per gallon) of the blender or retailer by creating a higher octane-grade of gasoline at a reduced cost.

Table 3 shows data from the U.S. Department of Transportation comparing use of low blends of ethanol and gasoline and use of ethanol.

Table 3

Use of Gasohol in 2003 (In millions of gallons)			
	E-10 (10 Percent Ethanol)	**Less Than 10 Percent Ethanol**	**Total Ethanol in Gasohol**
California	0	10,329	589
U.S.	20,493	12,036	2,749
California Share	**0.0%**	**85.8%**	**21.4%**

Source: U.S. Department of Transportation

The estimated ethanol consumption in the U.S. for 2005 is more than 3.0 billion gallons per year. This estimate assumed a continuation of current laws and incentives for ethanol use, such as the maintenance of oxygenate requirements and the potential ban of using MTBE in various states. The recent passage of the Energy Policy Act of 2005 should not significantly alter the 2005 consumption forecast, since the design of regulations for the implementation of the policies under this Act will take about a year. [*]

California Ethanol Consumption

By 2004, according to the Energy Commission, California demanded approximately 900 million gallons of ethanol, about one-fifth of the current U.S. ethanol production capacity. Since 2004, ethanol in California has been mostly used to meet the oxygenate requirements of the Clean Air Act (the Act specified a minimum of two percent oxygen content in gasoline during the winter time in specified areas). Ethanol replaced MTBE, the oxygenate of choice until December of 2003, when its use was banned after indications that this additive contaminated groundwater.[†]

Market Outlook

Ethanol consumption has been supported by the reformulated gasoline program and the oxygenate requirements of the Clean Air Act that required the addition of two percent weight oxygenates in gasoline in some areas with high pollution (these policies are

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[*] Policies are discussed later in Section III. The Energy Policy Act of 2005 introduced changes that will alter the assumptions underlying these forecasts.

[†] Regulations supporting the ethanol market are discussed in a separate section.

discussed in a later section). The recent passage of the Energy Policy Act of 2005 signed into law on August 8, 2005, amends the Clean Air Act and introduces a series of measures oriented to reduce petroleum dependency, including the introduction of a renewable fuel program that establishes goals to increase the quantity of renewable fuel (primarily ethanol). The renewable fuel program will assure a significant demand for ethanol in the U.S. Nationwide, the Energy Information Administration predicts that with the Energy Act in place, ethanol consumption in 2010 will be about 60 percent higher than in 2003. The Act also terminates the oxygenate requirements for California.[26]

Projections for the effect of the Act on California are not yet available. Some experts, such as Mike Scheible, Deputy Executive Officer of CARB, believe that state's ethanol consumption could drop 20 percent with the passing of the Energy Act.[27] However, there are many elements in the law that makes the future consumption of ethanol in the state difficult to predict with confidence:

1. Renewable Fuels Program. The law applies to refiners, blenders, and importers rather than geographic areas. EPA has a year to complete the regulations for the implementation of this law. Thus, it is impossible to know how refiners will change their fuel blends. However, the law also introduces credit trading: surplus or deficit amounts of renewable fuels with respect to the baseline can be traded among those required to meet renewable fuel targets. In addition, the Act provides a one-year period to balance these credits. Hence, it is difficult to forecast the implications for any specific geographic region. Oil companies may, for example, choose to blend ethanol/biodiesel in their plants in other states and to sell or transfer excess credits to California refineries. However, since California consumes a large share of national ethanol consumption, it is unlikely that a significant amount of credits could be traded with other regions.
2. Oxygenate Requirements. California is exempted from the oxygenate requirements, while other states, under this requirement, must use a minimum of 25 percent renewable fuel in one of two six month periods of each year up to 2012. Reformulated gasoline (RFG) is gasoline blended according to federal and state specifications to burn cleaner and reduce smog-forming and toxic pollutants in the air.

There are reasons to believe that refiners in California may continue to use ethanol despite the uncertainty brought about by the passage of the Energy Policy Act of 2005:

1. The Oxygenates Fuels Program still requires the addition of oxygen in gasoline sold during the winter months in areas with high levels of carbon monoxide (areas in the California South Coast Air Quality District). This assures the demand for 40 percent of total current California ethanol consumption during four months of the year, representing about 130 million gallons of ethanol. However, within a year the Air Resources Board expects to reassess the status of CO attainment of the region. If the area attains the CO goals, the oxygenate requirement during wintertime could terminate.
2. Refiners may use ethanol to boost octane.

3. Refiners may already have purchased ethanol for delivery during the period October 2005 through March 2006 to meet the oxygenate requirements recently rescinded by the Energy Policy Act of 2005.
4. Facilities and infrastructure are in place to use ethanol as an additive and it can be costly to the industry to change again, at least in the short run.
5. Currently, there are also price advantages of using ethanol as an additive. Recent increases in oil prices make the use of alkylates (a substitute for ethanol) or other blending components approximately 4.7 cents per gallon more expensive than ethanol.*

* According to the California Energy Commission (CEC), removing ethanol increases costs at least 4.7 cents per gallon (as of May 2005). The net cost of ethanol was about 80 cents per gallon and the cost of alkylate (a likely ethanol replacement) is about $1.80 per gallon. Currently, 4.56 cents of ethanol is blended into California RFG (5.7 percent ethanol blend). Replacing ethanol would take 10.26 cents of alkylate. That's an additional cost of 5.7 cents per gallon. However, using alkylate, refiners may be able to use some high volatility components currently removed for ethanol blending. The EPA estimates the cost of removing these components for ethanol-blended as less than 1 cent per gallon. Therefore, after crediting this possible cost savings, removing ethanol would still increase costs by 4.7 cents per gallon. (California Energy Commission, Committee Workshop, May 17, 2005.)

SECTION II: CHALLENGES TO THE ECONOMIC VIABILITY OF CALIFORNIA'S ETHANOL INDUSTRY

Is ethanol production profitable? For some, it is. Proof of this is that there are more than 80 plants operating today in twenty states of the United States.[28] For others, the industry would not survive without the government support it receives. This section discusses the main factors determining the profitability of producing ethanol and the challenges associated with these factors for California producers.

THE PRICE OF ETHANOL

This is the most important factor determining the profitability of an ethanol production facility. Ethanol sales account for more than half the revenues for an ethanol plant; the rest depends on the value of co-products.[29]

Between 1985 and 2001 ethanol has averaged 54 cents per gallon more than gasoline. Margins fell in 2001 and 2002 due to higher ethanol production. Since most ethanol in the U.S. is produced from corn, ethanol prices have also closely tracked the farm-level price of corn. Increases in corn prices have increased the cost and/or reduced the supply of ethanol.

Ethanol prices have fluctuated significantly. In 2005 the Chicago Board of Trade and the Chicago Mercantile Exchange offered corn-based ethanol futures contracts as an alternative means for both producers and buyers to hedge against ethanol price fluctuations. Today, most ethanol is sold on a long-term cash contract basis.

Since the late 1990s, the trends in the price of gasoline and the price of corn have been in ethanol's favor as national average monthly gasoline prices have risen above the $2.00 per gallon level while corn prices have decreased. However, in 2004, ethanol prices were high relative to gasoline. For example, during the week of June 14, 2004 the average retail price of E-85 ranged between $2.28 and $2.70 per gasoline equivalent gallon,[*] compared to $1.92 to $2.24 for regular grade gasoline. Historically, a federal production tax credit has offset most of the difference between gasoline and ethanol prices, helping ethanol to compete in the market. Currently ethanol producers receive a subsidy equivalent to 51 cents per gallon, about one half of the wholesale cost of ethanol.[†]

Since the beginning of 2005, ethanol has become more competitive as expanded ethanol production has driven ethanol prices down while gasoline prices have been soaring. In April 2005, ethanol spot prices in Northern and Southern California were around $1.25 per gallon. On a gasoline gallon equivalent and considering the federal subsidy, the wholesale cost of ethanol is calculated as 60 cents lower than the current wholesale cost of gasoline.

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[*] Derived by taking into account the relative BTU content per gallon of ethanol and gasoline by dividing ethanol's BTU unit rate by gasoline's BTU unit rate (125,000).

[†] Policies affecting the ethanol market are discussed in a separate section of this paper.

Challenges to California Producers

Ethanol price variability in the relationship with gasoline represents a significant risk for the industry. However, some of this risk is covered by long-term contracts. Ethanol currently remains cheaper than gasoline. Whether this continues will depend largely on crude oil price trends. At $50-$70 per barrel of oil, ethanol should continue to be cheaper. However, if the situation reverses, the profitability of the industry will rely on its ability to produce ethanol more efficiently. This is a more significant problem for production based on cellulosic materials where the state of art in the technological process is at an early stage. To survive, the industry may need support from the state, at least for the first years of operation. In 2000, before significant increases in oil prices took place, the Energy Commission calculated that a price support of about 20 cents per gallon would be needed for cellulosic plants.[30] With the current market conditions, this figure is probably high. However, some analysts believe that a price support should be implemented as a safety net to assure a minimum price in case ethanol prices periodically become unfavorable.

CO-PRODUCTS

The effective use of all resources, including the production of additional end products, is important for the profitability of the ethanol industry. Oil and Midwest corn-to-ethanol producers would not survive if they were producing only gasoline or ethanol. They operate their plants as a refinery producing a variety of products that increase the profitability of the company. For example, an oil refinery takes crude oil and turns it into gasoline and hundreds of other useful products, such as jet fuel coke, and by-products like propane, propylene, and petrochemicals. Biorefineries producing ethanol from biomass could generate a variety of other products, such as electricity and chemicals (acetaldehyde, acetic acid, glycerol and isopropanol) that could be sold in various markets.

Challenges to California Producers

There are plenty of opportunities in California to develop and sell secondary products. The challenge for California producers is to look for the most efficient ways to take advantage of these opportunities. For example, total cattle population in California exceeds five million, representing a significant market for ethanol co-products such as high value protein animal feed, a by-product from producing ethanol from corn.[31] The processing of cellulosic materials can produce lignin that can be used as a combustion fuel to produce power, or can be processed into specialty products such as plasticizers, extractives, or phenolic resins, which may be used as glues or binders in the production of plywood and fiberboard.[32]

THE COST OF PRODUCING ETHANOL

The most significant problem to the wide use of fuel ethanol has been its cost. Costs depend on the feedstock used and the efficiency of the production process, mostly defined by the technologies used. The development of new technologies has significantly decreased the cost of producing ethanol, particularly corn-derived ethanol. The future of ethanol production in California depends on using waste and agricultural residues as feedstock rather than corn, a more expensive feedstock. However, the cost of producing cellulosic ethanol is still very high. For some, the state of some of these technologies is currently in the experimental state rather than at the commercial state. Others believe that these technologies are already sufficiently mature and their commercialization just depends on capital infusions that innovators have not yet been able to access.

Feedstock Availability and Price Variability

One of the risks that ethanol producers face is feedstock price variability. As corn price increases brought about by corn shortages, profits for Midwest ethanol producers fall. A similar situation happens with the price of other feedstock, such as sorghum and sugar beets.

A related problem is that feedstock prices may increase as new uses for feedstock emerge that may be more economical than their use for ethanol production. For example, urban wood waste includes construction wood scraps and pallets that are currently used to make wood board and other construction-related products that may offer higher profit margins.

Although the cost of cellulosic feedstock is low, the collection and transportation costs can be high. However, the process of collecting agricultural waste and forest materials may have some adverse environmental effects as excessive residual removal may lead to loss in crop productivity, soil health, and carbon levels.

It is difficult to collect a sustainable feedstock supply of consistent quality year-round because:

- Cellulosic-feedstock characteristics vary widely in terms of physical and chemical composition, size, shape, moisture content, and bulk densities.
- Some materials, such as agricultural residues, may be available only on a seasonal basis
- Materials may have low ethanol conversion yields.

The availability of a steady and continuous supply of biomass feedstock requires that the amount of cellulosic materials available be larger than the amount used by the industry.[*] Furthermore, an efficient system to collect and store various cellulosic materials is very important to assure a steady supply of feedstock. For example, accessibility to forest materials can be expensive, particularly from remote areas.

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[*] Estimates indicate that, for cost efficiency, an ethanol plant should be located within a 50 miles ratio from the biomass used as feedstock.

Challenges to California Producers

There is a variety of feedstock in California including several energy crops and waste and cellulosic materials. The use of any of these feedstock varieties present unique challenges.

Using Energy Crops

The viability of an energy-crop-based ethanol industry depends on the market value of that energy-crop in alternative uses and the degree to which agricultural land resources are utilized.[33] In California, planting crops for feedstock is generally uneconomical, as the market prices of these crops or other alternative products that could be planted in the same land are relatively high. Furthermore, the irrigation requirements for cultivating some of these energy-crops (corn for example) are high. Land costs also make the use of energy crops very expensive, although it can become less of a problem as: (1) yields of energy crops increase, and (2) the demand for growing biomass is integrated with the demand for current agricultural products, so that farmers could sell different parts of the same plant to different markets.

Taking these factors into account, the California Department of Food and Agriculture, after conducting a series of field demonstrations and laboratory studies, has identified a variety of potential energy crops.[34] Among these crops are: sweet sorghum, kenaf, Jerusalem artichoke, industrial sugar beets, and tree crops such as eucalyptus. Assuming that energy crops would occupy one million acres of the state agricultural land, production of ethanol based on energy-crops in California could generate around 500 million gallons of ethanol per year.[35]

In the state, the use of California grown corn as feedstock to produce ethanol has been generally considered as not economically viable. However, some new ethanol plants in California (Pacific Ethanol, for example) are considering the use of imported corn previously used as animal feed. According to the industry's recent analyses, growing corn and processing it to ethanol and feed in California can be more energy efficient than in the Midwest, resulting in lower costs of production and greater greenhouse gas benefits. For example, about 30 percent of the energy used in corn processing for ethanol is used to dry the feed by-product.[36] In California, corn can be air-dried, and the high protein feed by-products can be fed wet to dairy cows rather than dried and shipped from the Midwest.

