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ENERGY
COMMISSION

COSTS AND BENEFITS OF A BIOMASS-TO-ETHANOL PRODUCTION INDUSTRY IN CALIFORNIA

COMMISSION REPORT

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Introduction

As part of an on-going effort to evaluate options for the replacement of methyl tertiary-butyl ether (MTBE) in gasoline, the California legislature included in the State budget a line item to study the economic costs and benefits of a California biomass-to-ethanol production industry, which is presented in this study. The analysis presented here follows a prior study completed by the Energy Commission evaluating the possibilities for a California biomass-to-ethanol industry. This study indicated that ethanol could be produced from biomass resources with technologies that are available in the near term.

This report focuses on woody biomass (containing cellulose rather than starch) because of the large amount of material available in the State. Ethanol plants based on the conversion of cellulose to ethanol could be economically viable; however they face challenges. Biomass-based technologies are newly evolving and present investors with higher perceived risk than other investments. Production costs are also expected to drop in the long-term, which would make biomass-based facilities more competitive with ethanol from other sources. Using waste and residue feedstocks for ethanol production results in environmental benefits; however, the collection and transport of these feedstocks is costly in some circumstances. Finally, size and duration of the market for ethanol fuel is uncertain, so ethanol producers find it difficult to enter into long-term contracts at favorable prices.

Ethanol produced from biomass must compete with ethanol from the Midwest and the combination of technology and market risk makes investors reluctant to invest in biomass-based ethanol production capacity. Even though ethanol prices are expected to rise with the phaseout of MTBE, uncertainty over gasoline specifications increases the risk for investing in biomass-based ethanol. State support of an ethanol industry would enhance the viability of a California ethanol industry and provide a source of ethanol that may be needed with the phaseout of MTBE. Production costs and the need for state support, however, is expected to decline in the future as the technology is developed at the commercial level.

The cost of state support for an ethanol production industry is compared to the potential benefits in this report. This study addresses the topics included in the State budget language. These include an assessment of economic costs and benefits of an ethanol production industry, impacts on consumer fuel prices, and impacts on rice straw burning. This report provides further depth on environmental and energy impacts and presents recommendations for further steps the state should consider.

This report was undertaken to examine the costs and benefits of ethanol production using cellulosic biomass wastes and residues and advanced processing technologies applicable to these types of feedstocks. However, the Energy Commission has recently become aware of potential opportunities involving projects that would employ more conventional ethanol feedstocks and technologies to produce ethanol in California from agricultural commodities and food processing wastes. Therefore, the report briefly describes prospects for conventional ethanol projects in the state and one of the recommendations included in the report involves exploring the potential for this type of ethanol production industry.

How did California State Agencies Contribute to this Study?

This study was conducted in cooperation with California State agencies. The California Energy Commission was the lead agency. Input was received from Air Resources Board, Integrated Waste Management Board, Department of Food and Agriculture, and Department of Forestry and Fire Protection. The analysis in this study was completed by Arthur D. Little and Jack Faucett Associates under the direction of the Energy Commission.

Findings of the Study

This study of the costs and benefits of a biomass-to-ethanol production industry in California leads to the following findings:

Markets for Ethanol in California

- California is poised to become a large and growing market for ethanol as a replacement for the gasoline additive MTBE. The size of the near-term market (2003) depends upon unsettled requirements for oxygen content in California gasoline, nevertheless, current estimates place ethanol demand in the range of 580 million to 715 million gallons per year (or 37,834 barrels/day to 46,641 barrels/day).

- Longer-term markets for ethanol as a neat motor fuel in flexible fuel and fuel cell vehicles hold potential but need evaluation.

Current and Future Ethanol Production Potential

- The earliest California could have cellulosic biomass-to-ethanol production facilities in place is 2004 –2005. Plausible in-state ethanol production scenarios developed in this study indicate the potential for 100 million gallons per year of capacity by 2005, and under an aggressive plant construction scenario, 400 million gallons per year capacity by 2010.

- Only two small ethanol plants currently operate in California and several cellulosic biomass-to-ethanol plant construction projects are under consideration. No firm commitments for construction of any new ethanol production facilities in California are known at this time.

Status of Biomass-to-Ethanol Conversion Technology

- Conversion technologies for producing ethanol from cellulosic biomass resources such as forest materials, agricultural residues and urban wastes are under development and have not yet been demonstrated commercially. Uncertainties regarding commercial scale performance and profitability combined with unclear market outlook in the longer term constrain private investment in such facilities.

- The federal government and a number of U.S. states provide financial incentives in several forms to encourage facility construction and the production and marketing of ethanol fuel. Such incentives have proven to be effective in stimulating the growth of the ethanol industry in the midwestern States using commercially available corn-to-ethanol conversion technologies.

- Establishing a waste-biomass ethanol industry in California will likely depend on further state government actions aimed at assuring development of feedstock supply, production facility construction and operation, and markets for ethanol and co-products. The specific set of financial and non-financial measures that can best assure a successful outcome for investment in this industry requires further evaluation.

Economic and Other Benefits to the State

- The benefits of a biomass-to-ethanol production industry for California's economy are potentially greater than the cost of state support for such an industry. The economic analysis estimates statewide economic benefits of $1 billion over a 20-year period, assuming state government incentives totaling $500 million for a 200 million gallon per year ethanol industry.

- The economic benefits of an in-state ethanol industry result from feedstock handling and processing activities, ethanol plant construction and operation, and product marketing. All contribute income to California's economy, due primarily to employment.

- Important environmental benefits also stand to be realized by a California biomass-to-ethanol industry, although these benefits are difficult to quantify in monetary terms. Nevertheless, environmental benefits would be real and should be considered in public policy-making regarding development of such an industry.

Rice Straw, Forests, Agriculture, and Urban Waste Considerations

- Most rice straw burning in California will be curtailed in the near future under current air quality regulations, with or without the emergence of an ethanol production industry. However ethanol facilities using rice straw as feedstock would give rice growers an option to more costly forms of rice straw management and disposal. Rice straw supplied to such facilities could support production of roughly 40 million gallons of ethanol per year.

- Removal of excess biomass materials from California's forests for ethanol production, if practiced in accordance with California's Forest Practice Rules and federal regulations, can have significant beneficial effects. These include reducing the frequency and intensity of forest fires, helping control the spread of diseases, and contributing to overall forest health and vitality. Well-developed strategies jointly designed and overseen by various stakeholder groups will be required to make this economically and environmentally successful.

- Use of forestry and agricultural wastes and residues for ethanol production is an alternative to the current practice of disposal of these materials by burning. The potential air pollutant emission benefits resulting from curtailed burning could be significant, and would far outweigh any new production- and transportation-related emissions resulting from an ethanol production industry.

- Ethanol facilities collocated with municipal waste recycling facilities could divert waste paper and other types of urban waste materials from traditional landfill disposal to production of ethanol. However, supplying enough suitable urban waste feedstock to support economically viable ethanol production facilities will be challenging.

Collocation of Ethanol with Biomass Power Plants

- Collocation of ethanol plants with existing biomass power plants in the state stands to improve the economic viability of both the biomass power and biomass ethanol industries. However, in areas of limited feedstock supply availability, tradeoffs between the extent of electricity and ethanol production will require careful project planning and design.

Energy Considerations and Carbon Emissions

- Ethanol production requires various fossil fuel inputs at various points in the fuel cycle while providing an overall favorable energy balance.

- Ethanol production from cellulosic wastes and residues offers a significantly better energy balance and associated carbon emission result than conventional ethanol production using corn. The production and use of ethanol in the state can also contribute to a reduction in greenhouse gas emissions.

Consumer Fuel Cost and Ethanol Supply Issues

- An in-state ethanol industry could help California supply its transportation fuel needs from indigenous sources and provide new sources of ethanol that would reduce import requirements and improve the overall ethanol supply/demand balance. Under the Governor's MTBE phaseout schedule by January 1, 2003, California will have to rely on imported ethanol to meet in-state refinery needs to produce adequate supplies of California Phase III gasoline.

- Production of ethanol in California would provide an additional source of fuel that would compete with imported sources. Although ethanol market prices are generally established by supply and demand conditions with the same market price applying to all sources of production, new production capacity in California could help exert downward pressure on ethanol prices and, in turn, consumer prices of ethanol-blended gasoline.

- California's demand for ethanol as an MTBE substitute could comprise a major fraction of current U.S. ethanol production in 2003. Additional ethanol demand on the U.S. supply may result from MTBE replacement in other states. Thus, the state could face difficulty securing adequate ethanol supplies at reasonable cost to meet its near-term needs. Escalating market prices of ethanol in turn would increase the price of California gasoline to consumers.

- In the longer-term, emergence of a California waste biomass-to-ethanol industry will be influenced by U.S. ethanol supply and price conditions. In turn, viability of a California industry will be affected by a number of factors, including gasoline prices, ethanol industry expansion in the U.S., progress in cellulosic conversion technology, and the extent of both federal and state government support.

Recommendations

Costs and Benefits of a Biomass-to-Ethanol Industry in California

This study provides the basis for several recommended steps California should consider regarding ethanol and other renewable fuel production and use in the state. These recommendations include state actions to further the development of cellulosic waste-based ethanol production as well as consideration of ethanol production using conventional agricultural feedstocks in the state. Also, actions to address potential consumer fuel price impacts are included.

State Investment in Cellulosic Ethanol

The potential economic and environmental benefits determined by this study for a cellulosic waste-based biomass-to-ethanol production industry supports continuation of state investment in the development of such an industry. Three steps are recommended to achieve further progress in the areas of cellulosic waste-based resources, technology for conversion to ethanol fuel and activities to encourage market development.

- Because technologies for ethanol production from cellulose have not been commercially proven, the state should co-fund activities to advance this technology towards market readiness on an accelerated schedule. The state should provide technical and financial support for one or more biomass-to-ethanol production projects to verify technical and economic performance of commercial scale demonstration facilities.

- The cost and availability of cellulose feedstocks in California for ethanol production remains problematic. The state should fund activities to enhance the availability and quality of cellulose resources for ethanol production.

- The form and duration of state financial support for emerging biomass-to-ethanol markets is crucial to the development of an industry capable of competing with conventional ethanol production. The legislature should direct an appropriate state agency to develop and implement a market incentives program to increase the certainty of markets for California produced ethanol.

Other Steps to Foster Cellulosic Ethanol

Besides direct financial assistance, California can assist the development progress of a biomass-to-ethanol industry in the state in a number of other ways. California state agencies with biomass-to-energy related interests should be directed to pursue coordinated program activities in order to resolve issues and challenges facing development of a biomass ethanol industry in the state, including (but not limited to):

- Facilitate the communication among stakeholders on harvesting of forest materials for ethanol feedstock.

- Develop appropriate revisions to state laws affecting use of agricultural and municipal waste and residues for ethanol feedstocks.

- Provide siting, permitting and environmental impact assessment assistance to prospective biomass ethanol projects.

Exploring Opportunities for Conventional Ethanol Production

Since cellulosic waste-based ethanol production is a technology yet to be proven on a commercial scale, conventional ethanol production in California using agricultural commodities and agricultural industry processing wastes could contribute to the State's ethanol supply needs sooner than a waste biomass-based ethanol industry.

- The legislature should direct the Energy Commission together with the California Department of Food and Agriculture to study the cost and benefits, assess state resources, and determine appropriate forms of state support (if needed) for this type of ethanol industry.

Mitigating Consumer Fuel Price Impacts

Due to the potential for price increases in ethanol imported to California with MTBE phaseout by December 31, 2002, actions are appropriate to reduce anticipated impacts on consumer fuel costs.

- The legislature should direct the Energy Commission to explore means to increase the state's ethanol import options, balance ethanol demand growth with available supplies, and limit ethanol price fluctuations.

Examining Other Renewable Fuel Options

California's potential biomass energy opportunities include a variety of other approaches to producing liquid fuels, other forms of energy and co-products from waste and residual materials and agricultural commodities.

- The state should continue to actively explore other technological paths that offer attractive means of supplying portions of the state's future transportation energy needs from renewable biomass resources.

CHAPTER I

INTRODUCTION

I. Introduction

This study was funded and mandated by California's State Budget for Fiscal Year 2000-2001, Chapter 52, which provides the California Energy Commission $250,000 to conduct a study of biomass for conversion to ethanol. The budget language further directs that this study be conducted with the assistance of other state agencies and departments and include, but not be limited to, the following:

1. The economic costs and benefits associated with the development of a biomass-based ethanol production industry in California

2. The impact on consumer fuel costs from an in-state ethanol production industry

3. The impact on consumer fuel costs from imports of ethanol from other states

4. The impact on rice straw burning in California

5. Recommendations on future steps California should consider with regard to renewable fuel production and use in the state

This study implements one of the concluding recommendations of the Energy Commission's previous study titled, "Evaluation of Biomass-to-Ethanol Fuel Potential in California," from December, 1999. That study was prepared in response to Governor Gray Davis' Executive Order D-5-99, and it recommended that an additional study be conducted to "develop a method to determine the cost and public benefits associated with developing biomass-to-ethanol and biomass to transportation fuels industry in California."

In accordance with the above recommendation and as mandated in Chapter 52 of the California State Budget for Fiscal Year 2000-2001, the purpose of this study is to examine the costs and benefits to the State of developing an industry to produce ethanol from biomass sources.

I.1 What Costs and Benefits are Considered in this Study?

This study examines a range of impacts from a California ethanol production industry. These potential impacts are shown in Table I-1.

These impacts can be treated according to the following categories:

- Economic costs and benefits
- Energy impacts and potential effect on gasoline and electricity prices
- Resource and environmental impacts

The economic activities associated with an ethanol industry were analyzed according to their costs and benefits to the State. Only the activities directly related to an ethanol industry were evaluated in terms of statewide economic costs and benefits.

Table I-1. Impacts of Ethanol Production

Impact	Status/Location
State Outlays	Chapter IV
Jobs, Taxes	Chapter IV
Energy, Power Production	Chapter V
Consumer Fuel Prices	Chapter V
Reduced Landfill Waste	Chapter III
Project Development (research, engineering)	Appendix
Capital (Plant and Equipment)	Chapters III and IV
Operating Systems	Chapter III
Air, Water, Soil Impacts	Chapter VI
Change in Natural Resources, Land	Chapter VI
Change in Cultural and Aesthetic Resources	Not addressed
Water, Soil Quality	Chapter VI

Due to limitations on the applicability of the economic cost/benefit analysis, energy, resource, and environmental impacts are quantified separately.

Ethanol plants are not being constructed in California because of several factors that make such an investment appear risky. While the demand for ethanol appears clear with the phaseout of MTBE, California's application for an oxygenate waiver and other factors make the size of the ethanol market uncertain. Biomass (cellulose-based) technologies are still evolving and these represent a substantial potential for ethanol production in California but are also perceived as being more risky than other investments. Also, the cost of feedstock collection, and near term operating costs make it unclear how profitable biomass-based ethanol production will be in the near-term. In addition, the use of some biomass feedstocks results in environmental benefits that are not reflected in the cost of the feedstock. For these reasons, it may be beneficial for the State to support an ethanol industry. The cost of this state support is compared to the benefits.

The benefit/cost analysis is conducted from the perspective of the State decision-maker. The question of interest is whether the economic benefits to the State outweigh the costs of state support. The cost to the State of a particular state sponsored ethanol support program is compared to the economic activity associated with a viable California State ethanol industry. The driving force for in-state ethanol production is the impending phaseout of MTBE by December 31, 2002. However, the biomass-to-ethanol industry may have other impacts that could support or impede its implementation. For example, the use of forest materials as a feedstock for ethanol production involves collection of slash and thinnings. Clearing of such material is likely to mitigate the danger of forest fires which may be considered as a benefit to the State. Whether state support of other options to reduce forest fire risks provide lesser or greater economic benefits than an ethanol industry is not in the scope of this report.

The economic costs and benefits of a biomass-based ethanol production industry are narrowly defined. They result from an analysis of costs and benefits of the ethanol industry's various economic impacts on the State. The economic costs are the opportunity costs that describe the value of goods and services lost to the California economy due to the State-sponsored establishment of the ethanol industry. These costs represent the amount of money that the State, as a whole, is willing to commit in order to pursue an ethanol industry. The economic benefits, on the other hand, are the net increases in state output, employment and income that result from the establishment of a state fuel ethanol industry. These net benefits measure the value that is added to the economy due to the industry.[1] The primary economic figures of merit that were used to represent the costs and benefits to the State are personal income and employment.

It is important to note that economic costs are different from cash costs, which are expenditures related to the ethanol industry. Relevant examples of cash costs are building construction, permitting and compliance, and pre-fire management. Throughout the report, it must be kept in mind that in many instances, cash costs are actually economic benefits since they represent capital, employment, or other additions to the economy.

In addition to the economic costs and benefits of an ethanol production industry in California, this study assesses the effects that such an industry would have on energy use and the environment. These effects are described in detail following the discussion of economic costs and benefits.

The impact of ethanol use on consumer fuel costs is also included in this report. Ethanol production in the State results in an additional source of transportation fuel that would be blended with gasoline. It is important to understand how fuel prices will react to ethanol produced in-state or imported from other states. This study discusses how oxygenate or octane requirements may affect fuel prices in the event of an ethanol shortage. Ethanol production would also affect the production and consumption of electric power in the State.

Finally, the impact of in-state ethanol production on rice straw burning has been a major area of interest. The likelihood of rice straw being used as a feedstock and the impact on rice straw burning are analyzed.

This report discusses the above issues and sensitivities in the study's findings and recommends future steps California should consider with regard to a biomass-based ethanol industry in the State.

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[1] An ethanol industry results in activities that produce both positive and negative impacts on the State economy. Under most circumstances the positive economic impacts are greater than the negative impacts; so the term benefit is applied to the net impacts.

I.2 How Is This Report Organized?

The following describes the organization of this report and the contents of each chapter:

Chapter II, "Ethanol as a Fuel – Background," discusses the uses of ethanol as a motor fuel and explains how air quality regulations affect the demand for ethanol. This chapter also describes past and proposed ethanol projects in California. It examines the potential for ethanol production in California and discusses the types and locations of feedstocks available for California ethanol production, as well as their cost. The roles of federal and state tax incentives in encouraging ethanol production are also discussed.

Chapter III, "Analysis of an Ethanol Production Industry in California," describes possible scenarios and sources of California ethanol production. A section describing ethanol plant operations contains an assessment of the availability of different feedstock sources, including rice straw. This chapter identifies the impacts of ethanol production in California. The economic feasibility of collecting and transporting different feedstock sources is also discussed.

Chapter IV, "Economic Costs and Benefits of In-State Ethanol Production," provides a general overview of how economic costs and benefits are analyzed and describes the economic impact assessment methodology used for this report. It identifies the capital expenditure involved in ethanol plant construction, operation, and maintenance. This chapter also discusses tools for measuring inputs and types of economic impacts, in general, and ethanol production impacts, in particular. This chapter assesses the total economic impacts of California ethanol production and sales. It shows how ethanol plant construction results in economic output in California and illustrates the economic impacts of plant operation. The effects of a California ethanol production industry on employment are assessed.

Chapter V, "Effects of California Ethanol Production on Energy Use," discusses what potential effects ethanol production would have on electricity, fossil fuel, and petroleum production and use. This section explores two different power production scenarios, one of which is analyzed further in the ethanol study. It describes the relationship between both imported and California ethanol industries and fuel prices and how gasoline prices affect the ethanol industry.

Chapter VI, "Effects of California Ethanol Production on the Environment," assesses the potential emission impacts of ethanol plant operations and transportation. It looks at both the negative and positive effects of forest material harvesting on forest soil, forest health, water resources, wildfire, and forest food chain, fish, and wildlife. This chapter explains how the benefits of biomass-for-ethanol removal would mitigate the adverse impacts, if conducted in appropriate forest sites using appropriate collection methods.

Chapter VII, "Sensitivity Analysis," evaluates how the price of ethanol, electric power, and natural gas, as well as the availability of biomass feedstocks and governmental tax incentives would affect the assumptions utilized in the report.

Appendices include documentation, additional information, and technical details for each chapter. The appendices are presented as a separate volume to the main report.