Using Cellulosic Materials

In California, where high-value agricultural products are produced, the ability to produce ethanol from low-cost biomass is even more important for the development of an ethanol industry.[*] Furthermore, the use of waste feedstock has the advantage that it does not require significant land use, an expensive resource in California.

An advantage of developing an ethanol industry based on the processing of cellulosic materials in California is that the state is rich in agricultural and forestry resources that can provide significant volumes of biomass. The state also has a large volume of commercial and municipal solid wastes.

The Energy Commission had estimated in 2000 that there was enough easily accessible biomass feedstock to support ethanol production of 200 million gallons per year in California and that, with very efficient methods of feedstock collection, this capacity could increase to 400 million gallons a year.[†37] A recent paper by the Biomass Collaborative estimates that there is enough biomass to support a production level of 1.5 billion gallons of ethanol in California. Their estimates are built on the assumption of an average yield of 70 ethanol gallons per ton of biomass, and the fact that not all biomass can be devoted to produce ethanol since a proportion of it will be directed to alternative uses or will be impossible to collect.[‡] The production of this amount of ethanol from corn would require three million acres, or more than a third of the total irrigated agricultural acres in the state, using 12 million acre-feet of water. This corn-based operation, however, would also produce additional 10 to 15 million tons of residue biomass.[38]

The most sizeable cellulosic sources for ethanol production in California are forest materials, agricultural residues, and urban waste. New grass varieties capable of providing high biomass yields have also been developed, offering potential for sustainable feedstock.[39] Animal manure can also be used as a feedstock for ethanol.

Forest materials are available from slash left on the ground after commercial timber harvesting, wood mill residues, and thinning operations. Forest thinnings help restore the health of forests and reduce fire risk. However, operations to obtain these materials must be carefully addressed to avoid potential damage to forest ecosystems.

Agricultural residues include orchard prunings, rice straw, vine or row crop residues (materials that remain in the ground after harvesting), non-rice straw, and some grasses. There are problems related to the collection of this feedstock. It requires new cost-effective engineering systems because of their low bulk density and low tons/acre yield. Moreover, it is difficult to collect residues in wet fields. Another difficulty is that these materials may need storage, raising costs. For example, agricultural residues may be left in the fields after harvesting. If left uncovered for some time, the accumulation of

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[*] We are using here biomass (plant matter) and cellulosic materials as interchangeable words. According to the report by the National Commission on Energy Policy, *Ending the Energy Stalemate. A Bipartisan Strategy to Meet America's Energy Challenges*, cellulosic materials and renewable waste resources are most highly concentrated in California, Minnesota, Illinois, Iowa, Texas, and Indiana.

[†] These estimates do not include out-of-state resources.

[‡] For example, some biomass can is used as feedstock for biomass power plants.

moisture may cause deterioration and spontaneous combustion of the feedstock. Therefore, these residues must be covered with tarps or stored in barns.

Among agricultural residues, rice straw is an attractive source of feedstock. Currently, farmers have three alternatives to dispose of rice straw: (1) burn a part of it (because of air quality concerns, rice farmers have been required to burn increasingly less of their rice straw), (2) till it back into the soil, and (3) bale it and sell it for uses such as animal feed, bedding, erosion control, building products, and ethanol production. The ethanol industry may be able to use a significant amount of rice straw as feedstock as long as they could pay rice farmers enough for the rice straw to make cutting and baling costs competitive with plowing the straw back into the soil.[40] However, collecting these materials can be problematic because the practices developed for the harvesting and handling of grain may not be adequate for the harvesting and handling of straw.

Urban waste is composed of residues such as waste paper (paper that is not recyclable) and other materials sorted at material recovery facilities. About one third of waste that goes to landfills includes organic materials that could be used for ethanol production. However, separation from inorganic waste will be required before using these materials as feedstock.

Hence, although the state has an abundant amount of feedstock for producing cellulosic ethanol, the industry faces enormous challenges to access this biomass. The current costs of feedstock collection are a negative factor for the flourishing of a cellulosic industry in California. However, this could change dramatically with the establishment of efficient systems to collect cellulosic materials.

The location of the plant near feedstock sources or the establishment of long-term contracts for feedstock may help to avoid fluctuations in the price and availability of cellulosic materials.

Plants located near feedstock sources will have lower transportation costs. For example, it is convenient for an ethanol plant that uses landfill-diverted feedstock to locate near a material recovery facility. The plant can use the collection and processing infrastructure of the facility, which already collects, sorts, and distributes regional waste for various uses (including markets for recycled materials). There are benefits for the ethanol plant and the material recovery facility. The material recovery facility operator can benefit from reduced or avoided costs of disposing the waste residuals used by the ethanol plant, and the ethanol plant will have much lower feedstock costs by just paying a fee rather than collecting and transporting feedstock from competing landfills.[41] A large transfer station/municipal recovery facility processes around 3,000 tons of total waste stream per day, supporting the necessary feedstock for a ten-million-gallons-per-year ethanol plant.[42]

Costs of Transporting Ethanol and Other End-Products

The costs of transporting ethanol are high. Ethanol is harder to transport and distribute (compared to gasoline or MTBE, for example). Ethanol is transported to terminals by railroads or trucks.* As a result of its high affinity for water, ethanol presents some blending and distribution-related problems. Pipelines have the potential of containing water. Once ethanol absorbs enough water from a "wet" pipeline system, it no longer stays blended with gasoline, and forms two liquid phases: a gasoline-rich phase and a water/ethanol-rich phase. In fact, phase separation due to ethanol's water solubility is the most extensive risk associated with pipeline distribution because the effects are irreversible. Ethanol can only be recovered from the water phase by re-distillation, or in some cases the level might be low enough that only adsorption would be necessary, but this is still costly. For this reason, ethanol/gasoline blends must be done at the terminals.

If high volumes of ethanol penetrated the California market, refiners might not be as reluctant to dry out intrastate pipeline distribution systems to ship ethanol-blended gasoline from refineries to various distribution terminals. Blends with greater amounts of ethanol resist separation longer than those with lower percentages of ethanol and blends are more likely to separate in colder temperatures. In Brazil, pipeline shippers of ethanol mitigate phase separation by shipping neat-ethanol following specified procedures.[43]

The proximity of ethanol plants to distribution terminals or a railroad network is important since it decreases the transportation costs of distributing ethanol and other co-products to end users.

Challenges to California Producers

The development of an ethanol industry in California requires an efficient transportation system to deliver ethanol from plants to the railhead and then to terminals by railcar. There is an ethanol supply and distribution network already established in California. The main distribution center is at shore terminals in Crockett. In addition, California's Tosco Refining has equipped their Sacramento, Martinez, and Colton terminals with ethanol blending infrastructure. California has successfully made the transition of using ethanol instead of MTBE to meet oxygenate requirements and the current supply and distribution network is capable of transporting ethanol and ethanol blends without major disruptions.[44]

California's petroleum infrastructure currently has all the storage and equipment needed to blend reformulated gasoline at terminals and transport it to retail stations and clients. If the use of E-10 or higher ethanol blends expands, some investment in infrastructure could be necessary.

Availability of Technologies to Produce Ethanol more Efficiently

Technologies that increase the efficiency of producing ethanol either by increasing crop yields or reducing the steps for converting feedstock into ethanol, make ethanol production less expensive. There have been major technological improvements in the

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* Terminals are distribution facilities where gasoline is received by pipeline, rail car or marine vessel, or is stored in a fuel storage tank at a refinery site, and is stored in bulk for distribution by fuel transfer vehicle.

production processes of ethanol from corn. While costs for corn ethanol are currently calculated in the range between $.75 and $1.40 per gallon.[45] According to the Department of Energy, by 2015 ethanol production cost could be reduced to 60 cents per gallon.[46] However, according to energy analysts, the future of ethanol depends on the development of technologies allowing conversion of cellulosic materials into sugars on a commercial scale and at low cost. Commercializing new technologies for converting biomass to ethanol raises uncertainties and presents challenges that must be overcome to foster and nurture a commercial cellulosic ethanol industry.

Challenges to California Producers

The feasibility of an ethanol industry in California depends largely on the development of new and more efficient technologies that convert biomass to ethanol and significantly decrease costs. This would require new technologies for the pretreatment of feedstock that includes a variety of materials that vary widely in physical and chemical properties, and the development of new enzymes that lower the costs of transforming cellulosic materials to ethanol by enzymatic hydrolysis.

Generally, existing cellulosic-to-ethanol technologies have not yet been well demonstrated or widely applied commercially. The good news is that some significant advances have been made in this direction:

- The company Iogen has patented a cellulose ethanol process called EcoEthanol™. The process uses an enzyme hydrolysis to convert the cellulose in agriculture residues into sugars.[*] These sugars are fermented and distilled into ethanol fuel using conventional ethanol distillation technology. In April 2004, Iogen Corp. began selling the world's first commercial cellulosic ethanol.[47] Iogen is considering licensing its technology. With this process Iogen's costs are expected to decrease from $1.30 an ethanol gallon to less than $1 a gallon.
- New innovations have reduced the cost of producing cellulosic ethanol. For example, Novozymes, a Davis biotech firm, recently found a way to drastically cut the cost of enzymes needed to create ethanol from rice straw and other agricultural waste. Their innovation brought about a 30-fold reduction in the cost of using enzymes.[48] Assuming the cost of enzymes is about 10 percent of total production costs, this would represent more than 9.5 percent total cost reduction in cellulosic ethanol production.[†]
- Other examples are Arkenol and BC International. In Japan, Arkenol is applying its own technology that allows ethanol production from wood waste. BC

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[*] Iogen Corporation obtained the first (and non-exclusive license) from the Purdue Research Foundation for genetically modified yeast that can produce ethanol from agricultural waste. Unlike traditional ethanol feedstocks, the cellulosic materials contain two major sugars, which cannot both be fermented into ethanol by common Saccharomyces yeast, the microorganism used by industry to produce ethanol from corn. The Purdue researchers altered the genetic structure of the yeast so that it now contains three additional genes that make it possible to simultaneously convert both sugars to ethanol.

[†] Based on costs reported in documents published by the Aspen National Renewable Energy Laboratory.

International has also developed a technology that facilitates the fermentation of cellulosic materials. BC International has a plant in Louisiana, producing ethanol from sugar cane. These firms claim that they can expand their operations as soon as the financial resources are made available. However, according to some energy experts, these operations are still pilot projects rather than commercial operations.[49]

Permitting Process

Ethanol producers indicate that the permitting process significantly increases the cost of siting an ethanol plant.

Challenges to California Producers

The permitting process for a biomass-to-ethanol facility in California is a complex process that can take 12 to 18 months, or longer, depending on the specific issues related to the site of the plant and the technology used by the project. As in the case of any similar project, permitting is subject to the California Environmental Quality Act with review by a wide variety of public agencies.

According to BRI representatives, building a plant in California requires going through the same permitting process that is established for the siting of a major solid waste landfill. For example, this process in Los Angeles County requires a very complex environmental review with the involvement of 88 cities, and could take at least two years.[50] Advocates argue that streamlining of the permitting process would benefit the entry of new ethanol companies.

INTEGRATION OF ETHANOL PRODUCTION WITH OTHER ACTIVITIES

The most profitable way to operate a biomass-to-ethanol plant is as a refinery producing a variety of products from

Imperial Bioresources LLC: An Example of How the Integration of Ethanol Production and Other Activities Can Bring Significant Synergies.

In the Imperial Bioresources project, in the Imperial Valley, the process begins with the cultivation of 20,000 acres of sugarcane that yields 1,200,000 tons of harvested cane annually. Cane will be processed into sugar, bagasse, molasses, ethanol, carbon dioxide, power, and cattle feed. This project includes a cogeneration facility that burns bagasse and field trash for steam and electricity to meet the needs of the cane and beet processing plants with a surplus of power being available for the local grid. The beet-processing plant produces refined sugar and beet pulp (a desirable cattle feed material). Molasses generated from this plant can be diverted to the ethanol process. The cane processing will produce raw cane sugar, molasses, and bagasse. The molasses and any bagasse not required for the facility’s energy needs are used as feedstock in the ethanol plant. The production of ethanol would produce carbon dioxide that can be used in the sugar clarification process as well as in the industrial grade carbon dioxide market. Instead of producing just beet pulp for cattle feed, the integrated plants will also deliver large quantities of bagasse and silage solids for animal feed blending, at a value set by available competing materials.

This project expects to support the production of 60 million gallons of ethanol produced from imported corn mixed with molasses at the initial stages. Corn is already being imported in the area for cattle feed.

processing all the chemical components (hemicelluloses, cellulose, lignin, and extractives) of cellulosic feedstock. The plant could make uses of extractives by converting them to resin acids, or pharmaceuticals (taxols from specific conifers, for example). Cellulose derivatives can be processed into a variety of products including higher value animal feeds. The lignin fraction can be an energy source for the biorefinery or for an adjacent electric power plant.

For example, the integration of a power plant with biomass-to-ethanol facilities brings about significant synergies that significantly decrease the cost of operation of both facilities. The biomass power plant can be a customer for the lignin produced by the ethanol plant, using it as a fuel for the power plant, while the ethanol plant would benefit from cheaper steam and electricity.

Challenges to California Producers

California producers will have to look for innovative arrangements that allow the integration of various production processes and the access to feedstock sources. An example illustrating a creative arrangement integrating various processes to produce diverse products is Imperial Bioresources LLC.

PLANT SIZE

Size matters. There are economies of scale in this industry where costs decrease as the size of the operation expands. Even with the increase in biomass costs that accompanies increased scale, product cost still decreases for very large plant sizes because the unit capital cost decreases. Plant size or scale of operation is limited by the availability of feedstock collected economically.

Challenges to California Producers

Because of the nature of the industry, starting an ethanol plant in California (as in other places) requires an initial large amount of capital investment, which is the highest cost for ethanol producers.

COMPETITORS

The U.S., led by ethanol production in the Midwest, is the largest ethanol producer in the world market. Brazil is the second most important ethanol producer in the world. Since 1980, there has been an ethanol import tariff (currently 54 cents per gallon) to assure that only domestic U.S. ethanol production receives the benefit of ethanol tax incentives. However, shipments of foreign ethanol reprocessed in countries covered by the Caribbean Basin Initiative are exempted, and some Brazilian ethanol is processed in those countries.

Challenges to California Producers

Ethanol producers have to compete with a matured Midwest ethanol industry based on corn, and with other countries, where production costs are lower. Competitors receive strong government support. Midwest states receive state support and a variety of incentives, in addition to the federal producers tax credit that helps the profitability of ethanol in the United States. California does not have any state policies geared to support the ethanol industry.

SIZE OF THE MARKET FOR ETHANOL

The availability of a significant market is important for the development of any industry. Ethanol consumption has been supported by government policies and by the availability of vehicles that can use ethanol as an alternative fuel.

Government Policies Supporting Ethanol Consumption

In the United States, a variety of government policies have assured a market for ethanol producers. For example, air quality regulations and oxygenate requirements have created a significant demand for ethanol, particularly after the ban of MTBE, the competitor oxygenate. There are also a variety of incentives for the use of FFVs that have helped boost ethanol consumption. Government policies that strengthen the ethanol market are discussed in detail in a separate section.

Use of Flexible Fuel Vehicles (FFVs) and Advances in Vehicle Technology

The demand for ethanol is also affected by the availability of vehicles that can use higher ethanol blends, or ethanol as the alternative fuel for FFVs. Technological innovations that improve fuel efficiency and lower the costs of FFVs will increase ethanol consumption as the use of FFVs expands.

One critical element for the use of FFVs is the availability of an infrastructure to actually provide ethanol as an alternative fuel.

Challenges to California Producers

Since the ethanol industry has been supported by a variety of policy incentives, changes in policy significantly affect ethanol producers. Until recently, ethanol consumption in the state has been supported by the oxygenate requirements of the Clean Air Act, that assured a significant market for ethanol.[*] As a result, California has been the largest consumer of ethanol in the country. The recent passage of the Energy Policy Act of 2005 changed the ethanol market outlook in California. This Act terminated the oxygenate requirements for the state, although it also establishes renewable fuels standards. However, the law is directed to refiners, blenders, and distributors rather than geographic regions. There is uncertainty as to how these standards will be implemented, and their net effect on ethanol consumption in California. Moreover, CARB studies on the environmental effects of ethanol raise questions on the environmental consequences of using blends of about 5.7 percent ethanol in California and there is uncertainty on CARB's future policies. Furthermore, a significant increase in the use of E-85, that

[*] The oxygenate requirements are discussed in Section III.

appears to have significant positive effects on air quality, is not feasible in the short run until the infrastructure needed for fueling vehicles with ethanol is available. There are more than 270 ethanol stations (offering E-85) in the U.S., but only three in California, two of which are private.[51]

Positive factors that could still help to maintain a significant demand for ethanol are the relatively cheaper price of this fuel compared to gasoline and gasoline blending components, the ethanol value as an octane booster, the possible role of ethanol as a gasoline extender that effectively reduces dependence on imported oil, and the value of ethanol in reducing carbon monoxide and dioxide emissions.

SECTION III: GOVERNMENT POLICIES SUPPORTING THE ETHANOL MARKET

Several government policies have played a significant role in supporting the development of the ethanol market in the United States. Some regulations stimulate the demand for ethanol, others support the industry through tax incentives, subsidies, and other measures that help increase the profitability of the industry. These policies include federal regulations and policies designed by various states.

FEDERAL POLICIES SUPPORTING THE ETHANOL MARKET

Two types of federal policies support the ethanol market. The first encourages production while the second encourages consumption.

Policies that Encourage Ethanol Production

Volumetric Ethanol Excise Tax Credit (VEETC)

Since 1978 the U.S. government has been encouraging ethanol fuel production and use through tax incentives. Through these tax incentives the federal government supports the ethanol industry by assuring a level of profitability that would not be achieved by the ethanol's prevailing market price.

The primary mechanism of the federal ethanol incentive is a reduction in the federal excise tax collected on sales of gasoline when gasoline is blended with ethanol. Until 2004, there was a reduction of 5.2 cents per gallon for 10 percent ethanol blends (E-10). Ethanol blends of 5.7 and 7.7 percent also had proportionately reduced rates per gallon. This incentive was originally authorized through 2007, but decreased from 52 cents for each gallon of ethanol to 51 cents starting in 2005. On October 22, 2004, President Bush signed into law the American Jobs Creation Act of 2004. This bill established the Volumetric Ethanol Excise Tax Credit (VEETC) extending the ethanol tax incentive of 51 cents a gallon until 2010 and basically replacing the excise tax exemption with an equivalent immediate tax credit.

Concurrently, there has also been an income tax credit authorized through 2007. Fuel marketers using ethanol could claim income tax credit in the amount of 52 cents per gallon of ethanol used. However, the process for claiming the income tax credit was cumbersome and excise tax reductions must be deducted from the amount of income tax credit. Hence, distributors of ethanol-blended gasoline normally used the excise tax incentive rather than the income tax credit. The income tax credit can also be applied to ethanol used as an alternative fuel (E-85). Suppliers could obtain more through the income tax benefit, since the excise tax option has the maximum amount of 5.1 cents per gallon of ethanol blend (based on E-10 rather than higher blends). However, the complex and lengthy process to obtain this credit has discouraged E-85 suppliers from claiming it.

The American Jobs Creation Act of 2004 eliminated the need of the alcohol fuels income tax credit and simplified the system of excise tax collection. The new VEETC is expected to eliminate many of the tax barriers that may have been limiting production of E-85 and E-90 because: (1) the new system is based on gallons of ethanol rather than blend rates (5.7 percent, 7.7 percent and 10 percent) and (2) the volumetric system allows suppliers of E-85 and E-90 to qualify for the excise tax credit rather than having to use the income tax credit. As a result, any taxpayer eligible for the alcohol fuels tax credit will be able to file for a refund for every gallon of ethanol used in the marketplace without regard to the income of the taxpayer or whether the ethanol is used in a taxed fuel or tax exempt fuel (which effectively decreased the value of the refund).[52]

Small Producer Credit

Since 1990, a federal income tax credit provides direct support for small ethanol producers. Producers of 30 million gallons per year or less are qualified for an income tax credit of 10 cents per gallon for up to 15 million gallons.[53] The Energy Policy Act of 2005 allows this credit for producers of 60 million gallons or less.

The American Job Creation Act of 2004 allows the apportionment of the small ethanol producer tax credit among patrons of a tax-exempt cooperative,[54] and provides for additional cooperative and agriculture provisions that benefit cooperatives by farmers.

USDA's Incentive Payments

The U.S. Department of Agriculture's Bioenergy Program provides incentive payments (contingent on annual appropriations) on year-to-year production increases of renewable energy.[55] The USDA also provides financial assistance in the form of grants, loans, and financing with commercial lenders to construct and operate ethanol production facilities. Technical assistance and information resources are also available. California farmers should be able to take advantage of these programs.

Financial Assistance Provided by the Rural Development Office of the USDA

This office provides financial assistance in the form of grants and loans to improve the economy and quality of life in rural America. These programs can assist entities seeking to develop and build an ethanol production facility.[56]

Federal Support for Cellulosic Ethanol Production

Two provisions of the 2002 farm bill have encouraged research in cellulosic ethanol production.[57] The first provision allows for the use of Conservation Reserve Program lands for wind energy generation and biomass harvesting for energy production.[58] The Conservation Reserve Program is a voluntary USDA program available to agricultural producers to help them safeguard environmentally sensitive land. Resource-conservation includes improvement of water quality, control soil erosion, and enhancement of wildlife habitat. USDA's Farm Service Agency provides participants with rental payments and cost-share assistance. A second provision provides incentives for production and use of non-traditional biomass feedstock through funding for research and development projects on biofuels and bio-based chemicals.[59]

The Energy Policy Act of 2005

The Energy Policy Act was signed into law on August 8, 2005. Among other things, this Act amends the Clean Air Act and introduces a series of measures oriented to reduce petroleum dependency and encourage the development of renewable fuels markets. The most important aspects of the law affecting ethanol producers are:

- The Act includes incentives for the production of renewable fuel from these "non-traditional" sources, allowing greater credits for ethanol derived from cellulosic biomass or waste. Every gallon of cellulosic or waste derived ethanol counts as 2.5 gallons towards the renewable fuel program requirements.
- The Act amends the Clean Air Act to include renewable fuel definitions and provides funds for the creation of a cellulosic biomass ethanol and municipal solid waste loan guarantee program to carry out not more than four commercial demonstration projects for cellulosic biomass and sucrose-derived ethanol. Guarantees under this section can be issued for up to 80 percent of the estimated cost of a project, not to exceed $250 million per project. The technologies have to avoid, reduce or sequester air pollutants or man-made greenhouse gases, and the technology has to be new or significantly improved over what is available in the marketplace (Section 1511).
- The Act amends the Clean Air Act to provide grants to merchant producers of cellulosic biomass ethanol, waste-derived ethanol and approved renewable fuels to assist with building of production facilities. It authorizes $100 million in fiscal year (FY) 2006, $250 million in FY 2007, and $400 million in FY 2008 for these grants (Section 1512).
- The Act creates an Advanced Biofuels Technologies Program to be established by EPA in consultation with DOE and the Biomass Research and Development Technical Advisory Committee. This program funds demonstrations of advanced technologies for the production of alternative transportation fuels including the development of not less than four different conversion technologies for producing cellulosic biomass ethanol and for developing not less than five technologies for co-producing value-added bio-products. The program authorizes $550 million per year for fiscal years 2005 through 2009 (Section 1514).
- The Act provides funds for the cost of loan guarantees to carry out commercial demonstration projects for ethanol derived from sugarcane, bagasse, and other sugarcane byproducts. Loan guarantees can be for up to 80 percent of estimated project costs, not to exceed $50 million per project (Section 1516).
- The Act modifies the small ethanol producer credit, allowing producers of up to 60 million gallons per year to qualify for the credit.

Policies that Support Ethanol Consumption

Federal policies that help to create a market for ethanol and thus encourage the demand for this fuel are of several types:

Air Quality Regulations

Air quality regulations that contribute to the use of ethanol for gasoline blending include:

- *The phase-out of lead as a gasoline octane-enhancing additive.* Prior to 1995, lead was used to raise the octane rating of gasoline. In 1995, lead in gasoline was completely banned because it is toxic to humans and disables emission control devices. Since ethanol also raises the octane rating of the fuel while reducing emissions, the ban on lead was largely positive for ethanol producers because it resulted in greater use of ethanol. As lead was removed from gasoline, gasoline producers replace it with oxygenates such as ethanol to maintain octane rating.
- *The introduction of oxygenated gasoline requirements.* The use of ethanol has been stimulated by the Clean Air Act Amendments of 1990. Ethanol is primarily used in gasoline to meet minimum oxygenate requirements of two Clean Air Act programs, the reformulated gasoline (RFG) and the oxygenated fuel programs.

  Reformulated Gasoline is used all year around to reduce vehicle emissions in areas that are in severe or extreme non-attainment of National Ambient Air Quality Standards (NAAQS) for ground-level ozone[*] (air pollutant that causes smog and has adverse effects on health and plants).[60] The Act also specified that RFG contain oxygen - two percent by weight. Ten metropolitan areas including New York, Los Angeles, Chicago, and Philadelphia must comply with this requirement, while other areas have chosen to participate in this program. The recent passage of the Energy Policy Act of 2005 eliminated the oxygenate requirements 270 days after date of enactment (immediately for California). The remaining reformulated gasoline air quality performance standards were enhanced.

  The Oxygenated Fuel Program. This program required that ethanol or another oxygenate be mixed with gasoline (resulting in oxygenated gasoline or oxyfuel) in areas with excessive carbon monoxide. Oxygenates are used to promote more complete combustion of gasoline, reducing carbon monoxide and toxic air pollutants. This program started to operate in winter months in sixteen areas that were listed as carbon monoxide (CO) non-attainment areas. Currently, most of these areas have achieved compliance and have been redesignated and are no longer required to be in the program.[61] California still is subject to oxygenate requirements in wintertime in areas of the South Coast Air Quality District.

The Establishment of a Renewable Fuel Program

The Energy Policy Act of 2005 defines a Renewable Fuel Program to be established by EPA (Section 1501). This program requires that gasoline sold in the United States contain a specified volume of biofuel. It sets the following schedule and amounts for introduction of renewable fuel content for gasoline in the U.S.: 4.0 billion gallons in

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[*] Ground-level ozone is different from stratospheric ozone, a natural protective layer above the earth against harmful radiation.

fiscal year 2006; 4.7 billion gallons in 2007, 5.4 billion gallons in 2008; 6.1 billion gallons in 2009; 6.8 billion gallons 2010; 7.4 billion gallons in 2011; 7.5 billion gallons in 2012, and determined thereafter by EPA. Although the minimum requirement of renewable fuels use in 2013 is at the discretion of EPA, it shall not be less than the percentage of 7.5 billion gallons of renewable fuel to the total number of gallons of gasoline in 2012. The Program also establishes a minimum volume for renewable fuel derived from cellulosic biomass of 250 million gallons, starting in 2013 and thereafter.