CHAPTER II

ETHANOL AS A FUEL — BACKGROUND

II. Ethanol as a Fuel — Background

This chapter summarizes the uses of ethanol as a motor fuel, the role of federal and state tax incentives in fostering an ethanol market, federal and state air quality regulations affecting ethanol use, and the current status of ethanol production and use in California.

II.1 What Are the Uses of Ethanol as a Motor Fuel?

Alcohols have been used as fuels since the inception of the automobile. The term alcohol often has been used to denote either ethanol or methanol as a fuel. With the oil crises of the 1970s, ethanol became established as an alternative fuel. Countries including Brazil and the United States have long promoted domestic ethanol production. In addition to the energy rationale, ethanol/gasoline blends in the United States were promoted as an environmentally driven practice, initially as an octane enhancer to replace lead. Ethanol also has value as an oxygenate in clean-burning gasoline to reduce vehicle exhaust emissions.

In the United States, ethanol supplies today account for about one percent of the highway motor vehicle fuel market, in the form of a gasoline blending component. Currently, most of this ethanol is used in a 10 percent blend with gasoline traditionally referred to as “gasohol,” a term which is being replaced with “ethanol/gasoline blends” or “E10.” Lower percentage blends, containing 5.7 percent or 7.7 percent ethanol are also being used in some areas to conform to air quality regulations affecting the oxygen content of reformulated gasoline. The 5.7 percent blend is California’s formulation used to meet a 2 percent by weight federal oxygenate requirement in Phase II gasoline.

In addition to ethanol/gasoline blend markets, ethanol has other motor fuel applications including:

- Use as E85, 85 percent ethanol and 15 percent gasoline. Several models of passenger cars and light trucks are being manufactured as flexible fuel vehicles (FFVs), capable of using ethanol and gasoline in any combination up to E85.

- Use as E100, 100 percent ethanol with or without a fuel additive. Demonstration fleets of heavy-duty buses and trucks with specially designed engines adapted from diesel engines have been operated on this fuel. Ethanol can also be used as a fuel for fuel cell-powered vehicles.

- Use in Oxydiesel, typically a blend of 80 percent diesel fuel, 10 percent ethanol and 10 percent additives and blending agents. This fuel is being demonstrated in fleets of buses with unmodified diesel engines.

II.2 How Do Air Quality Regulations Affect Markets for Ethanol?

The regulatory climate of fuel policy has and will continue to play a critical role in determining ethanol demand. Complying with existing oxygen requirements creates the need for oxygen-containing blending components other than MTBE to be included in reformulated gasoline. As these restrictions and thresholds vary, so does the demand for ethanol.

Current federal oxygen requirements specify gasoline in California's ozone non-attainment areas to have approximately 2.0 percent oxygen by mass. This can be achieved by blending 5.7 percent ethanol and 94.3 percent gasoline by volume. Nearly 70 percent of California's gasoline is currently consumed in non-attainment regions. Based on 1999 California gasoline consumption of 14.5 billion gallons, California would require roughly 10.1 billion gallons of 2.0 percent oxygenated gasoline. To produce 10.1 billion gallons with 2.0 percent oxygen, approximately 580 million gallons (37,834 barrels/day) of ethanol would be blended with 9.6 billion gallons of non-oxygenated gasoline.

By 2004 it is estimated that California's annual gasoline consumption will reach 15.7 billion gallons. The San Joaquin Valley is currently a "serious" ozone non-attainment area. It is anticipated that the San Joaquin Valley's classification will be increased to "severe" as an ozone non-attainment region. This reclassification will push the current 70 percent oxygenated gasoline demand up to 80 percent, as oxygenated gasoline will be required in the San Joaquin Valley. The ethanol demand that would result from increased gasoline consumption and a broader oxygenated gasoline is approximately 715 million gallons (46,641 barrels/day) annually.

It is also worth noting that California has requested a waiver from the federal oxygen requirement in the Clean Air Act. If that waiver is granted, then the proposed ethanol demand levels could change from the figures listed above. Ethanol demand for oxygenate would not disappear entirely because ethanol would be needed as a blending component to augment fuel volume and provide octane given 11 percent lost volume with MTBE removal. It is possible that an ethanol market could develop from octane value alone.

II.3 What is Happening with Ethanol in California?

California's experience with ethanol fuel includes a number of project feasibility studies, a few demonstration projects, and several small commercial ventures.

Biomass-to-Ethanol Technology Status

A number of biomass-to-ethanol processes are at various stages of evolution. Of these, the two-stage dilute acid hydrolysis process is the most proven technology. Table II-1 lists some technologies and their status. In this report, all references to ethanol production unless specifically stated, imply the two-stage dilute acid process.

Table II-1. Status of Biomass-to-Ethanol Technologies

Biomass-to-Ethanol Process	2-Stage Dilute Acid	2-Stage Conc. Acid	Enzymatic	ACOS[a]
Overall Status of Technology	Pilot	Pilot	Pilot	Laboratory

[a] ACOS – Acid Catalyzed Organosolv Saccharification Process

Past Ethanol Projects in California

Between 1980 and 1983, the Energy Commission investigated alcohol fuels, including examinations of several potential ethanol production projects. Most of these prospective projects were judged not viable, based on various economic, technical, and environmental factors.

In 1997, the Energy Commission collaborated with the National Renewable Energy Laboratory to investigate potential biomass-to-ethanol production in San Joaquin County with the STEP 2 (Sustainable Technology Energy Partnership) Project. The STEP 2 project resulted in preliminary design data for a biomass ethanol demonstration plant, including a feedstock availability report, bench-scale ethanol production process testing, and other process-related research.

The California Department of Food and Agriculture (CDFA) has also conducted ethanol production feasibility and demonstration programs, such as the California Alcohol Fuel Plant Design Competition and the 1990 Energy and Chemical Feedstock Crop Demonstration Program.

The Quincy Library Group (QLG), with the assistance of various expert groups, conducted a study evaluating the feasibility of ethanol manufacturing in northeastern California forests (NREL, 1997).

The California Integrated Waste Management Board (CIWMB) prepared a study in 1999 of alternative methods of utilizing various types of agricultural and forestry residues, including application as feedstock for ethanol production (CIWMB, 1999). The report generally describes a bright future for beneficial commercial applications of these types of wastes and residues that will reduce the need for traditional disposal practices. Energy applications, including ethanol production, were seen as candidates among a variety of other promising uses.

A grant and loan program was administered by the the Department of Food and Agriculture under SB620. A grant from this program started Parallel Products, a Southern California company that can produce up to 6 million gallons of fuel-grade ethanol per year using residuals from the food and beverage industry. Parallel Products uses a variety of waste feedstocks in their ethanol production facility, including mislabled and expired alcoholic beverages, beverage syrups, candy, and other sugar products. Packaging materials are recycled and the sugar products are fermented to produce ethanol. Parallel Products operates their facility with a negative cost for the feedstocks.

The Renewable Fuels Association announced in February, 2001, that the Golden Cheese Company (GCC) of California has resumed production of ethanol derived from cheese whey residue left from cheese processing. GCC is a division of Dairy Farmers of America and is located in Corona, CA.

Proposed Ethanol Projects in California

In the 1990s, California witnessed renewed interest in ethanol production, with several new biomass-to-ethanol projects in the planning and development stages. These proposed projects all intend to use some type of waste or residue feedstocks and to use advanced production processes to produce ethanol, electricity, and other co-products.

In addition to proposed biomass-to-ethanol projects using cellulosic waste and residue feedstocks and advanced conversion technologies, there is new interest in possible California projects involving more conventional approaches to ethanol production. Such projects would employ sugar- and starch-based feedstocks and commercially available fermentation processing technologies that are the mainstay of the existing ethanol industries in the Midwest United States, Brazil and other countries. Candidate feedstocks include a variety of agricultural commodities suitable for California application, some of which were described in the previous (1999) Energy Commission report. Certain waste products from agricultural and food processing industries in the state are additional candidates.

One example of a conventional ethanol project proposal is that of Imperial Bioresources LLC. This group, consisting of agribusiness companies, farmers and researchers located in the Imperial Valley of Southern California, proposes to grow sugar cane to supply a plant producing from 25 to 66 million gallons per of ethanol, along with electricity cogeneration and other co-products. Although this project is still under study, initial sugar cane cropping experiments in the Valley show high per-acre yields and other results that indicate favorable prospects for this concept.

BC International, Gridley Ethanol Project

BC International Corporation, of Dedham, Massachusetts, is pursuing development of a biomass-to ethanol facility in Butte County. The Corporation has a proprietary patented processing technology for producing ethanol. The proposed Gridley plant to be colocated with a biomass power plant in the center of the State's rice-growing region, intends to use rice straw as a feedstock. The proposed production capacity of this facility is somewhat over 20 million gallons per year. The traditional practice of burning rice straw is being phased out under California air quality regulations, and the costs of alternate methods of rice straw disposal will rise. As discussed in Chapter III, baled rice straw for sale to ethanol production facilities is likely to be one of the lower cost disposal options available to rice growers. The proposed site is adjacent to an existing biomass electric power plant, offering the potential to combine electricity generation and ethanol production from the same biomass feedstocks. The Gridley project would be BC International's second commercial venture, following a project of this type currently under development at a former petroleum refinery and grain-to-ethanol site in Jennings, Louisiana.

Both the Energy Commission and the U.S. Department of Energy through the National Renewable Energy Laboratory (NREL) are providing funding support to develop the Gridley project. The City of Gridley would be a major partner and operator.

BC International, the Energy Commission and DOE/NREL are also co-funding a lignin test burn at the Pacific Oroville Power, Inc. biomass power plant, the primary site under evaluation for collocation of the Gridley ethanol production facility. As an objective, this project will demonstrate the technical feasibility and costs associated with lignin derived from rice straw and wood feedstocks and used as a boiler fuel for steam and power (electricity) production. A second objective is to define the engineering modifications required so that all the lignin produced by the ethanol facility can be used in the boiler and thus lower the cost of electricity production.

The Gridley ethanol facility conceptual design is nearing completion, with detailed engineering design contracts anticipated to commence in mid-2001. The project team targets facility financing for completion by the end of 2001. CEC staff estimates that facility construction, plant start-up and shakedown activities could lead to ethanol product in 2004 to 2005.

BC International, Collins Pine Ethanol Project

BC International and the Collin Pine Company, a timber firm, are planning to collocate a biomass-to-ethanol plant at an existing biomass electric power plant in Plumas County. A study team has completed a feasibility study of this facility, which would use forest thinnings and wood wastes as feedstocks (NREL, 1997). The team was headed by the Quincy Library Group, a forum for California environmental organizations, county officials, and timber industry groups seeking solutions to the accumulation of excess woody material in the Plumas and Lassen National Forests. Ethanol production is seen as one attractive option for beneficial application of forest material that needs to be harvested to lessen the potential for catastrophic wild fires and related forest health problems. The Energy Commission and the U.S. Department of Energy through the National Renewable Energy Laboratory are providing funding to support this project which could lead to an ethanol facility producing over 20 million gallons a year.

This four phase project is in its early stages. Phase I activities have led to the determination that sustainable supplies of forest feedstocks in the Chester area can meet the feedstock demands of a collocated ethanol production facility at the existing power plant site. Phase 1 has as an objective to identify at least one co-product derivable from the mix of the region's softwoods used for ethanol production. One co-product has been identified. Conceptual process and facility design is underway. Bench scale and pilot scale validation of pretreatment, proposed fermentation processes, and lignin tests as boiler fuel are scheduled completion by the end of 2001. CEC staff believes that while this project is at an earlier stage of development than the Gridley project, it could provide ethanol product in 2005-2006 if technical objectives and project financing goals are achieved in a timely manner.

II.4 What is the Potential for Ethanol Production in California?

A prior study was conducted by the Energy Commission to evaluate the potential of biomass ethanol in California (CEC, 1999). The study investigated the types of feedstocks that are available in California and the cost of ethanol production.

Types and Locations of Feedstocks Available for California Ethanol Production

California has substantial waste and residual biomass materials because of its rich agricultural and forestry resources and its large volume of commercial and municipal solid wastes. Roughly 50 million bone dry tons of biomass residue are produced annually in the State. While this amount of material could theoretically be converted to three billion gallons of ethanol per year, the actual potential production is lower. In order to produce ethanol, the feedstocks must be collected at a reasonable cost, have high cellulose content, and be close to potential ethanol production facilities. As discussed in Chapter III, sufficient feedstocks for 200 million gallons per year of production capacity can be readily identified, with about 400 million gallons per year corresponding to a more extensive use of available feedstocks.

The Energy Commission study of 1999 assessed the near-term potential for ethanol production by focusing on available feedstocks in close proximity to biomass power plants or potential ethanol production facilities. These biomass residues included primarily forest material near existing biomass power plants, agricultural residue, and urban waste processed in many small facilities.

Central and Southern California forests have been subject to damage from insects, drought, and catastrophic wildfires and could likely benefit from thinning. However, these forests are not located close to existing biomass power plants and forest roads are limited. Trees such as eucalyptus could be grown as feedstocks or removed from urban areas to reduce fire risk. Also, crops such as grains, sugar beets, sugar cane, and others, could provide feedstocks for ethanol production.

Following the detailed economic analysis and conclusions of the 1999 Energy Commission report, the principal feedstock sources considered in this study are thinnings from northern California forests, agricultural residue in the Central Valley, and limited urban waste. There is ongoing discussion concerning environmental effects of large-scale biomass removal from California forests. The long-term environmental issues posed by such removal are examined in detail in Chapter VI.

The Cost of Ethanol Production in California

The production cost of ethanol from these sources was evaluated in the 1999 Energy Commission study (CEC, 1999). The cost of ethanol production was evaluated for facilities operating on a variety of feedstocks. The costs were evaluated for near-term and mid-term plants with mid-term plants operating at a larger capacity (Table II-2). Feedstock costs for forest materials reflect the cost of collecting forest thinnings and some lumbermill waste. The cost of mid-term feedstocks increased because of higher transportation costs for larger facilities.[2] The analysis of ethanol production costs in the 1999 Energy Commission study included estimates of the amount of ethanol produced per ton of material. These yields depend upon factors such as the composition of the feedstock, types of cellullose, and inert ash content.

Table II-2. Assumed Feedstock Costs, Ethanol Production Yields, and Estimated Ethanol Prices from Cellulose-Based Biomass

Timeframe	Near-term	Mid-term
Feedstock Price ($/BDT)		
Forest Material	36	38
Agricultural Residue	24	26
Waste Paper	-10	-10
Ethanol Yield (gal/BDT)		
Forest Material	69.3	77.4
Agricultural Residue	62.4	64
Waste Paper	74.4	81.7
Target Ethanol Price ($/gal)		
Forest Material	1.73	1.23
Agricultural Residue	1.69	1.24
Waste Paper	1.64	1.39

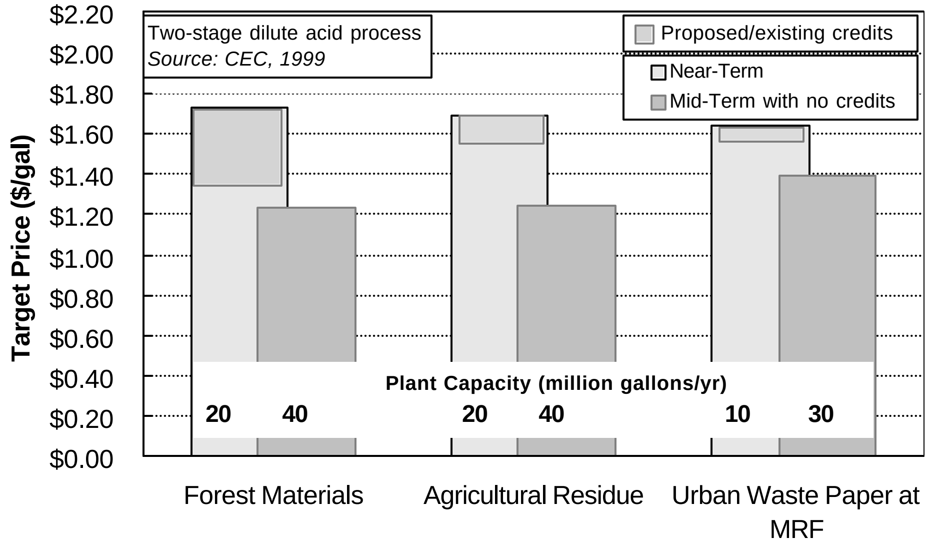
Plant sizes shown in Figure II-1.
Two-stage dilute-acid process.
Target price does not include small producer credit or credits for removing forest material or rice straw.

Source: ProForma Systems Inc., 1999 (from CEC, 1999)

The results were presented in terms of the required sales price needed for profitable plant operation, identified as the "Target Ethanol Price" in Figure II-1. The actual price of ethanol depends upon market conditions, which are largely beyond the control of the ethanol producer. The target price represents a sales price where an ethanol plant would be sufficiently profitable to achieve a rate of return expected by investors. This target price includes operating costs, debt service, and return on investment (CEC, 1999). The assumptions (see Table II-3) that have a significant impact on the target price of ethanol are the contingency for plant construction and the rate of return expected by investors as well as lenders. Economic assumptions for plants based on conventional technologies would include lower levels of contingency for unexpected construction events and lower hurdle rates. The target prices in Figure II-1 are based on fuel ethanol that is denatured with up to 5 percent gasoline. The projected ethanol target prices drop from near-term to mid-term time horizons, as process efficiency improves and production costs

[2] Near-term, midterm, and long-term time horizons correspond to 2003, 2007, and 2012, respectively.

drop. Long-term costs were also evaluated in the Energy Commission study; however, the mid-term projections are low enough to suggest that California ethanol production could be competitive with U.S. Midwest corn-based production as plant size increases and technology improves.



Source: Biomass-To-Ethanol Fuel Potential in California, CEC, 1999

Figure II-1. Production Facility "Target Price" for Three Feedstocks at Low and High Plant Capacity

Table II-3. Ethanol Production Facility Economic Assumptions

Parameter	Assumed Value
Plant life	20 years
Reference year	2000
Owner Equity	25%
Hurdle rate (owner return expectation)	30%
Loan term	10 years
Loan interest rate	8%
Standard Contingency	10% of Capital
Contingency for under-developed design	15% of Capital
Small producer tax credit	$0.10/gal

Source: CEC, 1999

The 1999 study evaluated the economics of the two-stage dilute acid and acid enzyme processes. The two-stage dilute acid process was estimated to have lower risk than the acid enzyme process and is the basis for estimating the cost of production facilities in this study.

Figure II-1 shows the target price with and without credits and state support for several biomass feedstocks. All of the near term values take into account the federal small producer tax credit that applies to the first 10 million gallons per year of production. A feedstock credit has been considered to support the cost of forest thinning. This credit resulted in an assumed feedstock cost of $16/ton in the 1999 study for near-term forest material-based facilities. Agriculture residue based facilities were assumed to operate on a mixture of rice straw and other agricultural materials. The feedstock cost for these facilities was estimated at $18.5/ton after a credit for rice straw use was taken into account (CEC, 1999). The value of reducing waste to landfills and reduced transfer costs is reflected in the negative feedstock cost for urban waste based facilities. The capital costs for these facilities are higher than those collocated with biomass power plants as additional equipment is required to generate steam for ethanol processing. This higher capital cost is offset by the lower feedstock cost.

The results from the 1999 study, as summarized in Figure II-1, show that the estimated near-term selling price of ethanol would need to between $1.60 and $1.70/ gallon to cover the cost of plant operation and investor expectations. In the mid-term, facilities based on the same feedstocks would be viable at target prices around $1.20/gal as a result of assumed process efficiency improvements and lower resultant ethanol production costs.

As the projected cost and required sales prices for cellulose-based ethanol production are higher than those from corn-based production, additional support may be required to make these facilities economically viable in the near-term. For the purposes of this study, it was assumed that the State would provide a producer payment of $0.20/gallon plus 10 percent of the estimated capital cost for facility construction discussed in Chapter III. The structure and level of State support that would yield the best utilization of financial and non-financial resources to encourage private sector investment in a California industry is beyond the scope of this study.

II.5 What is the Status of Tax Incentives?