The Act provides refiners flexibility by creating renewable fuel standards credits (for renewable fuel blended above baseline) that have a lifespan of 12 months. Starting in 2013 and thereafter, the amount of fuel additives would be determined by the Environmental Protection Agency (EPA) and the Agriculture and Energy departments, and would be based on the experience of increasing fuel additives in the previous seven years.

Renewable fuel regulations apply to refiners, blenders, and importers. Small refiners are exempted. The EPA has to promulgate regulations regarding how the renewable fuel and credit trading provisions of the Act will be implemented. For the years 2006 through 2011, the Energy Information Administration (EIA) is supposed to provide an annual estimate of volumes of gasoline sold or introduced into commerce for the coming year. On the basis of these estimates, the Department of Energy (DOE) must publish regulations to ensure renewable fuel obligations for refiners, blenders, and importers are met. If regulations are not yet issued, the applicable percentage of renewable fuels for 2006 is set at 3.2 percent.

Ethanol is the renewable fuel additive expected to be utilized the most by gasoline producers to reach this goal. As such, the agreement requires the Federal Trade Commission to conduct an analysis within 180 days of enactment of the market concentration of ethanol and to determine whether there is enough industry competition to avoid price-setting or other anti-competitive behavior.

EPA, in consultation with DOE and the Department of Agriculture (USDA), would have the authority to reduce or waive the requirement for a state. The requirement could be waived if it is determined that the mandate would have a significant adverse economic or environmental impact on the state or region, or that there is an inadequate renewable-fuel supply or distribution capacity to meet the requirement. Any waiver granted would last one year, but would be renewable.

The Energy Department could also waive the requirement if it determines that the mandate would impose an economic hardship on a refinery.

Energy Policies That Provide Incentives for Alternative Fuel Vehicles

The Alternative Motor Fuels Act of 1988

Beginning in fiscal year 1990, this Act called for the federal government to acquire the "maximum practicable" number of light-duty alcohol and natural gas vehicles. It also established an Interagency Commission on Alternative Motor Fuels to develop a national alternative fuels policy. A commercial demonstration program to study the use of alcohol and natural gas in heavy-duty trucks was also established under this Act. Since 1991 the Department of Energy has been supporting projects in this area, making the data available through its Alternative Fuels Data Center.[62]

The Clean Fuel Fleet Program

Established by The Clean Air Act Amendments of 1990, this program requires that cities with significant air quality problems promote vehicles that meet clean fuel emissions standards. Although it imposes similar requirements to those for the Energy Policy Act, it allows for the use of conventional vehicles as long as they meet National Low Emission Vehicle standards.

The Energy Policy Act of 1992

The Act requires that the federal government, state governments, and businesses in the alternative fuel industry purchase alternative-fueled vehicles. It also established tax deductions for the purchase of alternative fuel and hybrid vehicles.[63] Under this Act, California and local government are required to purchase 75 percent of their non-exempt light-duty vehicles as alternative fuel vehicles (including flexible fuel vehicles that can burn variable mixtures of ethanol). However, flexible-fuel vehicles can operate on 100 percent gasoline and are not actually required to use an alternative fuel. Changing this situation in California will be difficult because of the lack of the necessary fueling infrastructure to support the use of these vehicles.[64]

The Working Families Tax Relief Act of 2004

The Working Families Tax Relief Act of 2004 increased manufacturing incentives for alternative fuel vehicles (including ethanol) established by the Energy Policy and Conservation Act (EPCA) of 1975 through 2005. The incentives are lower in 2006 and end in 2007. The current law repealed deductions in the credit amounts for 2004 and 2005 established by the previous law.[*]

The Energy Policy Act of 2005

The Act contains a number of provisions designed to encourage development and utilization of alternative fuels:

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[*] The Working Families Tax Relief Act extended the *full deduction* for qualified vehicles purchased in 2004 and 2005. Under old law, the maximum amount of the deduction ($50,000, $5,000, or $2,000, depending on the gross weight and seating capacity of the vehicle) is reduced by 25 percent for vehicles purchased in 2004 and by 50 percent for property placed in service in 2005. Under the new law a taxpayer can claim 100 percent of the deduction for vehicles purchased in 2004 and 2005. However, for vehicles purchased in 2006, the allowable deduction is 25 percent, as under previous law. The credit will expire after 2006.

- Includes programs to provide alternative-fueled vehicles for municipalities and schools.
- Strengthens the requirement for federal alternative fuel fleets to ensure these vehicles actually use clean alternative fuels and requires the Secretary of Energy to report to Congress the effect of the law on the development, availability, and costs of alternative-fuel vehicles.
- Authorizes $200 million for an advanced vehicle program. This program, operating under the current Department of Energy "Clean Cities" program, would provide grants to state and local governments to acquire alternative-fuel and fuel-cell vehicles, hybrids, and other vehicles, including ultra-low sulfur diesel vehicles.
- Offers business and consumer tax credits for the purchase of alternative-fuel and hybrid vehicles. The value of the tax credit ranges from $2,000 for smaller, personal cars to $40,000 for the purchase of buses, etc.
- Provides a 30 percent credit (up to $30,000) for investments in alternative-fuel refueling stations. Qualifying fuels include E-85, natural gas, hydrogen, and biodiesel, among others. The credit expires after December 31, 2007.
- Creates the joint flexible fuel hybrid vehicle commercialization initiative to improve technologies for the commercialization of hybrid/flexible fuel vehicles. The program is intended to reduce petroleum consumption by bringing new clean technologies to the market faster.
- Requires a monthly survey of renewable fuels demand in the motor vehicle fuels market.

STATE POLICIES

Policies that Encourage Ethanol Production

Several states have incentives supporting ethanol production. Illinois is the state that leads in policies supporting ethanol. Some states have direct payments of state funds to qualifying ethanol producers on a per-gallon of output, generally for specified maximum amounts of annual production and years. Other state tax incentives include property or business tax exemptions for ethanol producers. Some states also have income tax credits related to output or facility investments. Various states have grants and loan programs to finance ethanol production activities. Finally, there are state efforts to streamline (or shorten) the process of siting and permitting ethanol facilities.

Policies that Support Ethanol Consumption

In addition to the federal regulations, many states have established a variety of policy measures to promote ethanol markets. These policy incentives include:

- Fuel tax-exemptions (reduction of state motor fuel tax on ethanol blends). For example, some states reduce their excise tax and/or sales tax on ethanol/gasoline blends.
- State laws requiring a specified proportion of ethanol in gasoline blends.
- Requirements that public fleet vehicles use ethanol-blended gasoline and/or use E-85 in flexible fuel vehicles used by state government vehicle fleets and other public fleets.
- Tax credits for investment in alternative fuel vehicles and fueling facilities.
- Grants, low-interest loans, and rebate programs for investments in alternative fuel vehicles and fueling facilities.

CALIFORNIA-SPECIFIC POLICIES

Policies that Encourage Ethanol Production

In California there is no specific policy incentive for ethanol production.

There are two existing bond financing programs available to ethanol producers: (1) the California Alternative Energy and Advanced Transportation Financing Authority (CAEATFA) finances facilities that use new energy sources and technologies, and finances development of advanced transportation technologies, and (2) the Pollution Control Tax-Exempt Bond Financing Program provides private activity tax-exempt bond financing to California businesses for the acquisition, construction, or installation of qualified pollution control, waste disposal, waste recovery facilities, and the acquisition and installation of new equipment. In some cases, however, ethanol producers, particularly those producing cellulosic ethanol, are unable to meet lending requirements for those programs (for example, they cannot obtain a letter of credit from a qualified financial institution, because these institutions usually do not endorse production plans that involve the application of new technologies).

Policies that Support Ethanol Consumption

Tax Incentive to Use E-85 or Higher Ethanol Blends

Ethanol/gasoline blends are subject to the state gasoline excise tax. Since alcohol fuels are taxed at one-half the prevailing California gasoline excise tax rate, purer forms of ethanol, (E-85) have a rate of about 70 percent of the gasoline excise tax rate on an energy equivalent basis.

California Revenue and Tax Code 8651.8 provides for a tax incentive for using gasoline blends with 85 percent ethanol or higher.[65] However, since there is very little of this fuel used in California, this incentive is not used.

California Reformulated Gasoline (CaRFG)

To comply with the oxygenate requirements established by the 1990 amendments of the federal Clean Air Act (CAA), California implemented a wintertime oxygenated gasoline program requiring 1.8 to 2.2 percent oxygen content (measured by weight), since most of the gasoline in the state was under the oxygenate program. The 2.2 percent minimum for oxygen content was to control the increase in emissions of nitrogen oxides. The federal RFG requirements of at least two percent oxygen still apply in most of Southern California and in Sacramento, accounting for 70 percent of the statewide gasoline use.

California regulated reformulated gasoline used in the state in three phases. In 1992, California adopted CaRFG Phase I regulations that capped summertime vapor pressure at 7.8 psi for the entire state and forbade the use of lead-containing additives.

In mid-1996 California implemented CaRFG Phase 2 throughout the state. In its initial form, the regulation created a "recipe" for gasoline by specifying eight parameters of gasoline volatility and composition. It placed limits on summertime vapor pressure, benzene, total aromatics, olefins, and sulfur content, and set other conditions for the preparation of the blend. It also required minimum oxygen content year-round.

Phase 2 was later modified. Rather than using the "recipe," refiners were allowed to certify alternative gasoline compositions through a mathematical model called the "California Predictive Model."[*] This model (still in place) allows refiners to provide complying blends by trading off some gasoline parameters for others. Refiners can use the predictive model to set alternative values of fixed (flat) or averaging limits (180-day average value of the fuel property) but may not exceed the cap limits. However, even when the Predictive Model is used, the eight gasoline parameters are still subject to limits. Some of these limits are less stringent than the equivalent limits in the original recipe, but are still quite restrictive. To comply with the oxygen content requirement in the RFG regulations, California's cleaner burning gasoline also specified oxygen content of 1.8 to 2.2 percent. In the non-winter season, refiners could reduce or even eliminate the use of oxygen in areas of the state not subject to federal RFG requirements.[66] However, more than 70 percent of California gasoline were sold in areas designated as severe or extreme ozone non-attainment, subject to oxygenate requirements.

California changed to CaRFG Phase 3 on January 1, 2004, although the new regulations were already written in 1999, and several refiners had begun producing the new fuel earlier. Phase 3 prohibits the intentional blending of MTBE into California gasoline, and leaves ethanol as the only oxygenate. It also sets lower limits for sulfur and benzene.

The most important changes in Phase 3 regulations affecting ethanol use are:

- The revision of limits in oxygen contents in RFG from zero to 3.5 to zero to 3.7 weight percent (zero to 10 percent ethanol). Federal regulations still require a

[*] U.S. EPA also has a mathematical model to assess emissions, called the Complex model. The California Predictive Model is similar to the Complex model, but different in some parameters.

minimum of 2.0 weight percent oxygen year around in selected areas in California.

- Replaces a variable range for Reid Vapor Pressure of 6.4 to 7.2 psi (pounds per square inch), instead of the 7.0-psi limit established in the Phase 2 regulation. One of the eight specifications is a standard for Reid Vapor Pressure (RVP), which is designed to reduce evaporative emissions during the summer months when ambient temperatures are the highest. The lower the psi in gasoline, the less evaporative emissions that generally will occur. The establishment of a variable range for Reid Vapor Pressure allows refiners flexibility to blend ethanol at higher RVP than under Phase 2 regulations. But higher evaporative emissions resulting from the use of the higher RVP fuel will have to be offset by reductions in carbon monoxide (CO). These two provisions favor the use of ethanol in reformulated gasoline because ethanol increases RVP of the gas but decreases CO emissions.

Ban on the Use of MTBE

The use of MTBE was prohibited in response to evidence that it could contaminate groundwater. The ban on the use of MTBE made ethanol the only oxygenate approved for use in California gasoline, significantly increasing its consumption in the state.

Originally, the prohibition on the use of MTBE was going to be implemented as of December 31, 2002. However, because of fears of a projected spike in consumer gasoline prices, California Governor Gray Davis postponed the ban until December 31, 2003. Before the use of MTBE was banned in California, most refiners had designed their refineries around the ability to use MTBE to meet state and federal requirements for oxygenated and reformulated gasoline and to provide the desired gasoline volume. Refiners liked MTBE because it has more favorable blending properties and lower cost than other oxygenates.

End of the Oxygen Requirement

Since April 1999, shortly after announcing the ban on the use of MTBE, California requested a waiver from the oxygen requirement. Many thought this action reflected the fear that, after changing from MTBE to ethanol, the refineries would increase their costs significantly, raising gasoline prices in California. The justification for the waiver was that studies showed that gasoline formulated to California standards burns cleaner without oxygenates than with oxygenates (ethanol). After six years of EPA's denials, a lawsuit, and persistence by successive California Governors in reiterating the request, the Energy Policy Act of 2005 terminated the oxygenate requirements in California. The passage of this Act ends the demand for ethanol as an oxygenate in reformulated gasoline.

Assembly Bill 2076, Senate Bill 1170, and Senate Bill 1389

Other California policies that affect ethanol consumption include three important pieces of legislation.

In 2000 Assembly Bill 2076 (Shelley, Chapter 936, Statutes of 2000) required that the Energy Commission and the California Air Resources Board develop and submit a plan to the Legislature to reduce petroleum dependence in California. The Energy Commission and CARB held public workshops and meetings with environmental groups and representatives of the oil, natural gas, ethanol, and diesel engine industries to address these issues. The plan established both near-term and mid-term to long-term strategies to reduce the demand for petroleum fuels in California, including the use of alternative fuels.

Senate Bill 1170 (Sher, Chapter 912, Statutes of 2001) required the Energy Commission, the California Air Resources Board, and the Department of General Services to examine strategies to reduce petroleum consumption in the state fleet by no less than 10 percent on or before January 1, 2005. The state currently owns 1,649 flexible fuel vehicles capable of running on E-85. However, these vehicles currently run on gasoline because California lacks a retail fuel infrastructure to dispense alternative fuels. Another problem impeding the increase of FFVs in the state fleet is that current manufacturers of these vehicles do not meet state fleet procurement vehicle specifications. In January 2003, the Department of General Services adopted a new policy eliminating the option of purchasing FFVs (or any other type of alternative fueled vehicles), which uses fuel that is not widely available in California. Thus, the existing 1,649 FFVs are to be gradually phased out of the state fleet.[67] This situation may change with the passage of the Energy Policy Act of 2005.

Directed by the Legislature (Senate Bill 1389, Bowen, Chapter 568, Statutes of 2002) the Energy Commission prepared a biennial integrated Energy policy report, submitted to the Governor in 2003. SB 1389 directed state entities to carry out their energy-related duties and responsibilities based upon the information and analyses contained in the Energy Report. The Energy Commission has formed a number of working groups to establish strategies to achieve various goals (including a 20 percent increase in non-petroleum use on roads by 2020). Until recently, the Governor and the Legislature had not officially adopted these goals. However, in a letter to the President pro tempore of the Senate dated August 23, 2005 the Governor expressed that his energy policy views were consistent with most of the statements of the 2004 Integrated Energy Policy Report Update.

SECTION IV: THE DEBATE ON ETHANOL

There is controversy about how much energy is actually gained by producing ethanol, and how much ethanol use helps reduce petroleum dependency. Some feel that the industry is receiving too much government support, which is an inefficient use of scarce resources. There is also debate on the environmental benefits from using ethanol. Despite these unresolved arguments, significant resources have already been committed in the United States (and other countries) to support ethanol production, leading to a substantial expansion of the industry during the last decade. This section reviews the most important aspects of the debate on various effects of ethanol.

ENERGY BALANCE DEBATE

For a fuel to be energy efficient, its energy balance must be positive: more energy should be derived from its use than the energy used in producing it.

The energy balance of ethanol is a source of controversy. Studies vary in their estimates on the energy gain of producing ethanol, mainly due to the use of different assumptions, methodologies, or data. Many studies (including analyses by the California Energy Commission) report a positive gain of energy when the amount of energy required to produce ethanol is compared to the amount generated by its use. Some studies found a net loss.

The ethanol energy balance depends on the feedstock used and the technologies used in ethanol production. Estimates of the energy balance of corn ethanol have been rising over time.[68] The most recent report from the USDA Economic Research Service Office of Energy on this issue shows a positive ratio of 1.67 (one unit of energy spent in producing ethanol results in .67 percent energy gain) as a result of technological advances in ethanol conversion and increased efficiency in farm production.[69]

Research indicates that ethanol production from cellulosic wastes and residues offers a much better energy balance than conventional ethanol production using corn. For example, a Kansas State University study referenced an analysis concluding that the energy ratio for ethanol from cellulosic materials is 2.62 compared to .81 for gasoline.[70]

Other researchers have found much lower net energy balance values and some believe the balance is negative. Among them is Professor David Pimentel of Cornell University, College of Agriculture and Life Sciences, who has researched and published extensive criticisms of corn-based ethanol production, reporting that more energy is spent in producing ethanol than the energy generated by this fuel.

A study by Tad Patzek from the University of California, Berkeley also criticizes USDA estimates and concludes that it takes more energy to produce a gallon of ethanol than is contained in the final product. The authors criticize the USDA analysis for over-estimating the energy content of ethanol and omitting some of the energy inputs. At the same time, they acknowledge that estimates of the energy balance for gasoline may be too favorable because they do not include energy losses from oil recovery and conversion processes.[71] A more recent joint study by professors Pimentel and Patzek goes further and argues that ethanol produced from cellulosic materials also has a negative energy balance.

Differences between these studies and a number of other studies including those published by the Department of Energy and the U.S. Department of Agriculture are explained in differences in the coefficients used to measure energy inputs and crop yields per acre. For example, Pimentel's estimates of the amount of energy needed to make a pound of fertilizers are higher than the ones used by other investigators. He also included more sources of energy spent in the ethanol production process, such as the food energy consumed by the workers. Furthermore, co-products resulting from ethanol production were not counted to the benefit of ethanol in Pimentel's computation. Furthermore, energy experts indicate that it always takes more energy to convert one form of energy into another (in the ethanol case, converting solids into liquids or esterifying the oils). When biomass (plant matter) is converted, the excess energy used is solar energy. Taking this into account, the net energy ratio with respect to fossil fuels is positive.[*]

THE ENVIRONMENTAL DEBATE

One of the main benefits attributed to using ethanol (even as an additive) is that it improves air quality and it has been widely used as an oxygenate. However, there have been many evaluations of ethanol's impact on air quality yielding conflicting results. Closely related to that discussion is the debate on the effects of using ethanol as an oxygenate to reduce air pollution. The use of any ethanol blend, however, significantly reduces carbon monoxide emissions. There are also gains in carbon dioxide emissions over the life cycle of this biofuel.

Effect of Using High Ethanol Blends on the Environment

As an alternative fuel, in blends containing high levels of ethanol content (E-85), it reduces carbon monoxide emissions and eliminates health-threatening toxics contained in gasoline. There is general acceptance on the benefits of using higher-than-40-percent ethanol blends for air quality. Evaporative emissions of ozone forming compounds (VOCs)[†] due to increased RVP start to decline at 20 percent blends or more, reaching a level equal to pure gasoline once there is about 40 percent ethanol. Above 40 percent, the blended fuel results in fewer evaporative VOC emissions than does gasoline. Furthermore, studies have shown that ethanol E-85 (blended with 15 percent gasoline) derived from biomass can reduce carbon emissions by 80 to 85 percent, compared to a 22 percent reduction from corn-derived ethanol E-85.[‡]

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[*] Memorandum from David Morris, Institute for Local Self-Reliance (October 30, 2005).

[†] VOCs are also known as reactive organic gases or hydrocarbons.

[‡] Analysis by Argonne National Laboratory showed that in its pure form (E-100) ethanol derived from biomass can reduce carbon emissions by 100 percent, assuming that there is no use of energy from fossil fuel sources at any stage of the fuel cycle process. Corn-derived ethanol uses fertilizers and fossil fuel to grow and process corn to ethanol, therefore, the reduction of carbon emissions using corn-derived ethanol

Effect of Using Low Ethanol Blends on the Environment

When used as an additive (at lower blends), reductions of carbon monoxide emissions and other toxics are partly offset by higher emissions of volatile organic compounds (VOCs). The net effect of using low ethanol blends is still in debate, and a variety of studies yield conflicting results depending on the methodology used.

Exhaust Emissions:

1) EPA's studies concluded that the RFG program reduced VOC emissions from vehicles by 17 percent, and toxic emissions by 30 percent.[72] Studies show that a 10 percent blend of ethanol (E-10) reduces carbon monoxide (a precursor for ozone formation) by more than 25 percent. Higher ethanol blends lead to larger reductions in carbon monoxide emissions.

2) It is widely accepted that, because of higher vaporization,* gasoline blends with less than 20 percent ethanol† increase some evaporative VOCs such as butane (less reactive for ozone formation), but decrease the volume of some exhaust pipe VOCs, which are more reactive and most toxic (for example benzene, toluene, and xylene). At higher blends (above E40) all evaporative VOCs emissions are lower than in gasoline.

3) EPA has established risk factors for air toxic pollutants, which give an indication of the relative risk of each toxic compound. Based on these risk factors, research supports that low ethanol blends meet the requirements for toxic air pollutants, which affect ozone formation. Toxic air pollutants (1,3-butadiene, benzene, and aldehydes such as formaldehyde and acetaldehyde) have adverse effects on human health and are specifically classified as known or probable carcinogens. Combustion of ethanol increases aldehydes emissions. The major products of concern for ethanol are acetaldehyde and peroxyacetyl nitrate (PAN, an eye irritant and cause of plant damage). However, the emissions of these compounds are offset by reductions in benzene and butadiene that have higher cancer risk factors. Furthermore, ethanol supporters indicate that aldehydes emissions can be generally controlled through tailpipe oxidation catalysts.[73]

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is substantially lower. Methanol is also capable to achieve carbon reductions comparable to those achieved by the use of ethanol.

* See section on ethanol properties.

† Evaporative emissions decrease dramatically with blends of 20 percent or more.

4) Although the use of lower ethanol blends lead to lower exhaust emissions of some VOCs and of carbon monoxide (CO), there are concerns that they lead to higher emissions of nitrogen oxides (NO_x) that also contribute to the formation of ozone.[*] Some studies indicate that the benefits of lower VOCs and CO emissions do not offset the cost of higher levels of NO_x emissions.[†]

   Some ethanol supporters feel that CARB exaggerates NO_x emissions associated with ethanol's use as a transportation fuel. They note that current law permits refiners to increase ethanol concentrations provided they adjust other aspects of the formula to reduce NO_x emissions within the limits set by the predictive model. Others argue that these adjustments are difficult and expensive for refiners to implement.[74]

5) Emissions of particulates are also a concern. Particulate matter, or PM, is the term for particles found in the air, including dust, dirt, soot, smoke, and liquid droplets. Ethanol helps reduce emissions of coarser particulate matter (10 microns or less, known as PM_{10}) but may increase the formation of fine particulates (related to the increase in NO_x emissions associated with low ethanol blends). The overall effect of particulate emissions when using ethanol blends is still under debate.[‡]

6) The controversy on the environmental effects of ethanol when used in low-ethanol blends has raised questions on the effectiveness of using it as an oxygenate to improve air quality. In California, 5.7 percent ethanol has been used to meet the oxygenate requirements. Since 1999, CARB studies suggest that current RFG formulations under California law have a lower level of toxic substances than conventional gasoline,[75] and that the use of clean burning gasoline could reduce emissions at similar or even lower levels than the ones achieved with the use of ethanol blends. This is because under California specifications, the fuel property changes necessary to reduce VOCs resulting from removal of oxygen also reduce emissions of CO. According to CARB, this reduction is larger than the reductions in CO due to the addition of ethanol to gasoline. The

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[*] Ozone is formed by the interaction of various chemicals in the presence of sunlight, including nitrogen oxides and carbon monoxide.

[†] For example, responding to a request by the Environmental Protection Agency (EPA) for an objective study, a May 1999 report by the National Research Council on "Ozone-Forming Potential of Reformulated Gasoline," concluded that the effect of oxygen in RFG was small and that data suggest that oxygen causes just a small reduction in the mass of VOC and CO exhaust emissions. The National Research Council also found that data on the effect of oxygen on nitrogen oxides and other emissions was inconsistent; pointing out that some results suggest that oxygen in RFG leads to an increase in those emissions. Their study also concluded that the most significant advantage of using oxygenated additives in RFG appears to be a reduction in the emissions of some air toxics (e.g., benzene, butadiene) that are attributable to the displacement of toxic components from the blend, and may or may not be associated with the presence of oxygen."

[‡] Analysts point out that there is no NO_x increase when comparing 5.7 percent ethanol blends to 11 percent MTBE blends.

results of their study only apply to 5.7 percent ethanol blended gasoline, as used in California, and does not necessarily apply to higher concentration ethanol blends or different gasoline compositions* sold in other states, where blending ethanol and conventional gasoline may still yield significant environmental benefits.

7) Another argument is that innovations on vehicle technology make the ethanol reduction of carbon monoxide emissions from using ethanol less significant to the environment. Modern vehicles have oxygen sensors, fuel injectors, and computer controls to compensate for non-ideal combustion. If the oxygen sensor detects too low a level of oxygen in the gases coming from the engine, the computer control automatically compensates by reducing the amount of fuel being injected into the engine cylinder (closed loop operation). Vehicles certified to California LEV II or Federal Tier 2 standards have efficient catalytic systems that reduce CO, VOCs, and nitrogen oxides (NO_x) emissions to very low levels. However, if on one hand modern vehicle technology eliminates the necessity of using ethanol as an oxygenate, on the other, it also helps its use as an additive by lessening some of the adverse emission effects from using low ethanol blends.

Differences in sampling procedures and the model used to assess emission effects could explain the apparent contradictory results from research on emissions:

- Different emission models, such as the EPA model and the California predictive model, differ in calculating the effect of high emitters.† The benefit of ethanol blends is greater for high emitters vehicles (for example, with older emissions technologies), reducing the exhaust emissions of VOCs and CO.
- The California Air Resources Board's conclusions are based on the use of the agency's predictive model, which, according to many analysts, requires updating. The California Air Resources Board is currently in the process of revising and bringing up to date the parameters of the predictive model.
- Critics believe that the measures used by CARB misrepresent the positive effects of using ethanol. For example, the credit for CO reduction from adding ethanol in the predictive model is about one-third the credit in the EPA model.‡
- Experts have questioned the sampling procedures used by CARB studies. Furthermore, aggressive driving effects are not considered in the study.

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* See www.crcao.com or www.arb.ca.gov/fuels/gasoline/gasoline.htm CARB "Fuel Permeation from Automotive Systems." CRC Project No. E-65. September 2004.

† LEV stands for Low-Emission Vehicle. LEV II (adopted by the California Air Resources Board in 1999) amends LEV regulations, improving emission reduction standards for automobiles.

‡ This is because EPA and CARB use different measures of reactivity of carbon monoxide (how many units of CO are equivalent to one unit of ozone). The California Air Resources Board model uses a ratio of 48:1. USEPA uses a 15:1 ratio. With a higher ratio, the benefit of using ethanol on CO reduction becomes less significant.

To address those concerns, an independent assessment of the assumptions of the predictive model is needed. Furthermore, most of these problems are to be resolved as the use of new vehicles, with pollution control technologies that are able to decrease NO_x emissions, expands.