Federal Tax Incentives

In 1978, Congress enacted the first tax incentive for ethanol, a fuel excise tax exemption. Originally, this incentive was a full exemption from the $0.04/gal gasoline tax that applied at the time. Currently, two types of federal tax incentives apply to biomass-derived ethanol sold as fuel: (1) a partial excise tax exemption and (2) income tax credits. Table II-4 traces the history of the federal ethanol tax incentives to date.

Table II-4. Federal Taxes and Tax Exemption for Ethanol/Gasoline Blends

Year	Prior to 1978	1978-82	1982-84	1984-90	1990-93a	1993-2000	2001-02	2003-04	2005-07
Federal Gasoline Excise Tax (¢/gal)	4	4	9	9	14	18.3	18.3b	18.3b	18.3b
Excise Tax Exemption for 10% Ethanol Blends (¢/gal)	—	4	5	6	5.4	5.4	5.3	5.2	5.1
Blender's Income Tax Credit for Ethanol (¢/gal)	—	—	40 (as of 1980)	60	54	54	53	52	51

[a] Small producer's credit added in 1990 (10¢/gal for first 15 million gallons for qualified small producers with annual output less than 30 million gallons). Excise tax exemption became applicable to 7.7 percent ethanol blends and 5.7 percent ethanol blends as of 1992 (at per-gallon rates proportionately lower than the rate for 10 percent blends).
[b] Assuming current gasoline tax rate is maintained.

As the federal gasoline excise tax has increased to 18.3 cents per gallon, the excise tax exemption on ethanol also has increased somewhat, to $0.06/gal before being reduced to the current $0.053/gal. The key point is that the full exemption, $0.053/gal, applies to ethanol/gasoline blends, which are 10 percent ethanol. Proportionately lower amounts apply to lower ethanol/gasoline blends, 7.7 percent and 5.7 percent blends. In effect, this exemption structure provides a $0.53/gal exemption from excise taxes for each gallon of ethanol that is blended with gasoline.

In place of the excise tax exemption discussed above, certain businesses can take one of the following income tax credits:

(1) A $0.53/gal credit for each gallon of blended ethanol

(2) The same $0.53/gal credit for the sale or use of neat alcohol (neat alcohol is defined as fuel with 85 percent or more alcohol)

In addition, a small ethanol producer is allowed a credit of $0.10/gal for each gallon of ethanol produced up to 15 million gallons per year.

In 1998, Congress voted to extend the ethanol tax incentives until December 31, 2007. The effective amounts of the incentives, however, are to be reduced from the current $0.53 to $0.52 in 2003 and 2004, and $0.51 in 2005 through 2007. The issue of continuance of the incentives will be debated again before the 2007 sunset date.

The net cost of ethanol as a blending component is $0.53/gal less than the market price because of the federal excise tax exemption. By most estimates, this figure amounts to roughly one-half the actual wholesale cost to produce ethanol, allowing ethanol to enter the fuel market at a cost closer to that of gasoline on an energy equivalent basis.

State Financial Incentives

At least 30 states, including California, have adopted their own ethanol tax incentives at one time or another, with many patterned after the federal fuel excise tax exemption approach.

From 1981 to 1984, California had a state ethanol incentive in the form of a $0.03/gal exemption for 10 percent ethanol/gasoline blends from the State gasoline excise tax, which was then $0.07/gal. This excise tax exemption amounted to a $0.30/gal incentive for each gallon of ethanol blended this way. Since the sunset of California's incentive, ethanol/gasoline blends are assessed the full state gasoline excise tax, now $0.18/gal.

Neat alcohol fuels are taxed at one-half the prevailing California gasoline excise tax rate. For ethanol in the form of E85, this rate represents about 70 percent of the gasoline excise tax rate on an energy equivalent basis. California also has a biomass fuel producer incentive program that has not yet been funded by the Legislature in order to be implemented. The program was created in 1988 under SB2637 and would provide a $0.40/gal production incentive for liquid fuels fermentable from biomass resources in California.

Summary

In sum, air quality regulations affect ethanol demand. As MTBE-blended gasoline is phased out, the demand for substitute oxygenate blending components such as ethanol will increase. Cellulose-based feedstocks, among others, can be used to produce ethanol. The technology is just developing and costs are expected to be higher than those from corn-based ethanol, but are likely to be more competitive in the future. Government support could help in fostering an ethanol industry that is economically viable. However, the extent and structure of such government support requires further evaluation. The $0.20/gal producer payment and 10 percent of capital support presented in this study represent one "benchmark" scenario for evaluating costs to the State. The following chapter provides a more detailed assessment of potential scenarios and sources of California ethanol production and identifies the impacts this industry would have on the State.

References

California Energy Commission (CEC) "Evaluation of Biomass-to-Ethanol Fuel Potential," December 1999.

California Integrated Waste Management Board, "Feasibility Study on the Use of Agricultural and Forest Waste in Commercial Products", January 1999.

National Renewable Energy Laboratory (NREL), QLOG, CEC, CIFAR, Plumas Corp., and TSS, "Northern California Ethanol Manufacturing Feasibility Study, November 1997.

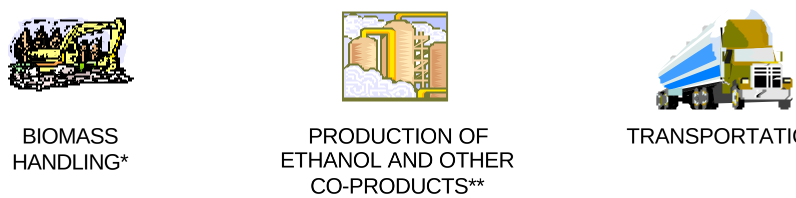
National Renewable Energy Laboratory (NREL), . . . 1998.

CHAPTER III

ANALYSIS OF AN ETHANOL PRODUCTION INDUSTRY IN CALIFORNIA

III. Analysis of an Ethanol Production Industry in California

The purpose of this section is to define the scenarios considered for the costs and benefits analysis. The types of costs and benefits resulting from a hypothetical California ethanol production industry are discussed and include the key elements shown in Figure III-1.



* Handling includes: harvesting, processing, storage and transportation.
** Co-products include biomass-power, lignin, extractives, etc.

Figure III-1. Elements of a California Ethanol Industry

The economic impacts of ethanol production depend on the types of ethanol plants, where they are located, amount of ethanol produced, and to some extent the total statewide ethanol usage. Figure III-2 below summarizes the three scenarios which assume no in-state ethanol production and imported ethanol in conjunction with in-state ethanol production.

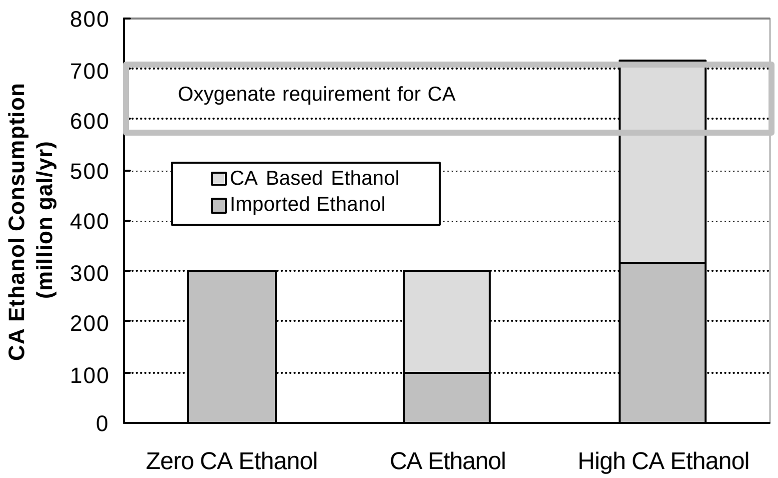


Figure III-2. Ethanol Production and Usage Scenarios

The complete economic costs and benefits are based on a scenario that includes ethanol related activities only within California. Within California, it covers the ethanol industry impacts from initial material gathering to the point where ethanol is delivered to the petroleum products terminal for blending with gasoline. The impact of related out-of-state CO_2 emissions are considered in this study as CO_2 emissions have global implications. The effect of California ethanol production on CO_2 emissions is discussed more fully in Chapter VI.

III.1 Definition of Scenarios for Ethanol Production

The California ethanol production considered in this report is evaluated in comparison to the alternative approach of no ethanol production in California. A scenario with 200 million gallons per year of ethanol produced in California plus 100 million gallons per year of imported ethanol is referred to as CA Ethanol (see Figure III-2). Alternatively, in a second case, (Zero CA Ethanol) no ethanol is produced in California and the entire 300 million gallons per year is imported. These two cases provide a basis for the evaluation of economic and environmental impacts. The comparison of these two scenarios forms the base case for this study. As indicated in Figure III-2, the ethanol demand in California due to oxygenate requirements could reach over 700 million gallons per year. California has requested a waiver from the federal oxygenate requirement; so, the market for ethanol is considered more uncertain than it would be if the oxygenate requirement were not in question. Another element of risk is the market being based on a future requirement for ethanol, which is based on the phaseout of MTBE. Consequently, the 300 million gallon per year cases represent a very certain market for ethanol.

The economic and environmental impacts of ethanol production were determined for the Zero CA Ethanol and CA Ethanol cases. The economic and environmental impacts were determined separately to illustrate the changes that occur with ethanol production. Under the assumptions for the CA Ethanol case, California-based ethanol production sources would be unable to provide all of the ethanol necessary by the time complete phaseout of MTBE by December 31, 2002, is implemented. Therefore, the remaining ethanol demand would be satisfied by importing ethanol from sources outside of California. National ethanol production capacity in 2000 was 1.6 billion gallons; thus, California demand could account for over 40 percent of current nationwide supply. A case for higher California ethanol production was also evaluated. A primary assesment of the potential feedstocks indicates that 400 million gallons per year of California ethanol could be produced from similar biomass feedstocks. Figure III-3 presents a hypothetical timeline for attaining this ethanol production capacity, if based on cellulose feedstocks.

Blending ethanol with gasoline boosts vapor pressure of the blend more than MTBE blending with gasoline. As a result, the lighter hydrocarbon chains, particularly butanes and pentanes, contained in gasoline must be removed if the resulting ethanol-gasoline blend is to meet Reid Vapor Pressure requirements. Thus, a fraction of the gasoline pool is lost in order to faciliate ethanol blending. This lost volume must be replaced with other types of hydrocarbons if refinery volume output is to be maintained under ethanol blending practice.

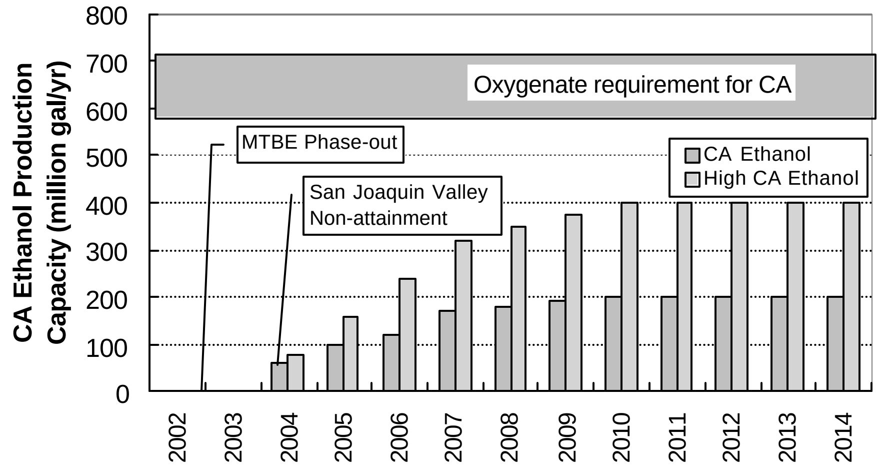


Figure III-3. Hypothetical Ethanol Production Timeline — Moderate and High Supply Case

The extracted pentanes can be used as fuel for the refining process, or as an export to chemical processing operations. The 2000 MathPro analysis of California Phase 3 reformulated gasoline suggests that every gallon of ethanol blended requires removal of approximately 1 gallon of pentanes to meet Reid Vapor Pressure standards (CEC, 1999).

III.2 What Sources of California Ethanol Were Analyzed

California ethanol production is examined for three cellulosic biomass sources: forest materials, agricultural residues, and urban waste. The forest materials are assumed to be mainly forest thinnings and slash, while the agricultural residues are mainly orchard prunings and rice straw. Urban waste is composed of residues sorted at material recovery facilities (MRFs).

A total of twenty-one potential biomass-to-ethanol plants were considered for the two production scenarios (see Appendix III-A). The locations for these twenty-one plants were selected based on available data on feedstock, transportation and potential for collocation with a biomass power plant. However, the selected plants do not represent the complete potential for plant sitings in California. For example, the potential for siting ethanol plants by taking advantage of available forest materials from the central and southern mountainous regions is not explored in this report. Of the twenty-one plants, nine plants were chosen for the California ethanol production scenario of 200 million gallons per year. Table III-1 presents the potential plant capacities and quantities of biomass available from the regions surrounding each of the nine hypothetical biomass-to-ethanol plants.

Table III-1. Potential Feedstock Supply Sources, Quantities for Various Plant Capacities

Plant ID	Forest Residues[a] (BDT/yr)	Agricultural Residues[a] (BDT/yr)	Urban Waste[a] (BDT/yr)	Plant Capacity (M Gal/yr)
1	520,000	—	—	40
3	260,000	—	—	20
4	260,000	—	—	20
7	—	640,000	—	40
8	—	640,000	—	40
12	—	—	100,000	10
13	—	—	100,000	10
14	—	—	100,000	10
15	—	—	100,000	10
Total	1,040,000	1,280,000	400,000	200

Notes:

The 200 million gallons per year California-ethanol production scenario is assumed to be distributed between 9 plants using approximately 2.7 million BDT per year of biomass. The 9 plants are comprised of: 1, 3 and 4 using forest residues; 7 and 8 using agricultural residues (rice straw + orchard prunings); and four plants using urban waste. The remaining plants of the original 21 considered would operate under a high ethanol demand and production scenario.

[a] See Appendix III-B

BDT - Bone Dry Tons

M gal/yr – Million Gallons per Year

It is assumed that both forest material and agricultural residue plants are dispersed such that each ethanol facility has a sufficient area for biomass collection. Plants with larger capacity are afforded a greater area from which to collect biomass. By contrast, urban waste plants are assumed to be clustered around urban areas and collocated with existing MRFs, where existing waste materials are already collected. The assumed biomass feedstock supply regions for this study are shown in Figure III-4. Based on existing biomass densities and current MRF waste capacities, Figure III-5 presents the assumed quantity of biomass for each source-type for 200 million gallons in-state ethanol production.

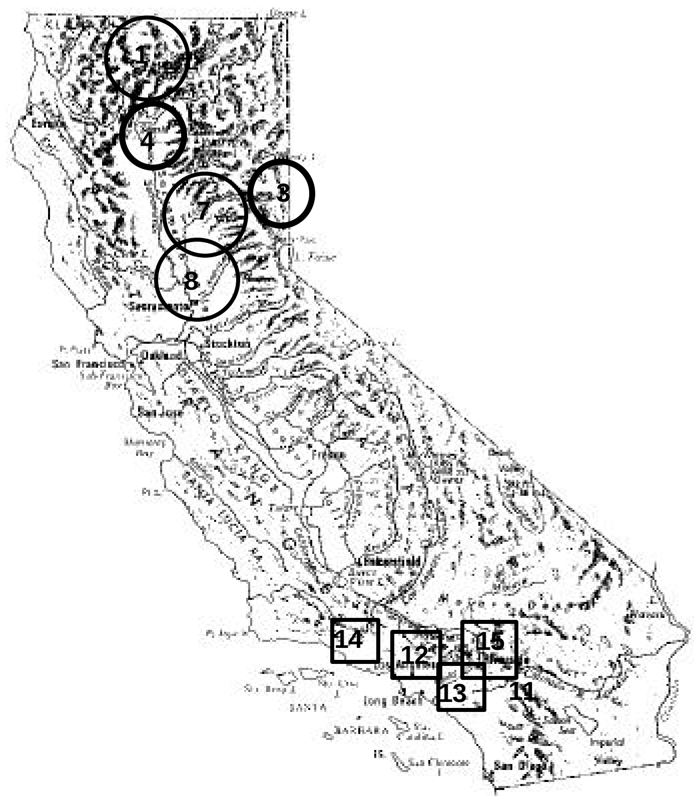


Figure III-4. Assumed Biomass Feedstock Supply Regions for a California Ethanol Production Scenario of 200 Million Gallons

Regions 1, 3, 4: Forest Materials

Regions 7 and 8: Agricultural Residues

Regions 12-15: Urban Waste

(See Tables III-1 and III-2 for further description)

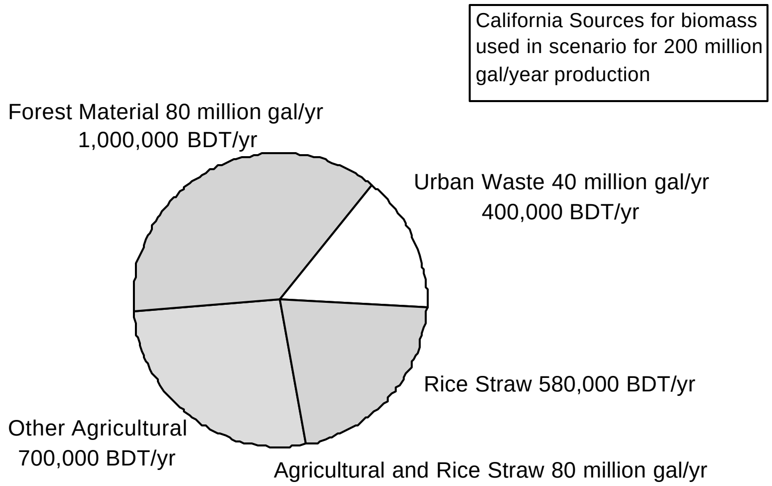


Figure III-5. Assumed Biomass Feedstocks for a 200 Million Gallon/Year Industry

III.3 Definition of Costs and Benefits Terms Used in This Study

Economists assign very precise meanings to the terms "costs" and "benefits" and it is easy to misuse these terms. In analyzing the costs and benefits of a public policy alternative, the term "cost" refers to the specific investment that has to be made by the state to bring about the desired policy. In this study, two investment options (i.e., cost alternatives) for the State were considered: a capital subsidy and a price support option.

The State's investment itself generates economic activities. Economists refer to these activities, whether positive or negative, as benefits or impacts. For this study, the State's investment in an ethanol production industry would give rise to two types of impacts. First, it would stimulate investment by the private sector. It is important to distinguish between these private capital expenditures, which are defined as benefits or impacts, and the investment by the State, which is defined as a cost. The second type of impact is the ongoing ethanol production operations that would ensue.

The private investment and ethanol production brought about by the State's investment would give rise to subsequent consumer spending and growth in supporting industrial sectors. Therefore, the aggregate impacts can only be determined after the immediate impacts have been considered within the spending "network" of California's economy. By accounting for the specific economic activities associated with private investment and ethanol production, and inputting these activities into an economic model, the economy-wide effects, or net economic benefits can be obtained.

Chapter IV discusses the aggregate effect, or economic costs and benefits, of a California ethanol industry, by analyzing state investment strategies, capital expenditures, plant operation, and employment associated with ethanol production.

III.4 Capital Expenditures

Plant Construction

The capital expenditures for ethanol plant construction will stimulate economic activity at the plant site location and throughout the State. In addition to the equipment and material costs and the plant design, all issues and costs associated with land acquisition, and permitting issues are assumed to be handled in a timely manner so that the first plant is online by 2004. Given the scale of these expenditures, investment, incentives, and financing issues must be addressed not only to ascertain financial feasibility, but to grasp statewide economic impacts of ethanol plant construction.

Each of the nine hypothetical plants require building materials for the physical structure that house the plant equipment. This will result in business for materials suppliers as well as the creation of the need for construction and structural engineering required to erect these facilities. Table III-2 presents the number of plants required for the scenario based on 200 million gallons annual California ethanol production.