Permeation Emissions:

In addition to exhaust emissions, there are other emissions that occur during fueling and storage, and due to permeation through the fuel system's rubber and plastic components (also referred to as "soft components").

A recent study sponsored by the California Air Resources Board on permeation effects of ethanol indicates that the presence of ethanol in gasoline results in a significant increase in the permeation of gasoline constituents through a motor vehicle's fuel system's soft components. Evaporative VOCs increase by about 45 tons per day on a typical ozone day or 75 tons per day[*] on a high-ozone day from on-road motor vehicles statewide in 2004.[76] Other studies have found different results. The firm Environ used new data and found an increase of VOCs by 19 tons. Research by the American Petroleum Institute, done by AIR, Incorporated, which uses new data, found numbers lower than CARB but higher than the ones reported by Environ.[77]

Some analysts have criticized the sampling procedure and methodology followed by the CARB permeation study. CARB indicates that a second study is being conducted to look at the effects of using E-85 and ethanol blends in more advanced technology vehicles, such as partial zero emission vehicles and flexible fuel vehicles.[78]

Although permeation emissions are currently a problem, they can be eliminated on new vehicles by using higher-quality hoses, tubes, and other connectors, but it will take some time until all old cars can have their components replaced (approximately 2020). Furthermore, some ethanol supporters indicate that at 10 percent ethanol blends the permeation emissions are lower.

Effects of Ethanol Blends on Soil and Water

It does not appear that ethanol spills or leaks will pollute groundwater (as does MTBE).[79] Although negative effects on groundwater from ethanol spills are not expected since ethanol is water soluble and readily biodegradable, its presence in gasoline blends may amplify gasoline's harmful properties. Because of its biodegradability, ethanol's rapid breakdown by microbes depletes available oxygen in soil and water, slowing the breakdown of gasoline and making harmful chemicals in gasoline (benzene, toluene, xylene) persist longer. For example, benzene could persist 10 to 150 percent longer than in a pure gasoline spill.[80] However, at higher blends of ethanol this is a minimum problem.

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[*] There is a great deal of debate on the actual resulting tons per day impact since several other analysts have reached much lower numbers (for example in the 22-25 ton/day range).

Furthermore, ethanol (at blends above 20 percent) can act as a carrier, extending as much as 2.5 times the distance that gasoline (and its toxic compounds) can travel. It can also exacerbate the effects of the gasoline's spill by remobilizing residual gasoline in contaminated soils (a problem most likely found at gasoline terminals where spills have occurred). Hence, government regulations on fuel handling that recognize these problems are recommended.

Greenhouse Emissions Reduction Over the Fuel Cycle

Because ethanol is a renewable fuel, it reduces greenhouse gas emissions over the fuel cycle (all the process of production, delivery, and final use of ethanol), and hence reduces the risk of global warming. Ethanol production from cellulosic wastes and residues contribute to a better energy balance and associated carbon emission results than conventional ethanol production using corn.

When ethanol is produced from cellulosic materials rather than corn, and if the lignin in the cellulosic material is used to generate the energy needed by the manufacturing process, a net reduction in greenhouse gases occurs. This is true despite negative emission impacts associated with ethanol production coming from the combustion of lignin and generation of extractives and other chemicals as well as the emissions from the transportation of feedstock to plants. A study by the Energy Commission evaluated various environmental impacts associated with ethanol production from cellulosic materials and found that the net balance is strongly positive.[81]

Other Environmental Effects from Cellulosic Ethanol Production

The following positive effects on the environment from cellulosic ethanol production are widely accepted:

- If cellulosic ethanol production uses forest residues, the removal of these residues helps to prevent forest fires. Compared to open fires, biomass utilization definitively results in substantial emission reductions for CO, hydrocarbons, and particulate matter.[*]
- The conversion of agricultural residues (rice straw, for example) to ethanol reduces air pollution by providing an alternative to open-field burning practices, which contaminates the air.
- When ethanol is produced from agricultural and other waste materials, there are also benefits associated with landfill use savings. Landfill space requirements could be reduced if a significant portion of the industry uses municipal waste (unwanted products or materials having no further value or use).

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[*] California Energy Commission. Pier Collaborative Report California Biomass Collaborative "Biomass in California: Challenges, Opportunities, and Potentials for Sustainable Management and Development." April 2004.

THE CONTROVERSY ON THE ECONOMIC EFFICIENCY OF SUPPORTING THE INDUSTRY

There is debate about the profitability of producing ethanol and the economic efficiency of providing government support to the industry.

The potential for ethanol production as an alternative fuel heavily depends on the relative price of gasoline to ethanol. Until recently, the price of ethanol was significantly higher than the price of gasoline. Most ethanol is produced from corn, thus corn prices are also a determinant of the industry's profitability.

The ethanol industry has been able to survive thanks to government support. Since 1978, the federal production tax credit[*] has offset most of the difference between gasoline and ethanol prices, helping ethanol to compete in the market.[†] Currently this subsidy is 51 cents, about one half of the wholesale cost of ethanol. Many believe that without this support and other federal and state policy incentives that have assured a market for ethanol, the operation of this industry would not be economical.[‡] However, this may no longer be true today, when the industry is more mature and the ethanol price is more competitive.

For many, government support to the ethanol industry is and has been an inefficient use of scarce resources, since it is government money that could have been directed to alternative uses producing higher returns. For example, it could have been used to support public investment in highways.

Ethanol supporters also point out that other industries, including the powerful oil industry, benefit from subsidies and a variety of tax incentives. The Energy Policy Act of 2005 includes a range of incentives for oil. Historically the U.S. government has supported emerging industries. Since the ethanol industry is small in comparison to their competitors (the oil companies) it may need help in the earlier years of operation to become successful.

Finally, there are studies showing that the benefits from government support to the ethanol industry outweigh the costs. For example, a cost-benefit study on cellulosic-ethanol production in California, conducted by the California Energy Commission and published in March 2001, calculated that state government incentives totaling $500 million for a 200 million gallon per year cellulosic ethanol industry could bring California benefits of $1 billion over a 20-year period.[82]

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[*] And also state tax credits are provided in some states.

[†] This policy is discussed in detail in Section III.

[‡] Policies have been discussed in Section III. The most important policies expanding the demand for ethanol has been the oxygenate requirements of the Clean Air Act and the Energy Act of that stimulate the use of alternative fuels. States like Illinois also have state policies that promote production and consumption of this alternative fuel.

Other studies show positive gains to commodity prices, farm incomes, and rural employment due to ethanol production.[83] Spillover effects could offset the costs of subsidies. Ethanol production helps economic development by job creation and income generated by this activity and by the demand of the industry for other products in the economy. New jobs indirectly related to ethanol production would include those required for the production and harvesting of energy crops; those related to the collection and transportation of cellulosic materials, and those related to ethanol transportation from ethanol plants to terminals. For example, according to an assessment by Ellen Burnes, of the California State University, Fresno, a 40 million-gallons-a-year plant may generate 41 full time jobs.[84]

Government support to the ethanol industry has also been seen as a mechanism to transfer tax money to Midwest agriculture, since the production of ethanol is mostly corn-based. The debate on this issue revolves around the following arguments:

- *Historically, the ethanol program essentially took money that would have gone to the Federal Highway Trust Fund, through gasoline taxes, and shifted it to Midwest agriculture.* With the American Jobs Creation Act of 2004 this problem was eliminated because the Act replaces the existing exemption with a tax credit paid from the General Treasury, as opposed to the Highway Trust Fund.

- *Ethanol incentives do not benefit most corn farmers, but are "corporate welfare" for a few large producers.*

  Ethanol production is concentrated among a few large producers. Indeed, the top five companies account for almost half of production capacity. According to many economists and agricultural experts, "the bulk of the profits generated from ethanol go to agriculture processors like the Archer Daniels Midland Company, which is turning greater volumes of low-priced corn into a high-priced fuel."[85] Others note that, while it is true that the ethanol industry benefits from economies of scale and a few large producers dominate production, more smaller producers and farmer cooperatives have been entering the industry.

  The Renewable Fuels Association reports that since 1990, farmer-owned cooperatives are responsible for the majority of new ethanol production capacity.

  According to some analysts, subsidies do not help farmers because corn farmers receive only about a nickel out of the 52 cents per gallon subsidy for ethanol. Others point out that this situation has changed since more farmers own ethanol production facilities, receiving dividends of 20-30 cents per gallon.[86] Critics respond that this only makes it more difficult to remove the subsidy because of the increased importance to the agricultural sector.

  Critics also argue that only a few farmers benefit from ethanol subsidies. Supporters of the subsidies counter by arguing that all corn farmers benefit because about 11 percent of the corn produced in the U.S. goes to ethanol production, which raises the price of corn for all corn farmers.[87] According to the

National Corn Growers Association, ethanol production raises the price of corn by more than 30 cents a bushel.* The Association argues further that these higher prices reduce federal spending on corn price supports by lowering payments to farmers.[88]

Furthermore, not all ethanol production is from corn. Many energy experts indicate that the future of the industry depends on the use of cellulosic materials as feedstock. An increasing amount of ethanol is produced from nontraditional feedstocks such as waste products from the beverage, food and forestry industries rather than corn. There are also some attempts to produce ethanol from agricultural residues such as rice straw, sugar cane bagasse and corn stover (residue left after corn harvest), municipal solid waste, and energy crops such as switchgrass.

THE USE OF CORN TO PRODUCE FUEL RATHER THAN USING IT TO FEED THE HUNGRY

Some critics contend that corn should be used to feed the hungry, rather than to produce fuel. The response of the ethanol industry is that the production of ethanol does not reduce the amount of food available since the corn used by the industry is from field corn fed to livestock, not corn for human consumption. Ethanol production utilizes only the starch portion of the corn kernel, which is abundant and of low value. The remaining vitamins, minerals, protein, and fiber are sold as high-value livestock feed.

USE OF ETHANOL TO REDUCE OIL DEPENDENCY

A strong argument for using ethanol is that it is a renewable fuel that can help reduce fossil energy and petroleum use in transportation, thereby improving the trade balance and decreasing the vulnerability of the U.S. economy to oil imports and oil price fluctuations.

The Problem

Gasoline consumption in California has been increasing as a result of population growth, growth in the number of vehicles on the road, declining real cost of gasoline during the last decade, and a shift in consumer preference to larger and less fuel efficient vehicles. While gasoline demand has increased, refining capacity in California has not. In fact, since 1969 the refining capacity has decreased by nearly 20 percent. Fortunately over the last decade refineries have been able to increase production of gasoline and diesel by process improvements.[89] Still California is increasingly relying on the import of fuels from other states and countries to meet the increasing demand for fuel. The Energy Commission projects that imports of gasoline and diesel will more than double by 2010.[90]

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* According to facts reported by the Renewable Fuels Association on its Web page, the U.S. Department of Agriculture estimates that ethanol production adds 25-50 cents to the value of a bushel of corn, or as much as $5.5 billion over the entire corn crop.

The price of gasoline could spike to record levels as oil prices increase, since fuel demand does not significantly adjust to oil price changes in the short run.

Table 4 shows gasoline consumption in the U.S. and California. California uses about 11 percent of total gasoline consumed in the U.S. or about 15.3 billion gallons per year.

Projected demand for gasoline in 2025 in the U.S. is expected to be between 38 and 44 percent higher than in 2003 (Table 5). The share of imported gasoline is expected to increase from 56 percent in 2003 to between 68 and 76 percent in 2025. The passage of the Energy Policy Act of 2005 lowers the share of imported gasoline (for example, 2025 forecasts of 68 percent would be adjusted to 64 percent due to the effect of this Act).[91]

Table 4

Gasoline Consumption in California (Billion Gallons per Year)	
Source:	**2003**
California Energy Commission	15.27
DOT (motor fuel use, combined gasoline and gasohol)	15.29
Gasoline Consumption in U.S. (Billion Gallons per Year)	
Source:	**2003**
DOT (motor fuel use, combined gasoline and gasohol)	139.00
California's Share of US Gasoline Consumption	**11.0%**

Table 5

Projected Growth in Gasoline Demand in the U.S.		
Source: (*)	**2003-2015**	**2003-2025**
AEO 2005 National Energy Modeling System	25.08%	44.34%
GII Global Insight Inc.	22.96%	39.75%
DB Deutsche Bank	21.61%	37.74%
PIRA Energy Group	3.92%	
(*) See Energy Information Administration. Annual Energy Outlook 2005, with Projections to 2025, p. 120.		

Table 6 shows projections for gasoline demand in California as calculated by the Energy Commission.

Table 6

Projected Gasoline Consumption, California (Million Gallons per Year)			
Source:	**2010**	**2015**	**2023**
California Energy Commission	17.3	20.7	19.8

The Energy Commission projects that, over the next 20 years, gasoline and diesel demand for on-road vehicles in California will increase 36 percent and the demand for jet fuel will more than double.[92] This increase in demand will be met by increased imports, since state refineries are already operating at full capacity. California refineries are already importing a significant amount of crude oil (22 percent from Alaska and 30 percent from foreign sources). Trends indicate that, by 2010, daily imports of gasoline and diesel will more than double to 10.1 million gallons. Furthermore, import facilities are also operating at full capacity hence, unless these facilities expand, the flow of gasoline and diesel into the market may become very volatile, with supply shortages and prolonged periods of high prices.[93]

This picture suggests that California needs to follow a strategy of reducing petroleum dependency. It might use a variety of measures, from improving automobile fuel use efficiency to increasing the production and use of alternative fuels. The California Energy Commission and California Air Resources Board have already done some work in this direction, addressing potential goals to decrease fuel demand in the future.

Advantages of Using Ethanol as a Replacement for Petroleum Fuels

Given the current state of the art and the amount of biomass available for ethanol production, it is unlikely that ethanol could completely replace gasoline given the current levels of gasoline consumption.

Currently, an ethanol blend at 5.7 percent displaces about five percent of petroleum fuels. A more aggressive scenario (using E-10) indicates that it is possible to displace 9 percent of petroleum fuel. Furthermore, an additional five percent could be displaced if existing FFV owners actually use E-85.

Ethanol supporters believe that, with increased use of flexible fuel vehicles and plug-in-hybrids, ethanol could become an alternative to gasoline, rather than being simply an additive (as it is used today).[*] Hybrids (HEVs) are vehicles using a combination of fuel and battery, and plug-in-hybrids (PHEVs) are battery-driven-hybrids utilizing electricity or solar power to charge the battery when the vehicle is not in use. Examples of these HEVs are the Toyota Prius and hybrid sport utility vehicles (SUVs), which are achieving high mileage (40 miles per gallon).

Hybrids combining high-energy efficiency and the use of alternative fuels (such as ethanol) offer the potential for large reductions in oil consumption. David Morris, from the Institute of Self-Reliance, points out that an urban-based hybrid electric vehicle can

[*] See for example, David Morris. *A Better Way to Get from Here to There. A Commentary on the Hydrogen Economy and a Proposal for an Alternative Strategy*. Minneapolis: Institute for Local Self-Reliance. December 2003. The report *Growing Energy. How Biofuels Can Help End America's Oil Dependence*, by the Natural Resources Defense Council (Op.Cit.) indicates that biofuels alone will not reduce petroleum dependency, but a strategy combining new sustainable fuel production, fuel efficiency, and smart growth will do it. A "package approach" of a combination of policies, including hydrogen and electric vehicles will be required in the path towards fuel self-sufficiency.

travel 60 miles on its batteries, potentially reducing fuel consumption by 85 percent. If all vehicles had this technology, gasoline consumption could decrease to less than one third the current volume, and if these vehicles would use ethanol instead of gasoline, the reduction in gasoline use would be even more dramatic.[94]

Advocates of ethanol note the following points regarding the use of ethanol to displace gasoline consumption:

- It is already used extensively as a gasoline extender or as an alternative fuel. In addition, ethanol has already been widely used as an oxygenate to meet the federal oxygenate requirements. Some states such as Illinois consume significant levels of E-85.
- Some infrastructure is already in place to support ethanol use.[95]
- Flexible fuel cars burning 85 percent ethanol do not need changes in design. Most major automakers are now producing these vehicles. There are already over three million cars capable of using both ethanol and gasoline in the United States, and more than two hundred thousand on California roads.[96]
- Ethanol can also be used in fuel cells. An example of this use is in Chicago, where buses are powered by fuel cells that are using hydrogen reformed from low-grade ethanol (containing 15 to 20 percent water).[97] Advocates argue that an ethanol-fueled transportation system could lay the groundwork for a slow transition to hydrogen because ethanol is a hydrogen-rich liquid, which overcomes both the storage and infrastructure challenges of hydrogen for fuel cell applications.[98]

Problems Associated with Using Ethanol as a Replacement for Petroleum Fuels

Controversy exists regarding whether or not ethanol should be used to replace petroleum-based fuels:

- Air regulators have opposed increasing ethanol content in gasoline from 5.7 percent to 10 percent. They argue against the use of low-blends of ethanol because its adverse environmental effects. However, other analysts indicate that increasing the ethanol content from E-5.7 to E-10 would have a net positive effect on air quality since it would significantly reduce carbon monoxide and other toxic emissions while the volume of NO_x emissions would only slightly increase.
- The use of higher ethanol blends, such as E-85, requires new fueling stations and an aggressive marketing campaign to inform consumers on its availability.[99] In addition, fueling equipment is not certified by CARB and it is very difficult to obtain the necessary permits in California. (All existing California E-85 fuel stations are permitted as research and development facilities.)
- Some critics question whether ethanol can significantly displace petroleum fuels. First, ethanol's *energy* content is lower than that of gasoline. That means that more ethanol fuel is required to travel the same distance because there is less energy in one gallon of ethanol than in one gallon of gasoline.[100] They also raise

the question of energy balance. As explained earlier this issue continues to be debated, but less so with regard to ethanol produced from cellulosic feedstock.

- In the absence of an oxygenate requirement for California, the state's refiners may discontinue its use if there are economic benefits of doing that.

EFFECTS ON REFINERS AND THE CAR INDUSTRY

The U.S. oil industry opposes policies that support the use of ethanol because it will reduce oil consumption. For example, Western States Petroleum Association (WSPA) strongly opposes state policy incentives for reducing petroleum demand, including government mandates to substitute alternative fuels for petroleum products and requirements that the oil industry sell or subsidize new fuels. This was expressed by Mr. Joe Sparano in a workshop organized by the Energy Commission on July 8, 2005: "We believe it's unproductive for government to set arbitrary goals for reducing the availability of what is arguably the cleanest reformulated fuels in the world while California's supply/demand imbalance increases."[101]

Furthermore, the required use of ethanol in reformulated gasoline can increase the cost to refiners during the blending process and distribution of the ethanol-gasoline blends.[*] Pipelines cannot transport ethanol-gasoline blends because pipelines have the potential of containing water and ethanol, which combine and separate from gasoline. In addition, ethanol use in blends results in higher evaporative emissions, requiring refiners to remove other gasoline components in order to meet the RVP (vapor pressure) limits set by the U.S. Environmental Protection Agency and California Air Resources Board standards.

The car industry may also face challenges adjusting to increased ethanol use. It is difficult for this industry to adjust the vehicle and provide fuel specifications for various vehicles as fuels and fuel additives change. The ethanol industry is advocating for a state mandate to use only FFVs in California, a policy that the automobile industry is expected to oppose.[102]

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[*] However, the MTBE ban removed 11 percent volume from the fuel pool, thus the addition of ethanol replaces some of this volume, with some net volume gain. If refiners had to make up the small volume ethanol contributes to the pool they would need to use alkylate, reformate or issoctane, which are more expensive than ethanol. Furthermore, the price of ethanol also plays a role in offseting the cost of adjusting the base gasoline. Current prices are more favorable, although they reflect an oversupply of ethanol in the market. (Comment from Mr. Robert Reynolds, Downstream Alternatives, Inc.)

SECTION V: CONCLUSIONS AND POLICY RECOMMENDATIONS

The use of ethanol may help to reduce oil dependency either in low-ethanol and gasoline blends or as an alternative fuel. However, there is much controversy on some aspects of ethanol use that needs to be resolved before the state seriously commits to support this fuel.

The most important issue to resolve is the energy balance of ethanol. A fuel that that uses more fossil energy than the amount it generates will not help to reduce fossil fuel dependency. Hence, there is a need for more research by independent parties on this subject.

The future of the ethanol industry, particularly in California, lies in its ability to use cellulosic feedstock rather than corn. However, there are two main challenges for the use of waste and agricultural residues as feedstock. First, it is difficult to collect and it may present problems from contamination and the diverse composition of these materials. Second, technologies to process cellulosic feedstock are just starting to emerge at a commercial scale. The industry needs more innovation on the pretreatment and the conversion of feedstock to sugars. The development of technologies that lower the costs of these processes will help create a flourishing cellulosic ethanol industry.

Another problem is the uncertainty that exists on the exhaust emissions and permeation effects of low ethanol blends on the environment. Again, this issue needs more scientific research by independent and well-known institutions. The model used by CARB to assess environmental effects needs to be updated (CARB is in the process of doing that) and also reviewed by independent reliable sources.

There is consensus that the negative environmental consequences of ethanol use disappear at higher blends of ethanol, particularly using E-85. With evidence of a positive energy balance, this could be the avenue to pursue. However, the lack of infrastructure for distributing E-85 is a problem in California.

As more modern cars are on the road and new technologies develop, the possibility of using ethanol expands since the potential environmental damage will decline. The state commitment to ethanol will depend on how serious the state sees the problem of its dependence on fossil sources for energy.

Based on the experience of other states, once the state commits to an ethanol strategy, there are potential additional benefits from supporting the development of an ethanol industry in California. California represents a large market for transportation fuels, has a large amount of cellulosic feedstock, and could stimulate development of a cellulosic ethanol industry in the farm communities.

The state may assist ethanol production in a number of ways. Some policy options are discussed below. Many of them have already been implemented in other states with different degrees of success.

DEVELOPING A COMPREHENSIVE AND COHERENT STATEWIDE ENERGY AND BIOMASS POLICY

California's transportation fuel policy is unclear. For example, the state's Energy Action Plan adopted in August 2005 by the California Public Utilities Commission is silent with regard to fuel issues, deferring them to other forums.

The lack of coordination between policies related to biomass management, use of renewable fuels, incentives for the development of flexible fuel vehicles, air quality goals and environmental goals, hamstrings the state and the ethanol industry.[103] For example, CEC has been focusing on the potential of ethanol to reduce oil dependency, while CARB has focused on the adverse effects of low-blends of ethanol and has also been criticized by industry for not developing a certification process to expedite the permitting of alternative fuel stations.

> The most important condition for the development of a significant ethanol market in California requires a full commitment by the state to support the market. Brazil illustrates this point. Ethanol production in Brazil is the most successful experience of large-scale renewable fuel production in the world. However, it would not have been possible without the commitment of the Brazilian government to move to ethanol production on a mass scale though its National Alcohol Program named "PROÁLCOOL" (created in 1975). Their most important objective was to substitute domestic fuel for imported oil. Their strategy integrated agricultural, industrial and infrastructure development needs. Although their program faced numerous challenges and uncertainties since its inception, it achieved outstanding results. Ethanol content in gasoline rose sharply from 4.5 percent volume in 1977 to 15 percent in 1979 and to 25 percent in 2002. Currently in Brazil all gasoline sold to the public contains ethanol. There are 2.4 million dedicated ethanol-fueled vehicles, the largest worldwide non-fossil fuel vehicle fleet in operation. In March 2004, flex fuel vehicles were introduced in the Brazilian market. These vehicles are capable of running on 100 percent ethanol or any blend of gasoline and ethanol.

There is some indication that the state would like to reduce fossil fuel dependency. For example, Assembly Bill 2076 (Shelley, Chapter 936, Statutes of 2000) required the Energy Commission and the California Air Resources Board to develop and submit a plan to the Legislature to reduce petroleum dependence in California. The California Energy Commission adopted its first Integrated Policy Report in 2003, which discussed major energy issues for California and recommended policies to address these issues. In their Integrated Policy Report, the Commission recommended that the state increase the use of non-petroleum fuels to 20 percent of on-road fuel consumption by 2020 and 30 percent by 2030.[104] However, CEC indicated in their 2004 update of the Integrated Policy Report that the state has made little progress to achieve the alternative fuel goals mostly due to the lack of sustained commitment and resources by the state (goals have not been officially adopted by the Legislature and the Governor).[105] Currently, there are working groups discussing strategies to limit petroleum dependency. In letter to the President pro tempore of the Senate dated August 23, 2005, Governor Schwarzenegger recognized the needs for an energy policy and found the 2004 Integrated Energy Policy Report Update consistent with his views. The letter included suggestions for the continuation of energy policies, including the goal of increasing the use of non-petroleum fuels to 20 percent of on-road fuel consumption by 2020 and 30 percent by 2030.

ESTABLISHING STATE INCENTIVES FOR ETHANOL PRODUCTION

Most of the ethanol-producing states have producer incentives in place. If the state wants to support the creation of a biomass-ethanol industry in California, there are a variety of incentives that could be implemented, many of which have been proven to be very effective in other states. Below there is a discussion of some of these policy options.

Providing Funding to Support Investment in Ethanol Plants

The main problem for plants producing cellulosic ethanol is the inability to meet lending requirements. Traditional lenders, even with a contractor personal guarantee, usually do not fund new technologies. Venture capitalists rarely fund this type of operations. State government could develop a mechanism to provide loan guarantees or some insurance policy assuring that, if the process does not work as expected, money will be made available to fix or repair the problem thereby reducing the risk to the investor.

There are two bond financing programs for which ethanol producers could qualify: (1) the California Alternative Energy and Advanced Transportation Financing Authority (CAEATFA), and (2) the Small Business Pollution Control Tax-Exempt Bond Financing Program. Ethanol producers using cellulosic materials in unproven technologies cannot apply for these funds since these programs require a letter of credit and the financial community generally do not provide letters of credit to projects using innovative techniques. These programs could be revised to provide loan guarantees or some insurance policy arrangement so that these producers could qualify.

The state may provide direct grants and/or low- interest loans to assist financing of ethanol production facilities. Initial capital costs are significant when starting an ethanol operation. Capital costs for a cellulosic ethanol plant are estimated to be two to four times the cost of a corn-based dry mill plant. State grants could be a key factor in leveraging private financing or in providing funds for some critical tasks that are carried out before actual project funding takes place (such as funding for feasibility studies). One example of this type of policy is Illinois's state grant program that provides financial assistance for new and expanding renewable fuel (including ethanol) production plants. The maximum amount of all their grants is $15 million per year.

The state may consider establishing a California seed fund and/or seed capital tax credit for renewable energy production. Seed financing is the small amount of capital needed to prove a concept and build a management team.

Investments in ethanol can also be promoted through capital gains tax cuts, targeting individuals and institutions making venture capital investment in early stage technologies. Ohio has a corporate and personal tax credit of 50 percent (with a maximum of $5,000 a year) for investment in a qualified ethanol plant. Angel investment could also be encouraged through tax incentives.