Table III-2. CA Ethanol Production Scenario Summary

CA Ethanol Scenario	Plants	Plant Capacity	Total Capacity
		Million gallons/yr Pure Ethanol	
Forest Material	2 1	20 40	80
Agricultural Residue	2	40	80
Urban Waste	4	10	40
Totals	**9**	**—**	**200**

Once the plant structure is in place, industrial equipment will be installed, including such items as tankage, feedstock processing systems, instrumentation, and control hardware. This equipment will require calibration and certification before production can commence. On completion, testing and limited production can begin. These activities will provide final facility validation and allow plant specific procedures to be developed in response to regional climate, feedstock supply, and employment considerations.

Ethanol Transport/Storage

Assumptions Regarding Ethanol Transport and Storage in California

The majority of U.S. ethanol is currently produced in the Midwest states. Ethanol is currently available in California by rail from production centers in the Midwest or by ship (via the Panama Canal route) from Gulf Coast storage terminals.

A leading producer of fuel ethanol in the U.S. announced, in June 2000, the establishment of an in-state ethanol supply and distribution center at Kareb Terminals (formerly Shore) in Crockett, California, to meet the potential demand for ethanol when MTBE is phased out by December, 2002. Transportation of ethanol blends in existing gasoline pipelines poses challenges. This is because of problems related to ethanol's affinity to absorb moisture, its phase separation from gasoline, and the attack on rust spots (especially in the joint areas) which accelerates corrosion in the existing pipeline system.

Many existing gasoline distribution terminals can be expanded to handle ethanol. A 1999 survey-report by the Renewable Fuels Association identified 40 terminals across California that indicated the capability to offer ethanol storage and distribution within six months if necessary. However, the CEC study on Alternatives to MTBE conducted in 1998 suggested 18 to 24 months to upgrade existing terminals to be able to handle ethanol (CEC, 1998).

Assumptions Concerning Transportation and Storage:

The locations of the potential biomass ethanol plants are shown in Figure III-6. The figure reflects the estimated locations for both the 200 and 400 million gallon/year scenarios. The locations correspond to existing biomass power plants as well as areas where urban waste might be collected. Also shown in the same figure are the major California railroad arteries. Ethanol manufactured in plants located in the Los Angeles and San Francisco metropolitan areas can be transported to nearby refineries or gasoline terminals by truck for storage and/or blending.

Ethanol manufactured in the Northern California plants are assumed to be transported either to the existing refinery locations in the Los Angeles or San Francisco Bay areas, or to existing gasoline terminal for distribution in the Sacramento/Central Valley areas. While railroad transportation of ethanol from the plant to the distribution terminal appears to be well suited given the proximity of most of the plants and the terminals to the railroad network, the current thinking is that this mode of transportation is doubtful in the near-term and trucks will have to be used. However, most of the forest-based northern California plants will be within 10 miles of the nearest railroad depot and on an average over 100 miles to a major distribution terminal. With large volumes of ethanol being produced, an infrastructure to deliver ethanol from the plant to the railroad depot (less than 10 miles away) and then transportation to the terminal by railcar is not inconceivable. Thus, for purposes of this study, this scenario is assumed. Under the assumption that there will be the stated demand for ethanol, the cost of this infrastructure will be absorbed into the capital cost of the ethanol plant.

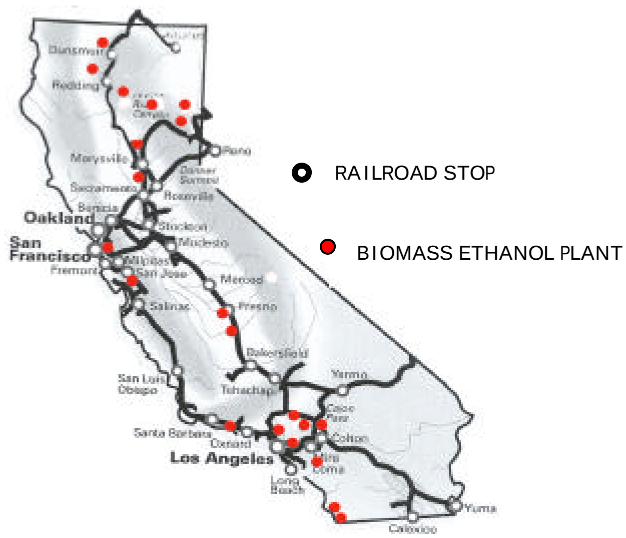


Figure III-6. Biomass-Ethanol Plant Locations and Railroad Network as Developed for this Report

A preliminary estimate of the average transportation distances for ethanol distribution from the plant to the nearest terminal was performed (Appendix III-B). The assumptions include primarily pipeline plus railroad transportation in the northern facilities and truck transport elsewhere. Depending on the plant size, capacity factor, and location:

- The average number of truck-trips per day per plant will vary between 4 and 14. (The average truck capacity is assumed to be 7,800 gallons.)
- The one-way distance traveled per truck per day will range between 5 and 100 miles.
- The length of a pipeline in the northern facilities between the plant and the railcar loading point will be between 5 and 10 miles.
- The one-way distance traveled by the railcar will range between 50 and 300 miles. (The average railcar capacity is assumed to be about 29,000 gallons.)

III.5 Ethanol Plant Operation

Ethanol Plant

Ethanol Plant Personnel and Feedstocks

Ethanol plant operation influences many upstream and downstream industries. Plant operations require a host of skills for optimal production. Shift supervisors, equipment operators, engineers, biologists, and a management team are required for plant operation. In addition to operations, each plant requires maintenance personnel and engineering expertise.

The biomass feedstocks that provide the raw materials for ethanol production must be collected, processed, and transported to each conversion facility. This requires collection personnel, equipment operators, truck drivers, and receiving personnel. In addition to raw biomass, ethanol plants require a host of other chemicals as process inputs that depend on the plant configuration. Examples of these inputs include enzymes, acids, gypsum, and diesel fuel. These resources result in revenue for the industrial sectors that produce them and costs to the biomass-to-ethanol plant. Ethanol plants also need water input.

Administering the end product of ethanol entails considerable labor. Ethanol sales in the volume-scales considered within this report would require a full-time sales staff as well as marketing and finance personnel.

Co-Products of Ethanol Production

Lignin is a component of lignocellulosic biomass, which generally passes through the biomass-to-ethanol conversion system unchanged. The energy value of lignin, depending on the biomass source, ranges from 9,000 Btu/lb to 12,000 Btu/lb. Lignin from the biomass-to-ethanol process can also be used as a combustion fuel. About 4000 tons of lignin is produced for every million gallons of ethanol produced in the biomass-ethanol conversion process. Lignin, depending on the quality, can also be processed into high-value, specialty products such as plasticizers, extractives, electrically conducting polymers, or phenolic-resins which may be used as glues or binders in production of plywood and fiberboard. In this study, the economics of lignin as a combustion fuel to produce power are included. The economic benefits of co-products is included as a feedstock credit of $1/BDT in the economic model used in this study (see Appendix IV-A) (CEC, 1999).

The concept of a biomass ethanol biorefinery integrated with a biomass power plant is illustrated in Figure III-7.

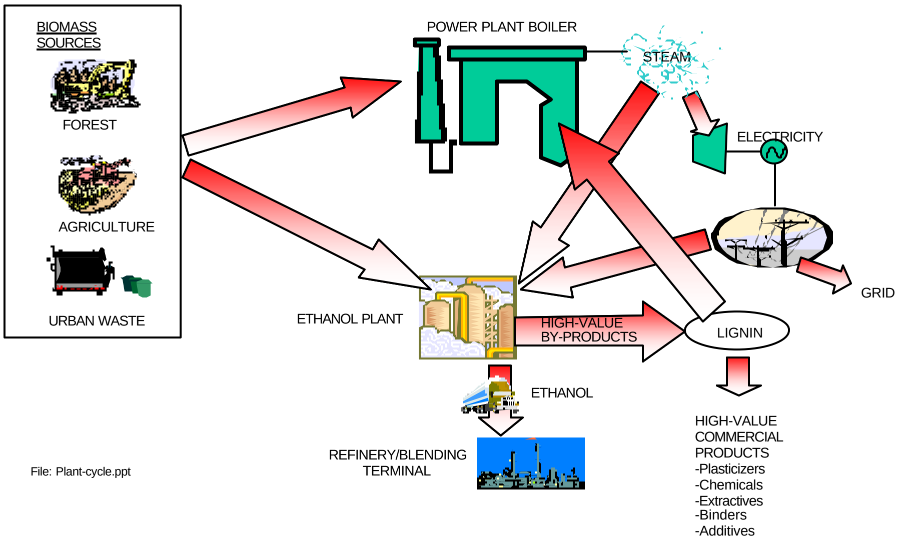


Figure III-7. Integrated Biomass Ethanol Biorefinery

Feedstock Availability/Sources

The location, area and quantity of feedstock available from each of the three source types was described earlier in Chapter III. The following presents a discussion on the availability of the feedstock for each source-type.

Forest Material Feedstock Availability

Excess woody materials are available in California forests, according to a study by the Quincy Library Group (QLG, 1997). This material is available in the form of slash left on the ground after commercial timber harvesting, pre-commercial selective thinning, and woodmill residues. A California Energy Commission biomass resource assessment estimated that over 8 million bone dry tons of forest slash and thinnings are available per year (CEC, 1999). In addition, an assessment by the Quincy Library Group indicated that 700,000 to 1.1 million bone dry tons of biomass per year could be thinned and gathered from timber harvesting slash in three northern California national forests (QLG, 1997).

Based on the Quincy Library Group study results, the baseline for this study assumes that enough biomass is available from forests to meet a demand of 200 million gallons per year. Some forest ecologists believe this availability is too high due to potential damage to forest ecosystems. As environmental impacts are further assessed, the estimated portion of feedstock from forest materials may be reduced and shifted to other feedstocks. At this time, many sources report that biomass is available through thinning operations for several reasons. One reason is that many forests have become extremely dense due to years of fire suppression. As a result, biomass can be removed in order to restore the health of the forest and reduce fire risk. Also, diseased trees and invasive species can be removed to prevent their spread and to restore water availability to remaining trees. (See Chapter VI for a discussion of forest health, including effects of forest fires.)

In addition to thinning, the California ethanol demand of approximately one million bone dry tons can be met with slash and woodmill residue. Slash treatment and forest thinning operations will conform to California's Forest Practice Rules or similar rules on Federal land. This will focus selective removal on the least environmentally vulnerable sites and forests (see Chapter VI for further discussion). In order to meet the demand for ethanol feedstock, thinning rotations would occur no more than once per decade for any forest unit. In addition, hand thinning may be necessary to prevent ecological damage.

Also, as mentioned in Chapter III.2, the forest thinning and slash removal locations selected for the study do not represent the complete potential for material availability in the State. Similar availability may exist in central and southern mountainous regions. Therefore, it is likely that more forest material is available than was analyzed in this study.

The recently issued Rules for Roadless Area Conservation in National Forests is not expected to significantly impede the harvesting of biomass for use in ethanol production, for several reasons. First, only 31 percent of the National Forest System (NFS) lands are roadless and thus affected by the new rules, and these forests collectively represent only about 0.5 percent of the total US timber harvest. Furthermore, biomass removals as part of forest management will not be affected on NFS lands for which timber contracts already exist, since these contracts are exempt from the rules. Secondly, biomass removals for ethanol production are unlikely to be economically justifiable in roadless areas due to the planning, permitting and implementation costs of logging road construction and the required mitigation of adverse impacts from such activities; even some NFS lands with logging roads may be too far from ethanol production facilities to be economically feasible as sources of biomass. Finally, the new rules contain provisions for new road building where needed to preserve or enhance the forest ecosystem, which arguably will include biomass removals that are needed for the dual purposes of preventing ecological damages from forest fires and diseases, while preventing property damage. Thus, the new rules for ecosystem conservation in roadless areas of the NFS can be viewed as posing no more of a restriction on the proposed harvesting of biomass for ethanol production than do California's existing Forest Practice Rules, along with other state and federal environmental regulations that require forestry operations to be conducted (and mitigated) in an ecologically sensitive manner.

Although the Rules for Roadless Area Conservation in National Forests may not affect biomass availability, many ecologists and environmental organizations are concerned about the removal of wood from forests, especially public lands. In an effort not to duplicate discussion of the environmental issues, potentially negative effects are discussed in Chapter VI. Although a formal environmental impact assessment would be necessary to determine site specific impacts, in general, it should be possible to remove biomass beneficially by using appropriate methods in least sensitive areas. Nevertheless, as stated above, availability may be limited if there is opposition to commercial use of forest material from public lands or if studies show unavoidable degradation to ecosystems. As a result, a forum that includes many stakeholders must be encouraged to determine who has the authority to choose areas to be harvested, the manner in which the material is removed, and which organizations will oversee and monitor the forest health.

Available Rice Straw Quantity Given Regulatory Constraints

Rice straw is a potential feedstock for California ethanol production. In all, there are over 500,000 acres of rice grown each year, mostly in Northern California (Paul Buttner, California Air Resources Board). Each acre produces between 1-2.5 tons of rice straw (Buttner; Ken Collins, Rice Straw Cooperative). In years prior, rice straw was burned by farmers because this disposal method offered them two advantages: the disposal costs were very inexpensive at about $2/acre, and burning was an effective method for controlling rice diseases. Over the years, however, rice farmers have been required to burn increasingly less of their rice straw due to concerns about air quality. Under the current law, rice farmers are now restricted to burning the rice straw from the lesser of 25 percent of their own acreage or 125,000 aggregate acres in the Sacramento Valley.

Since 1997 there has been a pause in the program to reduce rice straw burning to give more time for the development of alternative methods of rice straw disposal. 2001 is the first year that the pause will be lifted and the limit on burning will reduce to 25 percent for disease control purposes. As a result, growers are faced with having to plow under large amounts of the straw. Alternatives such as ethanol production may provide a potential lower cost option to rice growers.

Starting in 2001, they will be able to burn up to this amount only if they can show evidence of disease. Rice farmers are now faced with two, more expensive alternatives for disposing of their rice straw. The straw can be tilled back into the soil (Buttner; Collins). But the problems with this disposal method are its increased cost as compared to burning and potential disease and weed infestations, which will damage future crops. The other

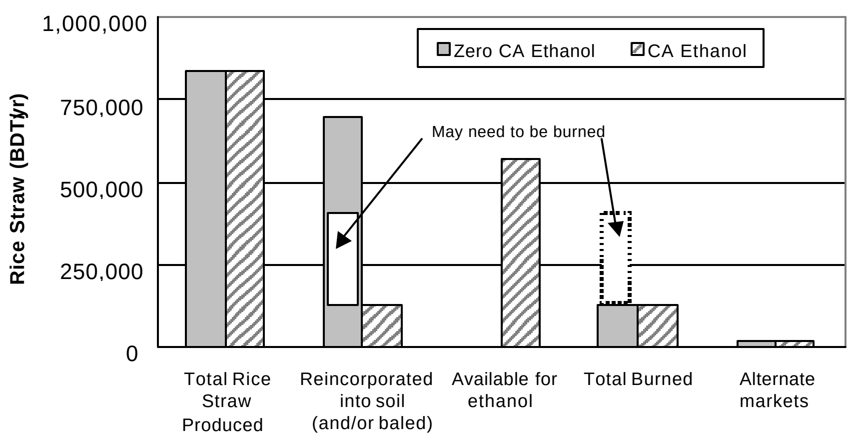


Figure III-8. Rice Straw Disposal Methods with and without Ethanol Industry

option is to cut and bale the rice straw. It is this latter option that may serve as a basis to provide rice straw as a feedstock for ethanol production in California (see Figure III-8). If growers cannot find favorable alternatives to plowing rice straw, they will continue to incur additional operational costs from management of rice straw. Accordingly, ethanol production will provide growers with an opportunity to reduce operational costs from management of rice straw. If demand for ethanol were to become significant, growers may elect to bale rather than burn or till.

Feedstock Cost

As of 2001, the law will permit rice farmers to burn up to 25 percent of their acreage that is diseased. However, rice straw suppliers predict that a smaller percentage will be burned due to the practical limitations imposed on farmers by agricultural burn programs that costing $2 per acre to burn rice straw. Accordingly, rice straw suppliers estimate that there will be a total of about 540,000 BDT of rice straw available each year for baling (Collins).

While there is a large supply of rice straw that could be baled in California, there is currently a very small market demand for this commodity. Rice straw suppliers estimate that, in recent years, only about 2 percent of California's total rice acreage was baled and sold. The remaining 98 percent of the statewide acreage was either burned or tilled back into the soil. When the demand for baled straw lags behind the supply in this manner, rice farmers often react by tilling the straw into their soil in subsequent years to save costs, instead of cutting and baling straw that cannot be sold due to the high costs of baling per acre. To date, the potential markets for baled rice straw include animal feed, animal bedding, erosion control, building products, and ethanol production.

Baling rice straw for ethanol production provides growers the opportunity to dispose of large quantities of rice straw while minimizing disease impacts on next year's crop yields. A likely example of the economics of collecting rice straw would include the grower's cost of plowing the fields of $20/ton plus an additional $15/ton to bale and collect the rice straw. Ethanol producers might pay the growers $20/ton plus additional incentives related to the success of the ethanol production facility (Hinman). The net cost to bale is expected to be less than the cost to plow under, making this an attractive option to the grower, especially when the yield impacts of plowing under are considered.

Unlike plowing under rice straw, cutting and baling results in a smooth field which is advantageous to growers. Fields are flooded to enable the rice straw remnants to rot and plowed fields absorb more water. Plowed fields are often flooded twice while fields with cut straw need only be flooded once. The avoided water consumption can be over 2000 gallons per gallon of ethanol (by avoiding 1 acre-ft of flooding).

Given the above considerations, it appears that about 500,000 BDT of rice straw could be available in California for ethanol production. The availability of the feedstock is based on the ethanol plants paying rice farmers enough for the rice straw to make cutting and baling costs competitive with plowing the straw back into the soil.

A law was recently passed in California for the purpose of stimulating demand for rice straw. Assembly Bill 2514, as originally drafted, provided a $20 per ton tax credit (not specified wet or dry basis) to rice straw end users (such as ethanol plants) with a statewide aggregate limit of $10 million. However, when Governor Davis signed the bill into law, the tax credit had been altered to a grant program with a $2 million limit over a three-year period. Rice straw suppliers are of the opinion that the original version of the bill is closer to the kind of government sponsored, economic jump-start that the rice straw end-user industry will need.

Economically feasible ethanol production would require the location of ethanol plants within about 25 miles of rice farms. This distance is consistent with one or two rice straw based ethanol production facilities in California. These plants would need to purchase the feedstock for $10 to $20/BDT which would be the alternative cost of plowing the rice straw into the soil. Growers would be motivated to cut and bale rice straw rather than tilling into the ground to avoid the potential for future disease infestations. As rice straw is produced seasonally, the feedstock would need to either be stored for ethanol production or the ethanol plant would need to operate on other feedstocks throughout the year. Consuming over 200,000 BDT/yr of rice straw would require either a very large capacity ethanol facility (which would be challenged to find feedstock the rest of the year) or storage of rice straw. BCI's planned ethanol facility in Gridley would operate on rice straw all year long.

An additional barrier to rice straw-based ethanol plants is the high silica content of the rice straw (about 13 percent). If left in the rice straw residue, silica would lead to erosion and slagging of combustors. The extraction of silica from the rice straw would enable it to be sold as a co-product. BCI and others have developed processes to extract the silica and enable the residual lignin to be combusted.

Other Agricultural Residues Used in CA Ethanol Case

A significant portion of biomass for ethanol production is other agricultural residues. This includes mainly orchard prunings, but other vine or row crop residues are possible feedstocks. The agricultural residues considered for ethanol production in this study are normally landfilled or burned. In an effort to divert material from landfills and reduce open burning, which is a major contributor to agricultural pollution, 700,000 bone dry tons of non-rice straw residues can be collected and transported to ethanol production facilities to help meet the 200 million gallon demand scenarios. This availability is based upon the volume of agricultural residue used in biomass power plants at Woodland and Delano.

Urban Waste — Barriers and Opportunities

Urban waste considered in this study amounts to 400,000 BTD/yr residual waste paper and other cellulosic municipal solid waste residues sorted at MRFs. Each of these is discussed in the following paragraphs, beginning with municipal solid waste.

Impact of Diversion Law on Ethanol Feedstocks

AB 939 is a law in California that requires each municipality to divert 50 percent of their municipal solid waste (MSW) from disposal in landfills into recycling or other diversion methods by 2000. Under the present language of the law, municipalities are strongly discouraged from attempting to meet this quota by diverting MSW to ethanol production instead of diverting it to paper mills. The reason is that the law distinguishes between diversion methods that are considered "recycling," such as making paper products from other paper products, and those that are considered "transformation," as when waste paper or other organic material is turned into ethanol.

Current Law Regarding MSW

As AB 939 is currently written, municipalities are generally discouraged from diverting waste paper products that are capable of being recycled into transformation processes like ethanol production. These activities are discouraged because only 10 percent of the diversion credit may be obtained by transformation processes. That being the case, if a given municipality is assisted in meeting its 50 percent diversion quota by diverting some of its MSW to recycling, it would not likely be able to continue to meet its quota if the same MSW was instead diverted to ethanol production.

Even so, AB 939 as currently written is not likely to affect the availability of MSW feedstock for ethanol production in California. This is because the types of MSW that are capable of being recycled and thus eligible for full diversion credit under the law are usually too expensive to be ethanol feedstocks. Conversely, the types of MSW that are not generally recycled (and are thus landfilled) and have the lowest value tend to be well suited for ethanol production. These suitable MSW feedstocks include items such as low-grade waste paper and other organic waste. The only scenario in which AB939 might affect MSW ethanol feedstock availability is in the unlikely event that the selling price of ethanol was to become so high that ethanol producers could afford to compete with MSW recyclers for their feedstock.

In conclusion, the current transformation discounting provisions of AB939 would not have a significant impact on the economic feasibility of producing ethanol from MSW feedstocks. The feedstocks to be used for ethanol usually are not diverted to recycling. And since these feedstocks are placed into landfills, the economic feasibility of using them for ethanol production will depend on the cost advantages, if any, that ethanol production from these feedstocks will offer as compared to placing them in landfills.

Opportunities for Ethanol with Changes to Current Law

If AB 939 was amended to provide equal diversion credit for both transformation and recycling activities, there would no longer be any diversion quota inhibition for diverting recyclable MSW to transformation activities like ethanol production. However, although ethanol production then would be entitled to full diversion credit, ethanol producers would still not likely compete for recyclable MSW feedstocks, due to their high cost. As a result, even if AB 939 was so amended, it probably would not affect ethanol producers' use of recyclable MSW feedstocks such as higher grades of waste paper or urban wood waste.

However, if AB 939 was amended, residual ethanol diversion could be increased or encouraged in the following way: Some jurisdictions in California now struggle or fail to meet their diversion quotas. Some of these jurisdictions could be assisted in meeting their quota by diverting their MRF waste paper residual. If diversion to ethanol production was the lowest cost alternative available for meeting their quota, then ethanol diversion of MRF residual might become an attractive diversion option. In this situation, residual ethanol diversion could be adopted by some municipalities as the most cost effective method for meeting their quotas, even if such ethanol diversion would not have been cost effective on strictly economic grounds. Amendments to AB 939 could therefore help to boost and encourage an ethanol from waste paper industry in California in those situations where it would be more cost effective than other means of waste diversion.

Waste Paper as Feedstock

Due to its high cellulose content and large volume of availability, one of the potential feedstocks for ethanol production in California is waste paper product. Waste paper includes a wide variety of materials such as white ledger paper, newspaper, phone books, plastic coated paper and items such as cardboard pizza boxes that have been exposed to or contaminated by food, beverages, or grease. Some of this material is recycled by paper mills or by other recycling processes, and some of it is placed into landfills.

Recyclable Paper Grades are not Feasible

As a general matter, the same types of waste paper products considered capable of recycling tend to command prices per ton on the recycling market that are above that with which the ethanol industry could compete for its feedstocks. Mixed paper, for example, one of the lower grades of paper, was selling for $50-60/ton at the time of this publication. Ethanol producers could only afford feedstocks if the selling price of ethanol reached approximately $3/gal. Many other grades of recyclable waste paper, such as white ledger paper, command even higher prices per ton and are thus less likely to be suitable feedstocks for ethanol production.

Non-Recyclable Paper Grades are Feasible

There are grades of waste paper that are considered sub-standard for paper recycling purposes but which are suitable for ethanol production. These types of waste paper are often disposed of by materials recovery facilities (MRFs) after they are separated and sorted from the recyclable grades of waste paper. These lowest grades of waste paper are generally referred to as “MRF waste paper residual” and are disposed of in landfills. Since this residual would most likely be disposed of in a landfill if it were not diverted to ethanol production, ethanol diversion of MRF residual does not pose any of the AB939 quota disadvantages that are involved with recyclable waste paper grades.

Disposal Cost Savings with Ethanol Diversion

Once MRF waste paper residual is sorted at a MRF, a municipality usually incurs two additional costs to dispose of it into a landfill: first, the cost of transporting the residual to a landfill, and, second, the cost of depositing the residual into a landfill (otherwise known as a landfill “tipping” fee). Statewide, about 10 percent of all the waste placed in landfills consists of such post-MRF waste paper residual (over 3.5 million wet tons/year).

Rather than disposing of MRF residual in a landfill, a municipality could choose to conduct some additional sorting of the MRF residual in order to better sort and prepare it as an ethanol feedstock. After such sorting, the average municipality could then pay a collocated ethanol plant to accept the sorted residual and still incur lower residual disposal costs than by transporting and placing the residual into a landfill. By diverting its residual to ethanol production, a municipality could reduce its waste paper disposal costs.

Insufficient Feedstock Quantity: Supplementation Necessary

While the diversion of MRF waste paper residual to ethanol production could provide cost savings to municipalities on a disposal cost per ton basis, the minimum sized ethanol plant of 10 million gallons per year would not likely obtain a sufficient amount of this feedstock from even larger sized MRFs. The other potential sources of supplemental organic urban waste materials can generally be divided into two types: those for which there is already an established market demand and those for which there is not. Ethanol production will most likely have to be based on the latter. Organic feedstocks for which there is already an established market demand include yard waste, tree trimmings, and urban wood waste.

Yard Waste/Tree Trimmings Not a Feasible Supplement

Organic feedstocks such as yard waste and tree trimmings would not be feasible ethanol feedstocks because they are generally utilized by landfills for what is called “alternative daily cover” (ADC), or as a substitute for covering the landfill waste with dirt layers. Materials that are used as ADC are counted toward the 50 percent diversion requirements of AB939. Landfills also have a need for these materials to avoid the cost of bringing in actual dirt. Accordingly, landfills usually offer a substantially lower tipping fee for ADC materials, since they want to encourage their supply. And under the current law, any diversion of them to ethanol production would interfere with a landfill’s 50 percent diversion quota. For these reasons, ethanol plants would not be able to compete for these types of organic feedstock to supplement MRF paper residual.

Urban Wood Waste Not a Feasible Supplement

Urban wood waste includes items such as pallets, two-by-fours, and construction wood scraps. These items are valued at about $50/ton when they are used to make particle wood and other construction related products. Because of its established market and high dollar value, urban wood waste would not be a feasible feedstock supplement for ethanol production.

Feasible Supplements: Landfilled Organic Waste

Organic materials for which there is not an established market and which are currently landfilled could serve as a feasible feedstock supplement for ethanol plants. These materials include food, textiles, and other mixed organic waste. Statewide, these types of organic materials comprise close to 30 percent of all the waste that is currently placed into landfills. Since these types of materials are not considered recyclable, they are usually not placed with recyclables. As a result, they are not sorted by a MRF. Instead, these materials are collected as trash and sent to transfer stations for subsequent transport to a landfill, as depicted by the black arrow on the left side of the flow diagram in Figure III-9. It is possible that a low cost form of sorting could be done at transfer stations in order to separate organic types of waste from inorganic (concrete, re-bars, etc.), and that the resulting organic mix could then be diverted to a collocated ethanol plant. This diversion is shown as the movement of dashed-gray arrows in Figure III-9. Since transfer stations of this sort are often collocated with MRFs, this organic feedstock could thus be used to supplement a collocated ethanol plant's use of paper residual from a MRF, which is shown in gray on the right side of Figure III-9.

Collocation of Ethanol Plant with Transfer Station/Material Recovery Facility

Diversion of MRF paper residual and organic materials from landfills to ethanol production could result in cost savings in cases where the combined cost of the tipping fee charged by an ethanol plant and the cost of sorting ethanol feedstock is less than the cost of transporting and tipping to a landfill. Ethanol production that is collocated at transfer stations/MRFs could offer municipalities comparative cost savings for MSW disposal as the distance from the landfill to the transfer station/MRF increases and as the landfill tipping fees become higher. One key savings that an ethanol plant could offer is based then on its collocation at its feeding transfer station/MRF in order to avoid the costs associated with transporting MSW from these facilities to a landfill. A feasibility study could help determine the cost savings achieved by collocating the facilities.

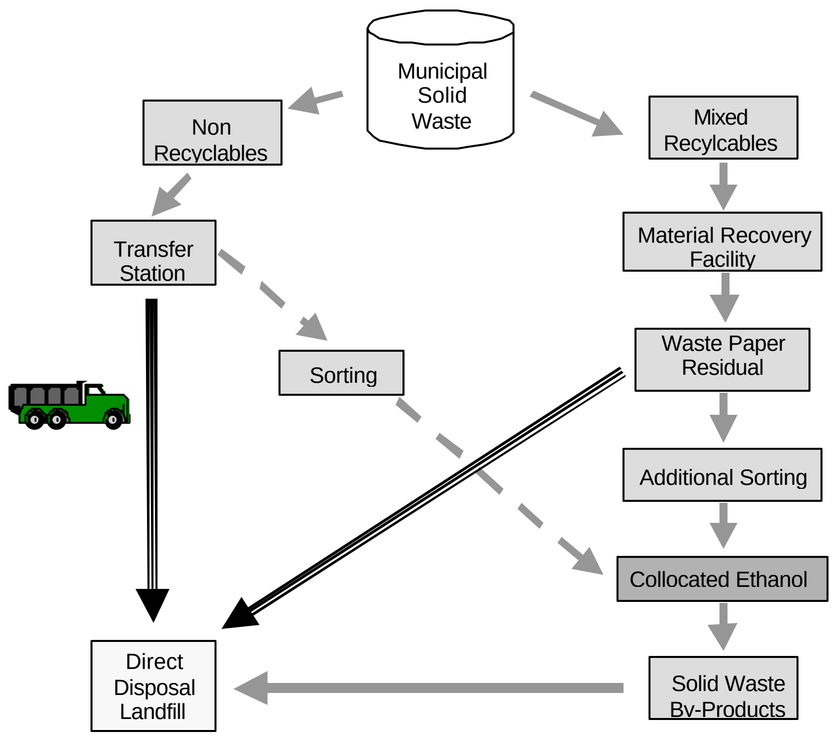


Figure III-9. Fate and Movement of Waste Paper and Other Materials with Collocated Ethanol Plant

Quantities of Diverted Landfill Feedstock Supply Available

Finally, the most feasible, cost effective scenario for a collocated ethanol plant that uses landfill diverted feedstocks would rely on a mixture of feedstocks including MRF waste paper residual and organic materials sorted from a transfer station's total waste stream. With this combination of feedstocks, a large transfer station/MRF (such as one that processed around 3,000 tons of the total waste stream per day) would provide the necessary three to four hundred wet tons of feedstock per day that a 10 million gallon/year plant requires.

Feedstock Collection

Doesn't California Already Have a Biomass Collection Industry?

California has a biomass collection industry that supplies forest residues and agricultural wastes to biomass-based power plants. This study assumes that ethanol production will be collocated with five biomass-based power plants and that four will stand alone. Historically, up to 6 million dry tons per year of biomass have been collected for biomass power production in California (CEC, 1999). These feedstocks consisted primarily of lumber mill waste, forest material, urban wood waste and agricultural residue. Other than urban wood waste, these feedstocks would be the primary materials used in an ethanol industry as shown in Table III-3. Urban wastes such as waste paper are already collected but not used for energy production. The collection of these materials is discussed in the following section. Figure III-10 presents the California power plant biomass fuel supply cost based on data between the years 1986 and 2000.

Supplying forest residue biomass fuel involves harvesting, collection, processing, and transportation. Biomass collection requires movement of forest residue to a landing site in or near the forest by skidding, cable yarding, or some other method. At the landing site, the biomass is processed for the plant by chipping. The biomass is blown directly into a chip van that loads the chipper. An average chipper can process about 15 BDT/hour and produce half-inch size chips. The processed biomass is then transported to the power plant site. Hauling trucks have a typical capacity of 13 BDT/truck/per load.

Agricultural waste such as rice straw is transported in bales. Conventional equipment such as hydraulic lifts, fork lifts and equipment specifically designed for handling baled straw are used for loading and unloading trucks. Typically, straw bales are hauled by conventional trucks and flatbed trailer rigs. Trucks and rigs carrying small bales will carry 10 to 15 tons per load, whereas trucks carrying large bales will carry 20 to 25 tons per load.

Figures III-11 through III-14 show examples of typical biomass collection and processing equipment.

Table III-3. Total Feedstocks Used in Zero CA Ethanol and CA Ethanol Cases (BDT/yr)

Feedstock	Zero California Ethanol	California Ethanol
Forest material	700,000	1,000,000
Agricultural Residue	400,000	1,300,000
Urban Waste	—[a]	400,000
Total	1,100,000	2,700,000

[a] Not used in energy production

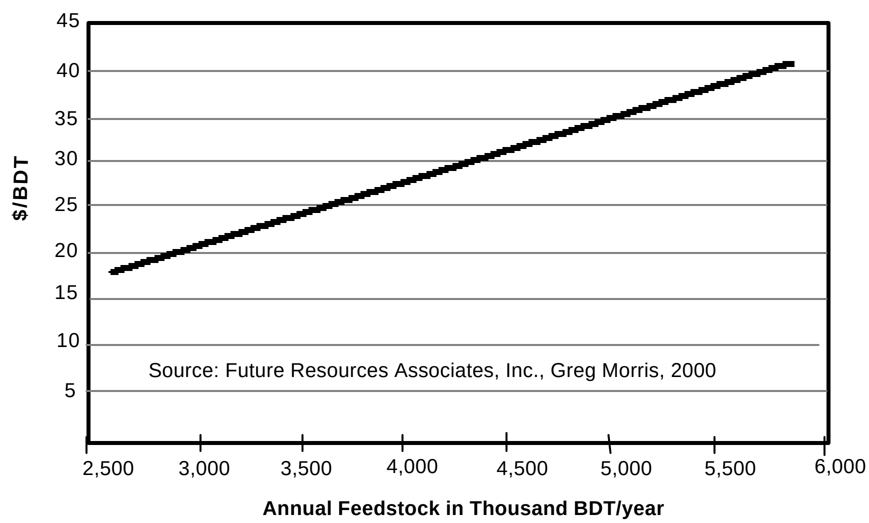


Figure III-10. California Power-Plant Biomass Fuel Supply Curve, 1986-2000

Figure III-11. Cable-Yarding Crane

Figure III-12. Wood Chipper

Figure III-13. Processed Forest Residue Biomass Delivery to Plant (2)

Figure III-14. Straw Baler

Feedstock Collection Economic Impacts

As noted earlier in this Chapter, the production of 200 million gal/year of ethanol in California will require approximately 2.71 Million BDT of biomass made up from various sources. The collection of this feedstock has significant impact on a number of factors that contribute to the economic impacts described in Chapter IV. Key factors related to feedstock collection are listed below:

- Approximately one million BDT/yr of forest residue will be used. Within the same collection regions, if no ethanol is produced, only about 700,000 BDT/yr of biomass will be used for existing power production. Therefore, equipment required for the harvesting, collection, processing and supply of biomass will increase with ethanol production.
- Employment in the feedstock collection industry will increase (see Chapter IV).
- Beneficial impacts due to forest fire risk reduction and reduction of agricultural open burning may increase (see Chapter VI).

Feedstock Transport Economic Impacts

Each type of feedstock used for ethanol production has unique transportation requirements that, in some cases, may be comparable to non-ethanol alternatives. Collecting feedstocks and transportation to production facilities are labor intensive activities. This economic activity is a positive direct impact.

- Forest Slash and Thinning: requires hauling by truck from the feedstock source to nearby ethanol production facilities.

- Lumbermill Waste: for ethanol facilities collocated with a lumbermill, additional transportation will not be required.

- Agricultural Residue and Rice Straw: requires hauling by truck to nearby ethanol production facilities located in California's Central Valley.

- Urban Waste: hauling distances and trips per day from material recovery facilities (MRFs) to ethanol production facilities are, on average, comparable to distances from MRFs to landfills. Some ethanol production is expected to be collocated with MRFs but transportation is necessary for feedstock from nearby off-site MRFs.

Table III-4 summarizes feedstock truck transport activities related to the operation of the ethanol plants.

Table III-4. Truck Activities Assumed per Million Gallons of Biomass Ethanol Produced[a]

Activity	Forest Slash Thinning	Urban Waste	Agricultural Residue
Truck Trips /million gal	600	500	1,100
One-way Miles /trip	25-40	20[b]	25
Number of New trucks /million gal/yr	0.6	0.4	1.0

[a] Appendix III-B, Ethanol Transportation
[b] Assumed average distance to ethanol plant from MRF

Feedstock transport, as well as plant construction, plant operation, and biomass collection, would provide economic benefits to the State. The following chapter explains how economic costs and benefits are analyzed and assesses the total economic impacts of an ethanol production industry in California.

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CHAPTER IV

ECONOMIC COSTS AND BENEFITS OF IN-STATE ETHANOL PRODUCTION

IV. Economic Costs and Benefits of In-State Ethanol Production

The previous chapter identified the categories of potential scenario impacts that California ethanol production would have on the State. This chapter explains the methodology by which these impacts were studied in determining the total economic costs and benefits of an ethanol production industry in California. Direct, indirect, and induced economic impacts are defined and calculated. In addition, the effects of capital investment in plant construction, operation, and maintenance on economic output, personal income, and employment are determined. Finally, this chapter looks at some of the possible ways the State could foster ethanol production in California.

IV.1 How Are Economic Costs and Benefits Analyzed?

The economic analysis of a public policy decision, such as state support for a fuel ethanol industry, follows a different set of rules than those that might be followed by an individual investor. The investor is interested only in the return on the capital invested and the certainty with which that return can be predicted. The investor will reject a potential investment that fails to meet a predetermined rate of return, often referred to as the hurdle rate. This is purely a financial analysis that weighs the cost of producing a product with the expected income from selling the product. In public policy decision analysis, the analyst considers a greatly expanded set of impacts including those on the community, the regional and state economies, government operations, and other policy goals such as income equity, economic development, energy efficiency, energy independence, etc.

The economic analysis conducted in this study is of a public policy that would have the State providing some financial support to the development of a California-based fuel ethanol industry. As such, the perspective from which this analysis is conducted is that of state government evaluating the commitment of state resources and the cost of the policy, against the potential benefits to individuals, organizations and the State's economy. The task is to calculate the economic impacts between the base case and selected alternatives. These impacts, both costs and benefits, include the direct, indirect, and induced economic consequences of a potential state fuel ethanol industry.

Direct impacts are the economic activities occurring at the plant site or a related site. Examples of direct impact include purchase of capital equipment and the process inputs to produce ethanol. Indirect impacts occur in other sectors of the economy that experience changes in output as a result of the ethanol production, such as the steel industry that would supply steel for the production of the capital equipment. Induced impacts occur as the direct and indirect expenditures trigger a chain reaction of spending through the economy. Any of these impacts may occur within or outside of California.

The costs and benefits related to the investment of government resources in a fuel ethanol industry will occur over time. Some direct impacts, such as plant construction, occur immediately, while others such as plant maintenance will be spread over the life of the plant.

Depending on the nature of the government support, the government expenditures will have different patterns. Construction subsidies would occur immediately, while price supports would follow production. Benefits will have distinct patterns as well, depending on assumptions about oil prices, ethanol imports etc. A dollar spent today does not have the same value as a dollar spent a decade from now. Economists call this the time value of money. The time value of money requires analysts confronted with cost or benefits occurring in different periods to adjust the estimates to a common period prior to the evaluation of program alternatives.