State tax credit and tax exemption programs are an alternative mechanism to support ethanol production. The state could offer property tax exemptions for ethanol production facilities during construction and/or for a specified time of operation. The state could provide income tax credits for facility investments, or other tax credits on equipment purchases. For example, Hawaii offers an income tax credit for investment in new ethanol plants of $300,000 per million gallons of capacity or 30 percent of the investment; whichever is less, as long as the facility operates at 75 percent capacity. Indiana provides a state income tax credit of 12.5 cents per gallon for new ethanol plants and expansion. Ohio has tax exemptions from property tax, sales, and use taxes and franchise taxes for waste-to-energy conversion facilities.

Providing Financial Support to Ethanol Producers

The federal ethanol fuel tax credit is the most significant incentive for ethanol production in the U.S. Many states have also additional producer payments and production-based tax credits that supplement the federal ethanol tax credit, making the price of ethanol closer to that of petroleum fuels. The state could consider providing direct financial support to biomass-to-ethanol facilities built in California. One example is offering direct payments to qualifying ethanol producers on a per-gallon-of-output basis. Minnesota, North Dakota, and Texas have ethanol producer payment programs offering a direct payment to producers.

The Minnesota experience provides evidence that producer payments can be more effective than consumer oriented excise tax exemptions. In the early 1980s Minnesota, mirroring federal government policies, introduced a partial exemption from the gasoline tax to provide incentives for the development of an ethanol industry in the state. However, although demand for ethanol increased, it was mainly met by imported ethanol rather than in-state produced ethanol. Hence, Minnesota changed this policy from a consumer-oriented excise tax exemption to a producer-oriented direct payment (20 cents a gallon for ten years for ethanol produced within the state). To encourage the construction of many plants the incentive applied to only the first 15 million gallons produced per year. This policy initiative has resulted in a large number of small and medium biorefinaries.[*]

To avoid unnecessary payments when the price of ethanol is high, North Dakota provides for quarterly payments that take into account both changes in the price of corn and in the price of ethanol. Texas enacted a program in 2003 that establishes a grant fund from which producer payments are authorized.

Other tax breaks may take the form of transferable tax credits per gallon of ethanol to producers. These credits are saleable to ethanol fuel marketers who may use them against state fuel tax liability. A program like this has been implemented in Nebraska.

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[*] Minnesota had a producer incentive payment of 20 cents per gallon. However, in response to budget problems, the producer payment was reduced to 13 cents per gallon in 2003, providing that the reduced seven cents per gallon would be paid in future years. The producer payments program will end in 2010.

This type of tax credit helps receive a higher ethanol-selling price, as distributors can apply these credits against fuel taxes.

California could consider providing a feedstock payment (credit) for waste biomass resources (including forest or agricultural residues) used to make fuel.

Another policy alternative to support ethanol producers could be the establishment of minimum price guarantees for specific amounts produced, contractually guaranteed over a period of time.

SIMPLIFYING THE PERMITTING PROCESS FOR ETHANOL PLANTS

Ethanol producers indicate that the permitting process significantly increases the cost of siting an ethanol plant. The state could consider streamlining or reducing requirements in the approval process for construction of production facilities. For example, in Oregon, the Energy Facility Siting Council facilitates and coordinates all permits required by state, federal, and local government agencies for siting power plants. California could do something similar, directing the Chair of the California Energy Commission to provide permit assistance for biofuel projects. The assistance should include working with the lead permitting agency to ensure that the agency understands the ethanol production process, appearing at public information presentations to discuss related energy policy issues, and coordinating the comments of other state agencies with permitting responsibilities.

SUPPORTING RESEARCH DEVELOPMENT AND DEMONSTRATION OF TECHNOLOGIES

The state could support the development of technologies by:

- Providing funds and technical assistance to support short-term demonstration efforts to develop biomass-based ethanol production.
- Offering financial incentives or facilitating private/public partnerships to promote research and development of new technologies to convert biomass to ethanol, as new technological breakthroughs are important to increase the productivity and feasibility of biomass based ethanol production.
- Developing and/or participating in public/private partnerships to pursue funding opportunities and technical support for demonstration projects, new technologies to produce ethanol, and biomass fuel use for transportation.

ESTABLISHING MARKET INCENTIVES

The state could design policies to help the ethanol industry by expanding the ethanol market, either stimulating the use of dedicated or flexible fuel vehicles or the use of high level ethanol blends in all cars.

Tax Reduction Incentives

Many states include tax reductions for ethanol/gasoline fuels, and some do not have any sales tax on E-10 or higher ethanol blends (Hawaii for example). Illinois has various tax reductions depending on the ethanol content of the fuel, with lower tax for E-70 fuel than for E-10 fuel. California could also reduce the gasoline tax for ethanol/gasoline blends, although such a policy runs counter to the state's long-standing link between fuel taxes and highway use.

Expansion of Fueling E-85 Fueling Stations

A crucial step for the development of an ethanol market is the establishment of E-85 fueling stations in California and supporting infrastructure for FFVs. FFVs have become widely available commercially because they help automobile manufacturers meet Corporate Average Fuel Economy requirements and fleets meet quotas for alternative fuel vehicles (AFV)[*] purchases regulated under the Energy Policy Act. More than 230,000 FFVs are registered in California (potentially demanding more than 180 million gallons a year, slightly less than 10 percent of the state's demand for gasoline).[106] However, E-85 fuel is almost unavailable in California at retail gasoline stations and fleet dispensing facilities (there are five stations, four belong to a private fleet).[†] As a result, FFVs are driven exclusively on gasoline, making no contribution to the development of an ethanol market. Half of the consumers owning a FFV do not know that they have them and that they can use E-85.

The state may consider different incentives for the expansion of an ethanol infrastructure in California, including:

- Projecting the needed number of E-85 stations to promote the actual use of FFVs in the state.
- Facilitating private-public partnerships for the development of ethanol stations (with ethanol producers as well as the car industry).
- Providing tax credits for installation of ethanol fueling facilities.
- Providing tax credits for retail fueling stations dispensing ethanol blends.
- Providing state grants for installation of E-85 fueling stations.
- Providing a low interest loan program for installation of E-85 fueling facilities.

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[*] Alternative fuel vehicles include, in addition to FFVs, those that use other sources of energy such as hydrogen, coal-derived liquid fuels, and electricity.

[†] One retail station exists in San Diego. The four fleet involve three federal operations and one municipal utility (Sacramento Municipal Utility District) fleet in Sacramento. Lawrence Berkeley National Laboratory, Lawrence Livermore National Laboratory and Vandenberg Air Force Base dispense fuel to FFVs owned and operated by federal agencies.

- Establishing a system to distribute ethanol for operating FFVs in the state fleet, disseminate information on fuel stations locations, and requiring the use of the ethanol in those vehicles.
- Supporting the certification of vapor recovery systems compatible with E-85. (E-85 stations must demonstrate that they can meet the state's tough vapor recovery regulations). The California Air Resources Board (CARB) has never certified systems for dispensing E-85. To help the promotion of E-85 facilities, CARB grants a limited number of Research and Development approvals for uncertified vapor recovery systems. Currently, CARB has granted research and development status to install and operate an E-85 dispenser to four fleet entities and one retail facility in California.[107] The analysts from the Energy Commission project that at least 900 to 1,800 retail locations dispensing E-85 are necessary to foster large-scale consumption of this fuel. This could require several years.
- Participating in public-private efforts to increase the use (and number) of fuel stations for E-85. For example, a campaign of market awareness and enthusiasm driven by a public/private effort may help. This has been implemented in Minnesota where GM co-sponsored promotion of E-85. Drivers of flexible fuel vehicles could fill their tanks on a given day for a very low price in specified ethanol fueling stations.

Incentives for the Use of FFVs

Once an adequate infrastructure is underway, the state may provide incentives for the use of flexible fuel vehicles through a menu of policies such as, providing:[*]

- State tax credits or rebates for use of alternative fuel vehicles (sales or excise taxes).
- Tax credits for the purchase of ethanol vehicles or flexible fuel vehicles.
- State income tax credits for costs of converting vehicles to use alternative fuels.
- State grant programs for commercial and local government fleets run with alternative fuels, or for the purchase of alternative fuel vehicles.
- Exemptions from gasoline tax for fleets using alternative fuels.
- An income tax credit for the use of alternative fuel. A special credit card for paying for alternative fueling could help track the actual use of alternative fuels.

Other potential measures include:

- Requiring that all new cars or a proportion of them sold in California are FFVs.

[*] See the Alternative Fuels Data Center web site for some specific examples, at: www.afdc.doe.gov.

- Disseminating information to consumers who own FFVs on their ability to use ethanol. According to the Energy Commission, half of the FFVs owners are not aware that they own an FFV.
- Designing a program similar to the Carl Moyer Memorial Air Quality Standards Attainment Program, providing incentives for petroleum reduction and use of ethanol. The Carl Moyer Program is administered by the CARB in partnership with local air quality districts throughout the state. It provides grants to cover a major portion of the cost to replace or retrofit existing engines or vehicles to achieve lower emissions. A similar program could be established to adjust engines to the use of ethanol. Eligible project types could include marine vessels and off-road heavy-duty equipment (construction and farm equipment) as well as on-road vehicles.

Requiring a Specific Amount of Ethanol in All Gasoline Sold in the State

To reduce the uncertainty created by changes in demand brought about by government policy changes,[*] the state could consider establishing requirements that gasoline blends contain a specific amount of ethanol (or establishment of various renewable fuels standards). For example, in Minnesota most gasoline sold is required to contain a minimum 10 percent ethanol. This minimum is expected to double by 2010.[†]

A standard for ethanol above 5.7 percent may present some problems:

1. Blends above E-10 are not considered gasoline. It may be necessary to obtain a waiver from U.S. EPA.
2. There may be problems using higher ethanol blends in vehicles that are not FFVs and the car industry may not provide warranties for cars using these blends.

A renewable fuel standard encouraging various blends of ethanol (E-10, E-20) creates the need for dedicated underground storage for each blend offered. For example, an E-10 blend requires its own storage tank at the retail site. If the retailer offers a range from E-10 to E-85, additional storage tanks are required, along with separate storage for each octane option offered in gasoline, i.e., 87, 89, or 92. Multiple underground tanks are expensive for the retailers, particularly due to the stringent underground storage regulations. This problem could be solved using on-site multi-product dispensing systems as developed in Sweden. Sweden's distribution fuel system provides flexible fueling options using blending equipment that mixes and dispenses the desired blend on the retail site, utilizing only one underground tank for ethanol and another for gasoline. This multi-product dispensing mechanism reduces tank-storage requirements, while providing for several ethanol blends of choice.

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[*] As could be the effect of the elimination of oxygenate requirements.

[†] In September 2004 the governor of Minnesota, Tim Pawlenty, announced a series of initiatives to increase the use of biofuels, mainly ethanol. Doubling by 2010 the minimum 10 percent content currently required was among these measures.

SUPPORTING POLICIES THAT FACILITATE THE AVAILABILITY OF CELLULOSE FEEDSTOCK FOR ETHANOL INDUSTRIES

The state could financially support and promote research and development on low cost and environmentally friendly ways to collect and store cellulose.[108] Another possibility is to provide subsidies for the removal of biomass, such as logging slash and undergrowth from forests, which have the benefit of reducing the risk of forest fires. Some parties oppose these practices, however, because the practices might adversely affect soil conditions and wildlife habitat.

Some analysts suggest revising state laws related to the use of agricultural and municipal waste and residues. For example, the Energy Commission suggests changing the 10 percent waste diversion credit limit that applies to "transformation" technologies as defined in the Integrated Waste Management Act (Public Resources Code sections 40201 and 41783).

Under the California law AB 939 each municipality is required to divert 50 percent of its municipal solid waste from disposal in landfills into recycling or other diversion methods. This law distinguishes between diversion methods that are considered "recycling," such as producing paper from other paper products, and "transformation methods," such as waste materials converted to ethanol. Materials diverted by transformation processes obtain only 10 percent of the diversion credit, which makes it uneconomical to use recyclable materials for ethanol production (feedstock costs would be too high). However, if the law were to give equal credit to materials diverted for ethanol production, municipalities that currently are unable to meet their diversion quotas could consider adopting residual ethanol diversion if they see this option as the most cost effective way to meet their quotas.[109] AB1090, introduced in 2005, tries to address this problem.

The State could design policies to facilitate the integration of local markets for raw materials and products. This could require developing a policy for the creation of a more consistent and integrated solid waste collecting, sorting, and processing infrastructure to stimulate waste based production of ethanol or other energy related products.

SUPPORTING NEW ENGINE TECHNOLOGIES THAT COULD USE ETHANOL AND FUEL CELL VEHICLE APPLICATIONS

The State could provide grants or other incentives (tax credits, low interest loans) to companies for the creation of new engine technologies and fuel cell vehicle applications that would use ethanol.

The State may design policies that focus on reformer technology that uses ethanol to produce hydrogen. To accelerate the development of ethanol fueled reformer/fuel cell units, the California Public Utilities Commission could designate ethanol as Level I in its Self-Generation Incentive Program. This program provides financial incentive to customers that install new, qualifying self-generation equipment. Pacific Gas and Electric (PG&E), Southern California Edison (SCE), the Southern California Gas

Company (SoCalGas), and the San Diego Regional Energy Office (SDREO, serving SDG&E customers) administer the program throughout their respective service territories. This program distinguishes three different categories (or levels) of clean and renewable distributed generation. Currently, level 1 includes photovoltaics, wind turbines, and fuel cells operating on renewable fuels generation. Some energy analysts recommend that adding ethanol to Level 1 in this program could accelerate the development of ethanol fueled reformer/fuel cell units.

EDUCATING THE PUBLIC ON ENVIRONMENTAL, ENERGY AND WASTE DISPOSAL BENEFITS OF A BIOMASS-TO-ETHANOL INDUSTRY

The state could enhance the use of ethanol flexible fuel vehicles by disseminating information on the availability of renewable fuels and the economic and environmental advantages of using them through car distributors or other sources.

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