Thus, in order to compare costs and benefits of alternative ethanol fuel industry support programs, it is necessary to bring the estimated stream of costs and benefits to a present value. Then, present value benefit can be calculated for program comparison. Programs that exhibit the highest benefit provide the most benefits per dollar of expenditure. Programs with the largest net benefits offer the largest impact on the economy.

The impact on the State of California is measured in terms of the following economic variables:

- Gross output
- Employment
- Personal income
- Value added

Gross output reflects the total quantity of goods and services produced in the State. This figure includes inter-industry sales and therefore exceeds the value of goods and services sold for final consumption. Value added is a measure of economic output that eliminates inter-industry sales and therefore reflects the amount of output added by each industry. Employment and personal income correspond to the jobs and salaries associated with a California ethanol production industry.

Total personal income is the total current income received by individuals minus contributions to social insurance. Income sources include wages and salaries, dividends, interest receipts, transfer payments, and proprietors' income. Proprietors' income includes both compensation for proprietor labor as well as profits; it comprises approximately 8 percent of total personal income. Given this small percentage and the fact that it was not possible to separate proprietor profits from returns to proprietor labor, we assumed that these profits would be spent in consumer channels rather than in capital markets.

The different metrics are reported and used for different purposes. All of the direct impacts used to stimulate the I-O model were measured in terms of gross output; for comparison purposes, therefore, it is useful to have the secondary impacts reported in the same metric. Changes in value added are reported because it is the best indicator of newly created economic activity. Employment changes help identify job creation potential. Finally, as noted elsewhere, changes in personal income are reported because it is the only suitable metric that can be used to compare the costs and benefits of the proposed scenarios.

IV.2 Ethanol Production Impacts

There are several impacts that result from a California ethanol industry. For the purpose of this report, these impacts are divided into four categories: economic, employment, energy, and environmental. While the energy and environmental categories are addressed in detail in Chapters V and VI, a brief discussion of each category follows, to provide an industry overview. It is worth noting here that the term "impact" is used with neither positive nor negative implications. Because of the coupling that exists between industrial sectors, the use of a given resource may or may not have a positive economic effect. Many of the direct, indirect, and induced impacts detailed in this section stem from the linkages between industrial sectors. The economy-wide effect of consuming a resource is dependent upon the conditions in all related sectors. As a result, it is difficult to assess whether a given economic activity is either positive or negative. The implications of each economic activity are discussed further in Section IV.4 below.

Economic and Employment Impacts

Economic impacts, as defined within this study, include ethanol plant construction, plant operation, displaced ethanol imports due to domestic production, and tax revenues. Plant construction effects include employment for the construction industry, equipment purchase, and material purchase. Employment impacts include plant operation and maintenance, biomass feedstock collection, ethanol transportation, and ethanol sales and marketing. Both employment and economic impacts are examined in this chapter.

Energy Impacts

The scenarios in this study are based on ethanol production technologies analyzed in the Energy Commission's 1999 report. This study focuses on plants that would operate on forest material, agricultural residue, and urban waste. Biomass-to-ethanol plants are assumed to be collocated with several biomass power facilities. Consequently, some ethanol plants would have electricity as a by-product, which would be redistributed to the power grid. Net electricity to the grid would be reduced if the biomass power facilities were to remain operational in the absence of ethanol production. This situation, which reflects high power prices in 2001, is the baseline scenario for this study. The energy impacts of collocated power plants are discussed in Chapter V.

Environmental Impacts

There are significant environmental implications of introducing a biomass-based ethanol industry. Several of the biomass feedstocks, such as orchard prunings and forest slash, are currently incinerated to simplify disposal or to provide forest fire protection. Since these feedstocks would be consumed by ethanol production facilities, airborne emissions would be decreased as open-field burning is avoided with the introduction of biomass-to-ethanol plants. The details of the environmental impacts are covered in Chapter VI.

IV.3 Economic Impact Assessment Methodology

The methodology used to evaluate the benefits and costs of an ethanol production industry consists of three main steps. First, the inputs required to develop the ethanol production industry were estimated. This entailed defining and measuring the capital and operating costs, which were then used in conjunction with an economic impact (Input-Output) model to estimate the total repercussions on the economy. Next, the associated impacts were forecasted over a specific time horizon.

Types of Economic Impacts

The economic impacts of the fuel ethanol industry are measured by the cumulative flow of spending that originates at the ethanol plant level and eventually works its way throughout the local, regional, and perhaps national economies. The investment in ethanol plants creates demand for goods and services at the plant, in supply industries that support the construction and operation of the plant and in the goods and services purchased with the earned income associated with the entire ethanol production supply chain.

Firms or individuals in a market economy are assumed to respond to price changes. Consequently, economic stimuli can generate a variety of impacts. Examples of these impacts include: shifts in supply due to increases in productivity; changes in demand due to price changes; output growth due to improvements in regional competitiveness; shifts in the composition of factor inputs due to changes in relative input prices; increased demand for factor inputs due to output growth; and increased consumer spending due to improvements in earnings.

Tools for Measuring Inputs

General equilibrium analysis is the preferred way of estimating all of the different types of effects. Computable General Equilibrium (CGE) models have been developed for this purpose and attempt to look at all adjustments simultaneously. Unfortunately, they are extremely complicated and usually prohibitively expensive. Furthermore, the impacts associated with an ethanol industry are very small compared to the State economy. Therefore, small changes in activity may not be accurately reflected by a CGE model.

Input-output (I-O) models are the other standard economic modeling tool used to estimate economic impacts. In contrast to CGE models, I-O models focus exclusively on the links between related sectors of the economy. The goods and services required to construct and operate this industry were estimated through engineering analysis. I-O models are static and thus do not allow for responses to price. However, I-O models are relatively easy to understand and use and are fairly inexpensive. For these reasons, an I-O model was selected to estimate the economic impacts of ethanol production.

Direct impacts for a California ethanol industry include capital and construction, plant operation, feedstock handling,[3] and fuel distribution. Negative impacts include lost economic activity from importing ethanol, changes in electric power production, and reductions in gasoline production and handling. It is assumed that labor and other resources are available to support this industry, or that they can be made available from outside the State. In an input-output framework, there are three types of economic impacts: direct impacts, indirect impacts, and induced impacts. Direct impacts generally refer to those impacts that occur first in the economy. These first-round effects are often associated with changes in employment in an industry or institution. (These impacts can be measured in different metrics: e.g., employment, output, income, value added, etc.) For example, assume that a significant rise in the price of forest products causes paper manufacturers to use relatively more recycled paper in their production process. Two direct impacts ensue: employment falls in the forest products industry, while it increases in the paper recycling industry.

Indirect and induced impacts occur after the direct impacts and are often referred to as "secondary impacts." Indirect impacts reflect changes in downstream support industries. Continuing the example, the forest products industry utilizes fuel for its trucks; employment in the petroleum products industry, therefore, would likely decline due to the reduced demand for forest products. The increased demand for recycled paper, on the other hand, would give rise to additional demand for chemicals used in the deinking process. As a result, employment in the chemical manufacturing industry would increase.

Induced impacts are the result of employees spending their disposable income. Changes in expenditure levels generate related employment changes in the manufacture and distribution of consumer products. For example, as shown above, total earnings in both the recycled paper industry and the chemical industry would increase as a result of the increased demand for recycled paper. Part of these increased earnings would be spent on clothing, which would generate employment in its manufacture and distribution.

IV.4 Total Economic Impacts

Direct, Indirect and Induced Impacts

In considering the macroeconomic, or economy-wide, implications of a direct impact, two secondary effects must be accounted for: indirect and induced impacts. For the sake of explanation, an ethanol production example will be used to describe these effects.

For the case of a distilling column manufacturer, a direct impact would be the sale of a given distilling column. However, a host of indirect impacts are also triggered by this sale. Any related industries that provide components to the distilling column maker are affected by indirect impacts. For instance, the steel and plastics industries are influenced by the sale of a distilling column.

[3] Feedstock handling includes harvesting, processing, collection, storage, and transport.

Induced impacts are similar to indirect impacts, but take place at a broader economic level. To continue the distilling column sales example, each related industry links to the economy in a myriad of ways. Induced impacts account for these economic connections. Spending by employees of column makers and the circulation of this money in the economy are examples of induced effects. Only when direct, indirect, and induced impacts are considered can a given activity be considered a macroeconomic positive or negative benefit.

Although impacts are often reported in different metrics: e.g., changes in employment, changes in total output, changes in value added, and changes in personal income, in the case of California ethanol production and sales, the macroeconomic metric to be measured is personal income. The main cost of the program will be the government outlays used to promote development of the industry. It is assumed that the opportunity cost on all government funds is taxpayer income. Therefore, all other costs and benefits were defined in a similar manner.

Figure IV-1 shows how ethanol plant construction results in economic output in California. The total capital investment is $660 million for a 200 million gallon per year industry. Alternative uses, the opportunity cost, of these funds determine the impact on the State. If the invested funds were not invested in the California ethanol industry, they would be invested in other opportunities throughout the country. If this were to occur, approximately 11 percent of the funds would be invested in some other California opportunity, based on recent investment averages. This investment that would occur in California even without the ethanol industry is subtracted from the total capital investment.[4] The 11 percent of investment ($73 million) that would have occurred is not counted as new, to avoid double counting these effects.

Table IV-1. Economic Impacts from Capital Investment

Item	Million $ (Y2000)
Capital Investment	660
Total California Output = Direct Impacts + Indirect Impacts + Induced Impacts	
Direct Impacts	517
Indirect Impacts	180
Induced Impacts	198
Total California Output	**895**
Personal Income	397[a]

[a] Personal Income (PI) = results of I/O model, see Appendix IV-A.

[4]The net capital investment is $587 million. The alternative investment that would have occurred in the State is not viewed as a cost.

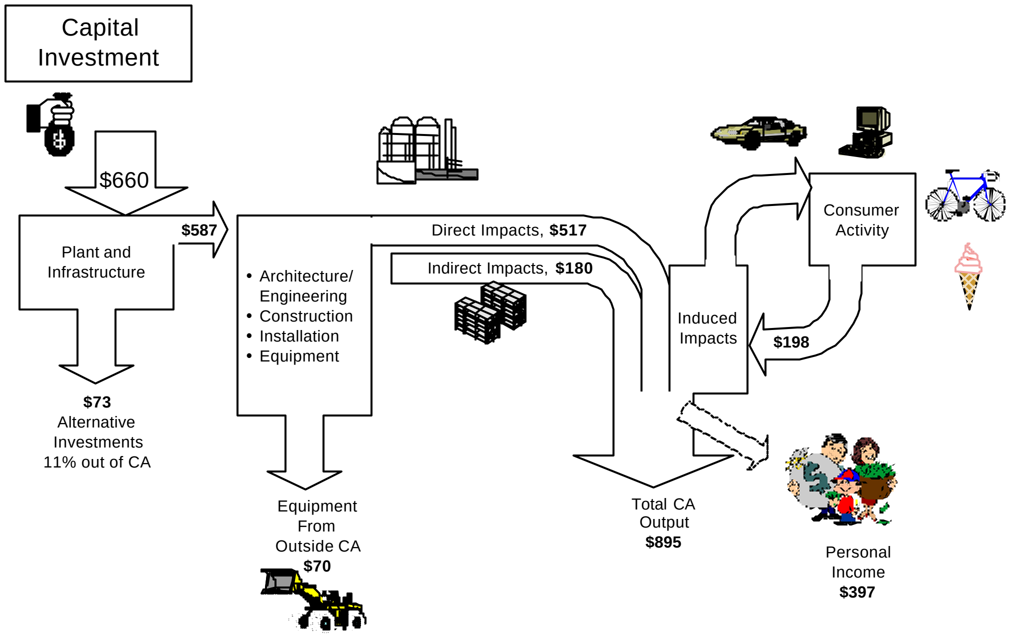


Figure IV-1. Economic Output and Personal Income from Capital Investment (Million $, Y2000)

The remaining $587 million provides architectural and engineering services, construction, installation, and equipment that would otherwise not have occurred. Of this investment, $70 million was estimated to occur outside the State. The remaining capital investment is analyzed in an input/output model which determines indirect economic impacts (such as economic activity in the steel industry), and induced impacts (consumer activity generated by employee spending) to determine the total economic output for capital investment ($895 million). The I-O model results also predict gross state product (GSP), employment, personal income, tax revenues, and value added. All of the construction and related activity results in positive economic impacts.

The key economic parameter addressed in this section is personal income. Data on employment levels in the counties that are candidates for ethanol plants was used to determine the growth in personal income. For construction and related activities, personal income is $397 million over a 20-year period.

Figure IV-2 illustrates the economic impacts of industry operations. The values in this figure represent personal income. The primary operating inputs are feedstock handling, plant operation, and fuel distribution, as well as materials such as water, acid, and enzymes. The California ethanol industry would result in a reduction in economic activity from the importation of ethanol from the Midwest. Economic activity from ship and railcar unloading are reduced and this effect is counted as a loss in personal income ($6 million) or an economic cost to the State. Fuel transportation activities to inland bulk terminals are counted as economic benefits.

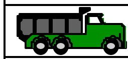
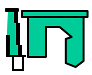
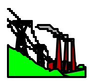
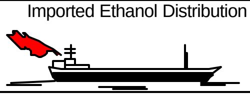
Category	Direct Impact		Total Impact	
	Output	Personal Income	Output	Personal Income
 Feedstock Handling	39	39	58	46
Processing Materials 	20	5	31	10
 Operation and Maintenance	0.6	0.4	1.1	0.6
Ethanol Marketing and Distribution 	3.5	1.1	7.4	2.5
Biomass and Natural Gas Power  	-1.6	-0.3	-2.1	-0.5
Imported Ethanol Distribution 	-0.4	-0.2	-0.8	-0.3

Figure IV-2. Economic Impacts from Ethanol Production, (million $ (Y2000)/yr)

California ethanol production would also change the dynamics of power production in the State. The total consumption of power in the State would increase as a result of the electricity used in the ethanol production process. On the supply side, the integration of biomass power plants and ethanol production facilities would lead to shifts in the amount of electricity supplied by different power sources. The economic output related to ethanol plant operation and bulk fuel distribution is an input to the IMPLAN model, which estimates indirect and induced impacts in a similar manner to the capital costs. Personal income related to ethanol plant operation is $822 million (Y2000 dollars) over a 20 year period.

The use of feedstocks such as forest thinnings and agricultural residue results in environmental benefits, which are not readily achieved through other means and warrant state participation to achieve these environmental benefits. Valuing the environmental benefits in terms of economic benefits is difficult since mitigating the impacts of forest damage and fire prevention cost also result in economic activity for the State. Therefore, valuations of the environmental benefits are treated separately.

The combined capital and operating cost elements of a California ethanol production industry result in impacts that are primarily economic benefits with few economic costs. However, many of the feedstocks considered for ethanol production may be too costly to achieve an economic cost of ethanol production in the near-term. The State could provide funding support, such as for forest thinning, for ethanol producer price payments, or for plant construction, in order to achieve the environmental benefits associated with ethanol production. These options for supporting an ethanol industry are discussed in Section IV.6. State outlays that support an ethanol industry result in the primary economic costs to the State. Alternatively the State could retire debt, reduce taxes, or use funds for other activities that result in economic benefits to the State. The impact of state outlays was treated as a reduced opportunity for tax reductions or income to taxpayers. This income to taxpayers would also result in indirect and induced impacts.

State outlays corresponding to a producer payment of $0.20/gal and a payment of 10 percent of the capital cost of the facilities was evaluated as a benchmark for state outlays. The expenditures for the producer payments were assumed to occur when ethanol was sold. Capital payments were assumed to be financed with the sale of bonds and paid off over 20 years.

The justification for state support would be in part the environmental benefits associated with feedstock removal; these economic benefits provide a substantial return to the State. The economic costs and benefits are illustrated in Figure IV-3 as personal income. As discussed previously, the primary economic cost to the State is due to outlays supporting the ethanol employment levels. While an ethanol production industry will create open positions for workers, that does not mean that jobs will be created at a state level. For instance, if an ethanol plant opened in an area with full employment, the plant would create a demand for labor that does not exist. In so doing, opening the plant would simply increase the cost of labor to all employers. This would be a negative impact on the region, as the price of goods and services offered to the consumer would have to increase to compensate for increased labor costs. This means that the specific location of any ethanol-related activities must be considered in determining the impact on Gross State Product (GSP). It is assumed that all production activities occur in regions with less than full employment, or that new non-California labor will migrate to the area to meet expanded regional labor needs. As many of the plants will be located in rural areas that traditionally suffer higher unemployment levels than urban areas, this is not considered a highly restrictive assumption.

In addition to labor, another issue that requires careful consideration is the collocation of ethanol plants with biomass power generation. Since lignin, a by-product of biomass-to-ethanol production, can be used as a power plant fuel, a hybrid ethanol/electricity plant can be installed. Consequently, an ethanol industry will produce not only transportation fuel, but also power that can be sold to electric utilities. The question remains: How does one evaluate this by-product? It is simultaneously a source of secondary revenue for ethanol producers and a positive value for the California economy since it provides electric power capacity, which is currently in high demand. Likewise, other higher value-added products such as extractives and other chemicals can also be produced as other source of revenue. However, impacts of these value added products were not quantified.

Figure IV-3 illustrates the total costs and benefits estimated in this analysis of a hypothetical California ethanol production industry. These costs and benefits are represented as personal income. The following discussion analyzes the effect on annual income and employment.

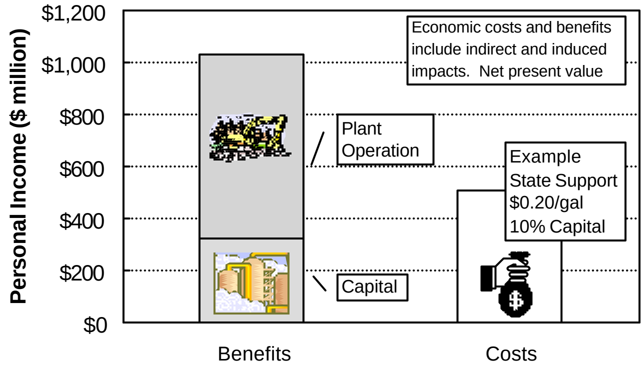


Figure IV-3. State Costs and Benefits Estimated for a Hypothetical California Ethanol Industry

Is this biomass power production a separate industry, given that several biomass power plants currently exist in the absence of ethanol production? If so, then careful consideration must be paid to ethanol plants that operate with or without a collocated biomass power facility. The potential impact on California power prices is discussed in Chapter V.

IV.5 What is the Impact of a California Ethanol Production Industry on Jobs?

New Jobs Due to an Ethanol Industry

A host of positions are created by a biomass-to-ethanol production industry. These positions stem not only from ethanol plants and biomass collection efforts, but also from the construction of the infrastructure and facilities that make ethanol production possible. Estimated positions directly related to ethanol production include 250 ethanol plant positions and 1,350 biomass collection and hauling jobs per 200 million gallons of annual production.

While these positions are created by an ethanol industry, the issue of statewide macroeconomic job creation is a separate issue requiring more analysis than simply counting the job openings in a given sector. For an economy with intertwined industries and labor markets, such as that found in California, creating positions in one sector will cause the economic equilibrium to shift as resources and employees adapt to new market conditions. These macroeconomic employment issues are discussed separately below.

Changes in Employment

In terms of determining a statewide employment benefit, several factors need to be considered: net wages, reduced welfare, and unemployment insurance. As previously mentioned, the regional and statewide employment levels influence the net benefit or cost of new job openings.

In the case of less then full employment, new job openings will result in lower unemployment rates, with minimal wage changes. For regions with full employment, new jobs may push the wage level up or new labor will migrate to the region to meet the demand. Wage changes will increase costs for all employers. This impact must be offset by the benefit realized from ethanol production.

Figure IV-4 illustrates the personal income on an annual basis for a California ethanol production industry. The economic benefits result from capital construction and ethanol production activities. These benefits include income from direct, indirect and induced impacts, as estimated by the I-O model. The negative economic impacts correspond to lost revenue from ethanol import terminal activities and state outlays. For this analysis, a state producer price payment of $0.20/gal for 20 years of plant life and a 10 percent state share of plant capital costs were evaluated. The impact of plant construction on employment is evident during the first 8 years. Once all of the facilities are operating, the impact of plant operation remains constant. A plant life of 20 years is assumed, so the positive impact of plant operation declines by 2028; however the facilities could continue to operate. The cost to the State is assumed to be a $20/gal producer payment, which is paid once ethanol production starts. The capital payments are spread over time, as they are assumed to be funded by bonds paid off over 20 years. Figure IV-5 shows the impact on employment in the State. The impacts correspond to the personal income in Figure IV-4.

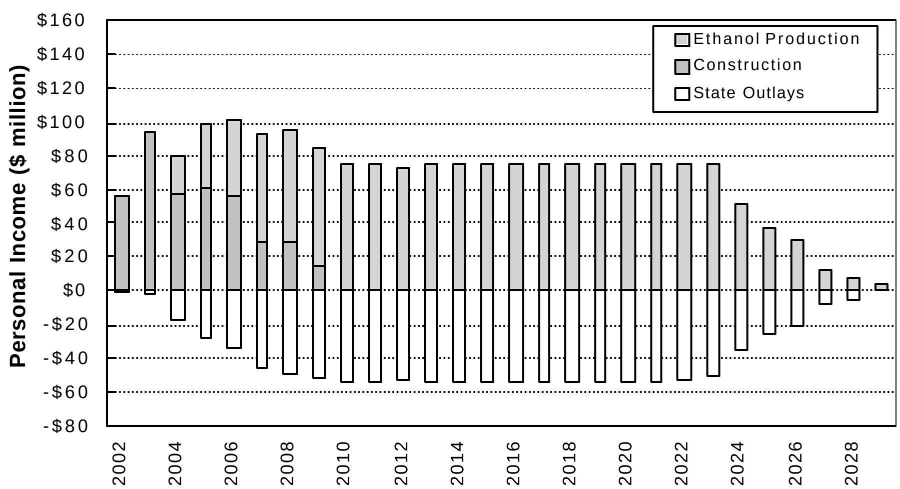


Figure IV-4. Annual Changes in Personal Income in California

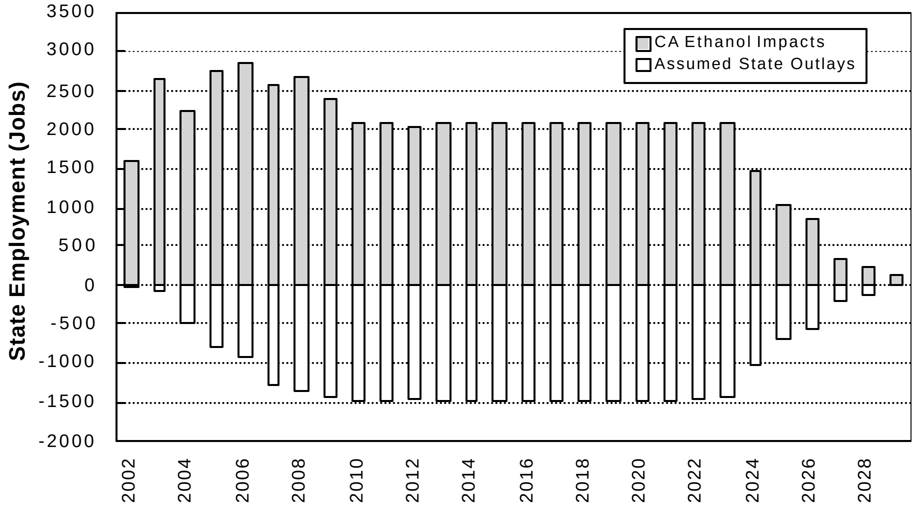


Figure IV-5. Annual Changes in Employment in California

IV.6 How Can Risk be Minimized for California Ethanol Producers?

The State could implement several measures to promote a California ethanol industry. The key factors that affect the viability of an ethanol industry are:

- High capital costs, especially in the near term as the technology emerges.
- Uncertain feedstock availability and potential high cost for feedstocks with environmental benefits.
- Sales prices that are potentially below the price for viable plant operation.

If the economic and environmental benefits of an ethanol industry warrant it, the State could provide incentives. Several incentive mechanisms are shown in Table IV-2, which include supporting capital purchases, higher ethanol prices, and lower feedstock costs.

Table IV-2. Some Possible Options for Supporting a California Ethanol Industry

Approach	Feature
Capital co-funding 10 to 50 percent	Traditional mechanism for government funding.
Loan Guarantees	Zero cost if facilities are successful.
Capital co-funding $0.5/annual gallon	Base funding on performance rather than cost.
Producer Incentive $0.10 to 0.40/gal	Results in payments only when ethanol is produced.
Feedstock incentive $10 to $30/ton or per gallon	Targets feedstocks with environmental consequences.
Ethanol Price support	Reduces cost to the State when fuel prices are high.

Capital Cost Support

State funding has often been used to support capital costs for emerging technologies. The most successful model for capital cost supports combine production requirements with plant co-funding. This approach is being used in Hawaii for sugar cane based ethanol production. Prior experience in Nebraska with loan guarantees resulted in projects that were oriented more towards building a facility than producing ethanol. Minnesota provided reduced interest loans for ethanol plant construction. A 10 percent of total capital cost was assumed in the analysis as a surrogate for part of the State cost, with the other portion being a producer payment. The adequacy, mechanism and levels of support of such payments require further evaluation.

Price Incentives for Ethanol Production

Incentives that support the price of ethanol have historically been used to foster the development of ethanol production infrastructure. The federal tax incentive results in $0.53/gal. Some states have additional tax incentives and credits. The Nebraska and Minnesota Programs have both been effective. The Minnesota incentives for ownership share increase constituency support for the program by insuring participation in profits after corn has been sold. Minnesota's producer incentive, limited to 10 years per facility, has been effective in expanding the State's ethanol production facilities.

Production incentives are an effective mechanism and are used in many states. They are a proven technique for getting ethanol produced and into the market and provide an effective incentive to initiate and expand capital investment.

Production incentives often take the form of exemption from state excise taxes, on the federal model. However, the Hawaii model, which provides for a tax credit against income that is refundable if income is insufficient to allow full use of the credit, is an alternative technique that may transfer money to a struggling new industry.

An alternative to price incentives are minimum price guarantees for specific amounts produced, contractually guaranteed over a period of time. The state would take or pay for ethanol produced by firms.

Feedstock Incentives

Incentives to an ethanol industry may have unintended consequences regarding the use of feedstocks. Some feedstocks that provide the most significant environmental benefits, such as forest thinnings and rice straw, may not prove to be the feedstocks of choice for an ethanol industry. In the event of high ethanol prices, producers may even compete for waste paper or wood chips that are currently utilized in other industries. Supporting feedstocks with environmental benefits would have the most direct impact on utilizing these feedstocks.

If a feedstock credit were made available for forest thinning or rice straw removal, these feedstocks would be available for alternative uses and might not be converted to ethanol. Ethanol production is favored by the $0.53/gal federal tax incentive. In the absence of this credit, power production may be a more economic alternative.

One way an ethanol production industry could impact the State's economy is through its potential effects on fuel and energy costs. The relationship between ethanol and fuel and electricity prices is described in the following chapter, which discusses how an ethanol industry could influence energy production and use.

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CHAPTER V

EFFECTS OF CALIFORNIA ETHANOL ON ENERGY USE

V. Effects of California Ethanol on Energy Use

This chapter discusses the energy impacts of a hypothetical California ethanol production industry. These impacts include benefits from an indigenous source of fuel, as well as impacts on electricity generation, fossil fuel use and petroleum use. Biomass-based ethanol would provide another source of transportation fuel for California. California ethanol production would compete with imported ethanol, so an ethanol industry in California would result in downward pressure on U.S. ethanol prices and to some extent gasoline prices. In addition to producing a source of transportation fuel, ethanol plants would consume electric power, however, ethanol plants collocated with biomass power plants would generate more than they consume. The potential impact of ethanol production on power generation is also analyzed. The costs and benefits of producing ethanol in the State were analyzed in the prior chapter, which takes into account the effect of the revenue generated from ethanol sales on the state's economy. The potential impacts of ethanol use on consumer fuel prices are also considered in this chapter.

V.1 Electric Power Production

Status of Biomass Power Plants

California's installed capacity for electricity generation from biomass plants reached over 9000 MW from 66 direct combustion facilities built in the 1980s and early 1990s. In 2000, there 29 operational plants with a total capacity of about 600 MW and another 16 idle plants. Table Table V-1 presents a list of the operational and idle biomass plants, plant electricity generation capacity, and biomass feedstock consumption.

The suitability of collocation of a biomass-ethanol production facility with a biomass power plant depends on a number of factors. Three key factors are elaborated below:

- Compatible feedstock. Power plants using mill wastes, forest residues/thinnings, agricultural residues, and urban wood wastes make good candidates for ethanol production.

- Feedstock availability. Collocation may result in competition for the same feedstock. Under the current climate of high electricity demand in the State, the use of biomass for power generation is economically attractive again.

- Proximity to major highways or railroad facilities is important for the continuous bulk movement of ethanol from the production facility.

The construction and operation of the ethanol plant would be subject to a number of local and state regulations. Operation of the biomass power plant is also regulated by a number of local, state and federal air, water and waste disposal permits. Lignin, a by-product of ethanol production, is a potential combustion fuel. The use of lignin as a fuel by the power plant may require a simple modification to existing permits. Plants that have been shut down and

Table V-1. Operational and Idle Biomass Power Plants – 2000

Project	County	Net MW	mBDT/y	Status	Startup	Shutdown
Western Power	Imperial	15.0	122	Idle	1990	1996
Colmac Energy	Riverside	47.0	330	Operating	1992	
Apex Orchard	Kem	5.5	48	Idle	1983	1988
Thermo Ecotek Delano	Tulare	48.0	375	Operating	1991	
Sierra Forest Products	Tulare	9.3	75	Idle	1986	1994
Dinuba Energy	Tulare	11.5	97	Idle	1988	1995
Auberry	Fresno	7.5	70	Idle	1986	1994
Soledad Energy	Monterey	13.5	98	Idle	1990	1994
Thermo Ecotek Mandota	Fresno	25.0	185	Operating	1990	
Rio Bravo Fresno	Fresno	25.0	180	Operating	1989	1994
SJVEP-Madera	Madera	25.0	182	Idle	1990	1995
SJVEP-El Nido	Merced	10.2	88	Idle	1989	1995
SJVEP-Chowchilla II	Madera	10.8	90	Idle	1990	1995
Redwood Food Packing	Stanislaus	4.5	36	Idle	1980	1985
Tracy Biomass	San Joaquin	19.5	150	Operating	1990	
Diamond Walnut	San Joaquin	4.5	35	Operating	1981	
California Cedar Products	San Joaquin	0.8	11	Idle	1984	1991
Jackson Valley, Ione	Amador	18.0	140	Idle	1988	
Fiberboard, Standard	Tuolumne	3.0	27	Idle	1983	1996
Chinese Station	Tuolumne	22.0	174	Operating	1987	
Thermo Ecotek Woodland	Yolo	25.0	200	Operating	1990	
Wheelabrator Martell	Amador	18.0	135	Operating	1987	
Rio Bravo Rocklin	Placer	25.0	180	Operating	1990	1994
Sierra Pacific Lincoln	Placer	8.0	70	Operating	1985	
Wadham Energy	Colusa	26.5	209	Operating	1989	
Georgia Pacific	Mendocino	15.0	119	Operating	1987	
Koppers	Butte	5.5	110	Idle	1984	1984
Ogden Pacific Oroville	Butte	18.0	142	Operating	1986	
Sierra Pacific Loyalton	Sierra	17.0	134	Operating	1990	
Sierra Pacific Quincy	Plumas	25.0	200	Operating	1987	
Collins Pine	Plumas	12.0	90	Operating	1988	
Sierra Pacific Susanville	Lassen	13.0	105	Operating	1985	
Ogden Westwood	Lassen	11.4	90	Operating	1985	
Honey Lake Power	Lassen	30.0	225	Operating	1989	
Big Valley Lumber	Lassen	7.5	59	Operating	1983	
Sierra Pacific Burney	Shasta	17.0	145	Operating	1987	
Odgen Burney	Shasta	10.0	77	Operating	1985	
Burney Forest Products	Shasta	31.0	245	Operating	1990	
Wheelabrator Shasta	Shasta	50.0	380	Operating	1988	
Wheelabrator Hudson	Shasta	6.0	66	Operating	1981	
Sierra Pacific Anderson	Shasta	4.0	60	Operating	1998	
LP Samoa	Humboldt	27.5	300	Idle	1985	1991
Blue Lake	Humboldt	10.0	79	Idle	1985	1999
Pacific Lumber 2	Humboldt	23.0	225	Operating	1988	
Fairhaven Power	Humboldt	17.3	140	Operating	1987	

are candidates for re-starting will require a new permit if the original permit has either expired or was surrendered.

Biomass power plants are subject to the vagaries of the demand for electricity. It used to be that forest material based power plants operated mainly in the spring and summer months when the demand for electricity increased and there was less moisture in the fuel. However, the increasing demand for electricity may make year around operation economically feasible. The desire for continuous availability of the power plant and a collocated ethanol plant may trigger a shortage of feedstock if not planned carefully. A desired outcome would be an expansion of economically viable harvesting of forest residues to meet feedstock needs.

The Amount of Electric Power Produced

The amount of electricity produced by biomass power plants can be affected by the presence of a biomass-to-ethanol industry. As first stated in Chapter III, it is assumed that the 200 million gallons of ethanol are produced by nine ethanol plants. Of these nine plants, four are assumed to be stand-alone urban waste -asedplants and are net consumers of electricity and five plants are collocated with biomass power plants that are capable of producing power (see Chapter III-2). Depending on the demand and economics of power and/or ethanol production, they can either be net producers of power, or net consumers. Table V-2 presents the existing power production rates for the five biomass plants and the likely effect of collocation of an ethanol plant on power production.

Table V-2. Electric Power Production and Usage

Plant ID [a]	1	3	4	7	8
Feedstock Source	Forest	Forest	Forest	Agriculture	Agriculture
Existing Operating Power Plant					
Feedstock Usage, 1000 BDT/yr	210	260	260	200	200
Power Generation[a], GWh/yr	210	260	260	200	200
Collocated Ethanol Plant					
Plant Capacity, million gal/yr	40	20	20	40	40
Feedstock Usage, 1000 BDT/yr	520	260	260	640	640
Lignin Production[b], 1000 tons/yr	160	80	80	190	190
Plant Power Consumption, GWh/yr	(50)	(20)	(20)	(50)	(50)
Potential Power from Lignin Combustion[c], GWh/yr	200	100	100	230	230
Collocated Net Power Available from Ethanol Plant[d], GWh/yr	150	80	80	180	180
Peak Production Capacity, MW	25	30	30	25	25

[a] Assumes average of 8,500 Btu/lb and 17,000 Btu/kWh
[b] Assumes 30 percent lignin by weight
[c] Assumes average of 10,500 Btu/lb and 17,000 Btu/kWh
[d] Lignin combustion power minus plant power consumption

Table V-2 raises a number of potential scenarios for the collocated operation of a biomass power plant with a biomass ethanol plant. In the absence of a collocated biomass-to-ethanol industry, the biomass power industry may not be sustainable over the long term. The cost of feedstocks is one major reason for the lack of viability.

Collocation synergies can be realized if the demands for power and ethanol do not peak at the same time and plant operation is flexible. For example, a certain amount of lignin could be stockpiled (when the demand for power is low) for use during peak demand periods for both ethanol and power. Biomass power facilities could also be modified to co-fire natural gas with biomass or lignin, which could help reduce emissions and improve combustion. On the whole, the ethanol biorefinery (see Figure III-7) can be operated to maintain a steady demand for biomass feedstock, thus mitigating the uncertainties in supply and demand of biomass for a stand-alone power plant.

As noted earlier, five collocated ethanol plants comprise the assumptions for this study (in addition to four stand-alone ethanol production facilities). Compared to the State's total electric generation capacity of 58,000 MW, these five power plants have a small generation capacity. About 11 percent of the State's power consumption is from renewable sources, with 34,000 GWh of production from biomass in 1999. Biomass production represented 16 percent of the renewable power or about 1 percent of the State's total power consumption. However, even relatively small amounts of generation capacity are important when power is in short supply.[5] Table V-3 presents two scenarios. The first scenario forms the basis for the analyses in this report. Five stand-alone power plants are assumed to be operating, producing 1,130 GWh/yr (data from Table V-2). With the collocation of five ethanol plants, and in the event of severe feedstock competition and lignin as the sole source of combustion fuel, the net power may decline to 600 GWh/yr. On the other hand, synergistic operation of the power plant and the ethanol plant may increase the net generation to 1,450 GWh/yr.

Table V-3. Energy-Related Assumptions

	Zero CA Ethanol		200 Million Gallons CA Ethanol	
Scenario	Power Plants	Power Production GWh/yr	Collocated Ethanol Plants	Net Power GWh/yr
1	5	1,130	5	600 – 1,450
2	1	200 - 260	5	600 – 1,450

[5] The difference between a Stage 1 and Stage 2 power alert is 3 percent or 900 MW.

In the second scenario, in the absence of an ethanol industry, only one of the same five power plants is assumed to be economically viable, generating between 200 and 260 GWh/yr (see Table V-2). However, in the presence of a biomass-based ethanol industry, all five power plants are assumed to operate, increasing generation to between 600 and 1,450 GWh/yr. This scenario represents the situation where the power plants would otherwise eventually be forced to shut down due to economic considerations in the absence of collocated ethanol facilities. Ethanol plants could also be sited with idle power plants. Whether the faclities are built at idle power plants or plants that would be shut down in the future doesn't affect the way that their future power output is represented for Scenario 2.

Figure V-1 illustrates the effect of an ethanol industry on power generation. The figure presents the range in assumptions for the fate of the biomass power industry in the Zero California Ethanol and California Ethanol cases. Biomass power plants would either be sustainable over the long term or competition from new natural gas fired generation would prevent them from being economically viable. Scenario 2 assumes that the biomass power industry would not be economically viable without ethanol production. Under these circumstances, annual power generation would increase with collocation of ethanol production facilities.

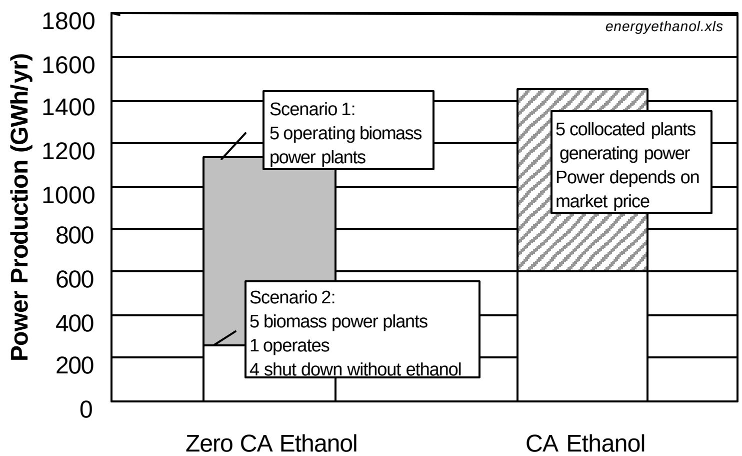

Figure V-1. Power Generation Under Two Potential Scenarios

Electric Power Prices

With the mix of facilities and feedstocks assumed in this study, an ethanol industry would provide a modest amount of electric power to the State. Ethanol plants and biomass power plants compete for some of the same feedstocks. Most of the biomass power plants were built in the 1980s when trends in power prices suggested that it would be favorable to obtain generation capacity from biomass at $0.10/kWh. Biomass power plants entered into contracts with utilities that guaranteed them $0.10/kWh for the first 10 years of operation, after which the price for power would be equivalent to the avoided cost from a utility's natural gas fired power plant. When natural gas prices dropped in the 1990s, the viability of biomass power generation came into question as these plants would need to compete with other plants that burn low-cost natural gas. Even in the year 2001, when biomass power plants are profitable with power prices over $0.20/kWh, the long term viability of such facilities is unclear as it hinges on the future price of electric power.

A key variable in the viability of ethanol plants is the federal tax incentive, which is available for ethanol production but not biomass power production. This incentive corresponds to about $40/ton of biomass feedstock.[6]

Additional generation capacity would provide power that would compete with existing producers to reduce the price of power. Elevated electricity prices might mean that biomass is worth more for power production than for ethanol production. A collocated power plant would have the flexibility of producing either ethanol or additional power during periods of high power prices. Biomass power plants are operated in a base load manner and do not generally vary their load to meet changes in power price. Collocated ethanol plants could be designed for flexible operation whereby steam used for ethanol processing could be diverted to power production if power prices were sufficiently high. The biomass boiler would operate at full capacity in either case. The load in steam power generation turbines can be varied more readily than the biomass boiler.

The impacts of biomass power plants on power production and natural gas imports depends upon case by case details for each ethanol production facility. Ethanol production that is added to an operating biomass power plant would reduce the amount of power that is produced for a fixed amount of feedstock, however, feedstock consumption can increase, especially if ethanol production receives support from the State. Facilities that are collocated with power plants that are not commercially viable on their own would result in an increase in power production over the long term. With high power prices, biomass facilities may choose to produce power and only produce ethanol in periods of low power demand.

Conversely, if gasoline prices were to increase, an ethanol industry may want to increase capacity. Increasing ethanol production capacity would come at the expense of biomass power production for a fixed amount of feedstock supply; however as indicated previously, peak power generation would likely not be reduced substantially. Biomass energy facilities have a regional influence over their feedstock prices. The high cost of transportation has a tendency to prevent biomass from being shipped too far.

Electric power shortages occur primarily during peak power demand periods. A collocated biomass power and ethanol plant could be operated in such a manner that its power production capacity at peak times is not reduced compared to a typical biomass power plant.

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[6] The federal tax incentive for ethanol amounts to $0.53/gallon. For an ethanol production yield of 78 gallons per ton, the tax exemption translates into $40/ton of feedstock. An additional $0.10 per gallon of ethanol produced tax incentive is available for small ethanol producers.

Natural Gas Imports

As discussed in Chapter III, ethanol production facilities with additional power generation capacity would compete with other power producers in the State.[7] If biomass power production is reduced, power from other sources, which are likely to burn natural gas on the margin, could be increased, with an increase in natural gas imports to the State.

Ethanol facilities that are located in urban areas would need to either import electric power or produce their own power through cogeneration with natural gas. Ethanol production has often been considered an ideal match for cogeneration. Operating a natural gas boiler or cogeneration facility would require more environmental review and permitting than an existing biomass power plant.

Ethanol plants located in urban areas that require natural gas as a source of process heat will result in increased electric power demand and natural gas imports. If these plants are located with cogeneration applications, they could enable the construction of additional power generation capacity.

V.2 Fossil Energy Use and Benefits

The energy inputs for ethanol fuel production processes are shown in Figure V-2. Processes for producing ethanol from the cellulosic feedstocks considered in this study are compared with ethanol production from corn and with gasoline production from petroleum. This figure illustrates the petroleum, natural gas, and coal energy inputs per unit of fuel product for the entire fuel production cycle. For example, the energy inputs for producing diesel fuel include crude oil extraction, transport, and refining. These fuel cycle energy impacts are analyzed in several studies (Wang, 1999; NREL, 1998), with the values in this study taken from work performed for the Energy Commission (Unnasch, 2000). While the results of these studies vary on a gram per mile basis, the energy use that correspond to the combustion of a gallon of gasoline or ethanol from corn are consistent. In the case of gasoline, about 140,000 Btu of total energy are required per gallon of gasoline which contains 113,000 Btu. Therefore the ratio of energy input to fuel output is 1.27 or 127 percent. In the case of ethanol production, the fossil energy input is less than that of the product fuel. When electricity is a by-product, more energy as electric power is produced than that contained in the ethanol and the net fossil energy input is negative.

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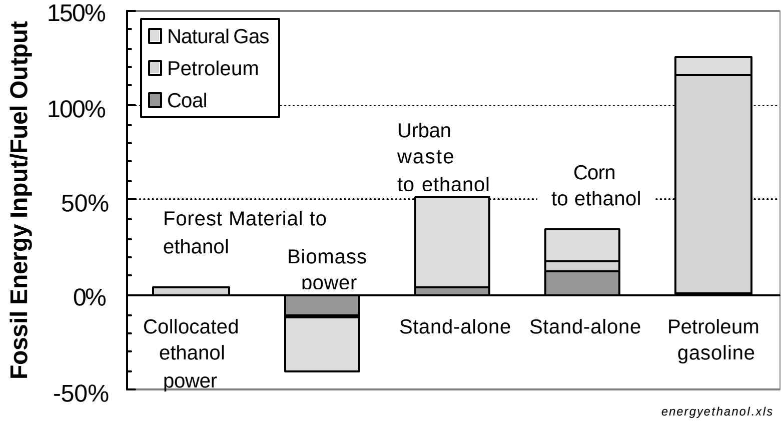
[7] During periods of power shortages, additional generation capacity may not displace imports but would simply enable more consumption.



Source: Unnasch (2000)

Figure V-2. Fossil Fuel Energy Inputs for Ethanol and Gasoline Production

Energy inputs are shown for ethanol produced from forest material, urban waste, and corn. In addition, the fossil fuel energy inputs for gasoline production are shown. These results are shown as a fraction of the total energy in ethanol or gasoline. Since ethanol would be used as a component in gasoline, these results are comparable. Ethanol production from the feedstocks considered in this study requires relatively little fossil fuel energy input.

The energy inputs for ethanol production from forest material include diesel for feedstock collection and transportation. In addition, power is generated from the ethanol facility, which displaces fossil fuel power from the grid (shown as a negative value). The impact of agriculture residue is similar. In the case of urban waste-based ethanol production, the residual material was assumed to be landfilled. Natural gas was assumed as a source for steam energy. Additional fossil fuels are required to generate electric power that the plant uses. If residual material from the ethanol production facility could be supplied to a biomass power facility, fossil fuel use would be reduced. The energy inputs shown for forest material and urban waste examples illustrate the range of energy inputs for ethanol production that can be expected from biomass feedstocks. Similarly, natural gas and coal provide energy for corn-based ethanol production. As food by-products are also produced from corn-to-ethanol facilities, some of the energy inputs are allocated to food by-products.

The energy contained in biomass is not shown in these comparisons for several reasons. The biomass energy is not a fossil fuel, and policy makers are more focused on the utilization and conservation of fossil fuels. Furthermore, the biomass energy considered here is a residue that would otherwise not be utilized except possibly for power production.

V.3 Petroleum Use

The global energy impact of California ethanol production depends upon the energy inputs for the fuel displaced by ethanol. Ethanol produced in California would either displace imported ethanol or California gasoline or petroleum-based octane enhancers (alkylates). For the California Ethanol case, the production in California would displace imports of ethanol.

The effect of new ethanol production depends on whether ethanol supplies are constrained or abundant. It is likely that ethanol will be in short supply in the near term and it will also be required as an oxygenate. Under these circumstances, ethanol produced in California would displace imported ethanol. As ethanol might also be in short supply outside of California, Midwest ethanol would be sold elsewhere.

Figure V-3 shows the potential consequences of producing 200 million gallons of ethanol in California. When no ethanol is produced in California, the 200 million gallons would be imported from the Midwest as shown by the arrow in Figure V-3. However, if the ethanol is produced in California, then the Midwest ethanol would have to be sold elsewhere. In the likelihood of a nationwide ethanol demand, the ethanol from the Midwest would find nearby local markets. The 200 million gallons of ethanol is an equivalent of 148 million gallons of gasoline. Therefore, 148 million gallons of gasoline that was being imported from Texas would no longer be needed. This would result in a loss of revenue for the Texas gasoline producers or necessitate finding new markets. In summary, the California production becomes California consumption, which displaces Midwest production, and ultimately results in lost revenue from gasoline production. This scenario reflects a situation where the supply of ethanol is limited.

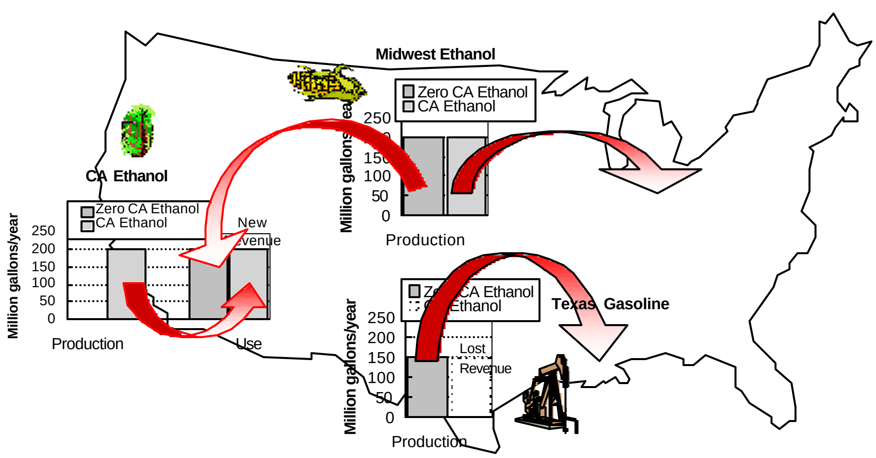


Figure V-3. Changes in Energy Production with California Ethanol (with ethanol in short supply)

In the event of an abundant ethanol supply, any ethanol that is produced in California would result in the reduction in the Midwest ethanol production. In the long term, factors such as gasoline prices, ethanol production costs, refinery oxygenate and octane requirements, as well as transportation costs will determine the market share of these fuels.

The energy inputs for corn-based ethanol production and gasoline production are evaluated. The energy impacts of ethanol production depend upon a variety of factors that are illustrated for each of the feedstock categories discussed below. In general, for all of the ethanol production options from waste feedstocks the energy contained in the ethanol product is far greater than the fossil fuel energy inputs.

Energy Inputs for Ethanol Production from Corn

Imported ethanol is produced from corn with energy inputs illustrated in Table V-4. Producing ethanol from corn requires energy for the production of fertilizers and processing into ethanol. These energy inputs are provided by natural gas and coal. Corn to ethanol plants produce by-products including corn oil and animal feed products. When evaluating the energy inputs for ethanol production, a fraction of the energy inputs (about 39 percent) for producing corn and processing ethanol are typically allocated to the by-products. In addition to the energy required for ethanol production, the fuel must be transported to California either by rail car or tanker ship.

Table V-4. Energy Inputs for Ethanol Production from Corn

Process	Primary Energy	Energy Input (Btu/gal)
Fertilizer	Natural Gas	4300
Farm equipment	Diesel	2100
Ethanol plant	Coal/Natural Gas	37,000
Feedstock Transport	Diesel	1300
Total Fossil Energy	—	44,700
Allocation to Co-products	—	17,400
Transport to California	Diesel	2900
Net Fossil Energy	—	30,200

Source: Unnasch (2000)

Energy Inputs for Ethanol Production from Biomass

Producing ethanol from biomass in California involves various energy inputs depending upon the feedstock and production technology. Biomass-based ethanol production falls into several categories depending upon the type of fossil fuel energy inputs. Forest material and agricultural residue generally provide residual lignin or cellulose residue to generate sufficient steam for ethanol production. Urban paper residue or other municipal waste materials are unlikely to be burned, and ethanol production facilities using these feedstocks would require natural gas for processing energy.

Forest Material and Woody Biomass Residue

For forest material and other woody biomass residues, the primary fossil fuel input is diesel fuel for collecting and hauling the feedstock as shown in Table V-5. Residual lignin and cellulose are burned to produce steam for the ethanol production process. Additional energy from the combustion of lignin is used to produce electric power. The energy inputs for the collection of agricultural residue are similar to those for forest material.

Table V-5. Energy Inputs for Ethanol Production from Forest Material

Process	Primary Energy	Energy Input (Btu/gal)
Feedstock handling	Diesel	3800
Power (Gas and Coal)	Natural Gas/Coal	-30882 (-3.2 kWh)
Transportation	Diesel	170
Net Fossil Energy	—	-26912

Ethanol produced from forest material requires relatively little fossil fuel input. Since forest residue would be collected for fire control, the only energy input is diesel fuel required for collection and transport to ethanol production facilities. Excess cellulose and lignin provide the energy for ethanol production, so almost no fossil fuels are used in this type of ethanol plant.

Rice Straw

Combustion of rice straw or lignin from rice straw has proven challenging in the past because it contains high levels of silica that, left untreated, prevent it from being used in a boiler. Experience with biomass power plants has indicated that silica particles in the combustion products are too abrasive to boiler tubes. However, several ethanol plant developers have demonstrated processes for removing silica from rice straw and producing a lignin product that would be suitable for power plant fuel. By treating rice straw residue to remove silica, a new source of biomass fuel is produced that would otherwise not be available for power production.

Urban Waste

In urban areas, waste paper, alternative daily cover, and other urban wastes would be the feedstock for an ethanol plant (see Chapter III.5). It is unlikely that a new facility in an urban area would be permitted for burning solid fuels. In addition, waste paper residue would contain some plastic that would be unacceptable to burn in ethanol plants located in urban areas. Consequently, ethanol produced from urban waste would require natural gas to produce process steam and would use electric power from the grid as shown in Table V-6. Cogeneration of electric power could also be an option if the waste heat from the cogeneration matched the requirements for ethanol production. Diesel fuel inputs for urban waste facilities would be minimal, as waste materials would already be hauled to MRFs or transfer stations. Since ethanol production would reduce the amount of material that is added to a landfill, diesel fuel consumption would also be reduced.

Table V-6. Energy Inputs for Ethanol Production from Urban Waste

Process	Primary Energy	Energy Input (Btu/gal)
Electric Power	Coal/Natural Gas	13360 (1.4 kWh)
Process Heat	Natural Gas	38000
Total Fossil Energy	—	41600
Allocated to Disposal	—	5000
Transportation	Diesel	170
Net Fossil Energy	—	36770

V.4 Effect on Consumer Fuel Prices

How Would a California Ethanol Industry Affect Consumer Fuel Costs?

The cost of producing gasoline in California is driven by the cost of crude oil, refinery capacity, and constraints on meeting California fuel specifications. Gasoline prices fluctuate with fuel demand and available gasoline supplies. Ethanol, when used as a blending component for gasoline, increases refinery product volume, increases octane and provides a source of oxygen to meet regulatory requirements.

California ethanol could benefit consumers by providing an additional source of fuel. This ethanol would compete with ethanol that is imported from the Midwest and thus put downward pressure on prices of ethanol delivered to California. However, in the event of a shortage of gasoline or ethanol an additional imported supply would help temper any price spikes. As the quantity of California ethanol may represent a significant fraction of the State's total ethanol consumption in the long-term, it could contribute to a reduction in gasoline prices.

To the extent that ethanol is required to meet oxygenate requirements in the future, a shortage of ethanol would have a significant impact on the price of gasoline since ethanol is the only alternate oxygenate to MTBE currently approved for use in California gasoline.

How Would Imported Ethanol Impact Consumer Fuel Costs?

Imports from the Midwest will be the principal source of ethanol for California in the near term. As it appears that over 70 percent of gasoline will need to meet oxygenate requirements with ethanol, the price of ethanol will affect gasoline prices for consumers. The price of ethanol depends upon the demand for ethanol, capacity for ethanol production, and ethanol production costs.

Three markets for ethanol comprise much of the U.S. demand. Ethanol used in the chemical industry is primarily obtained from petroleum sources as this use for ethanol does not benefit from the federal tax credit. Ethanol is a substitute product in the Midwestern gasohol market. Ethanol can be blended up to 10 percent and the fuel is valued as a gasoline replacement. Consequently, the price of ethanol follows the price of gasoline. Ethanol is also used as an octane enhancer and to comply with oxygenated fuel requirements. In this market, ethanol is a complementary product. The price of ethanol is affected by supply and demand considerations which relate to total gasoline sales, uses in other markets, as well as gasohol use.

It ethanol were to be blended into gasoline at 5.7 volume percent, a $0.50 increase in the price of ethanol would result in a $0.03 increase in the cost of gasoline. Consumer fuel prices would be at least $0.03/gal higher; however, actual gasoline prices might rise more. Historical gasoline prices have reflected shortages in supply. The extent of gasoline price rises due to shortages depends upon market expectations. In instances of unplanned outages such as refinery fires, gasoline price increases have been relatively short lived as the expectation was that the refineries would be repaired (Monitor 1999). The effect of an ethanol shortage on gasoline prices depends on the outlook for future ethanol capacity and oxygenate requirements throughout the United States.

California production capacity could help mitigate the effect of an ethanol shortage on gasoline prices. The effect of ethanol prices on gasoline will be determined well before significant ethanol production capacity can be built in California. With the phaseout of MTBE by the end of 2002, ethanol will be blended into gasoline before production capacity could come on line in California.

The level of demand, the cost of production and transport, the availability of substitute products, and other market forces will determine the price of fuel ethanol to petroleum refiners/blenders. When there is an oxygenate mandate in place and ethanol is the available solution, the price of ethanol will be linked to the demand for gasoline. Without the oxygenate mandate the ethanol price is determined by the marginal cost of ethanol production and the level of demand. With the mandate in place, demand for ethanol will exceed current supply resulting in higher margins to producers and higher market prices. The available supply in the short run would be from traditional midwestern suppliers. Expectations for continued strong demand would lead to an expansion in supply and a reduction in price toward the marginal cost of production and transport. By meeting the regulatory oxygenate requirements, ethanol demand will become a derived demand stemming from the demand for gasoline. As such, if the demand for gasoline falls, the need for ethanol will be reduced, leading to a reduction in the price of ethanol.

If Ethanol Were Required in Gasoline, What Would Happen in the Interim Period Before Plants are Built in California?

California ethanol capacity will take several years to come on line even if California commits significant resources to an ethanol industry. As discussed in Chapter III scenarios, an aggressive projection would be 200 million gallons by 2006 (See Figure III-3). In the interim period, ethanol prices would be higher if it were required as a gasoline blending component throughout the United States.

The price of ethanol delivered to California is estimated by the cost supply curves in Figure V-4 (ESAI, 1999). The price of ethanol delivered to California may resemble the solid line in the near term if MTBE were eliminated from gasoline throughout the U.S. In this case, refiners shift their oxygenate demand to ethanol and demand reaches the limits of the current domestic ethanol capacity. The supply constraints lead to higher prices as Midwest producers increase capacity utilization and margins.

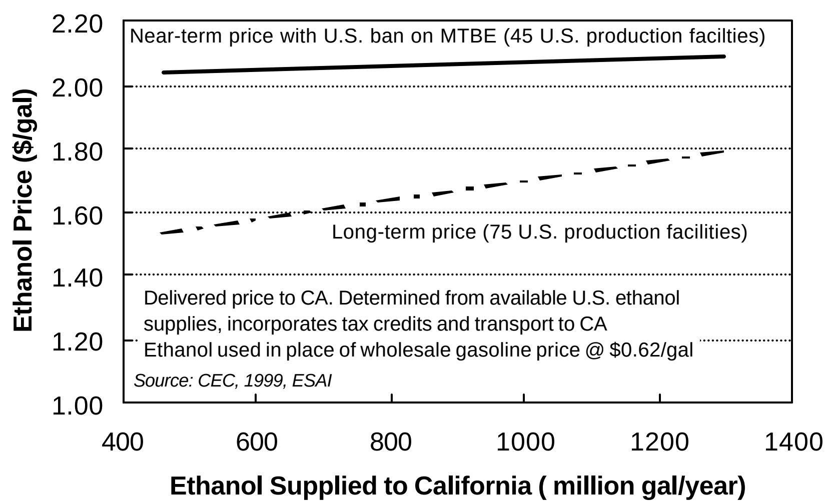


Figure V-4. Supply and Price Relationship of Ethanol delivered to California under a National MTBE Ban

For the purpose of this study, a $0.15/gallon price premium was evaluated as a benchmark price reduction for competition from California ethanol. This value is equal to the transportation cost of ethanol from the Midwest.

Over the next few years, additional ethanol production capacity is expected to be built in the U.S. The new capacity will meet demand at prices approaching marginal cost in the long run. This later circumstance is depicted in Figure V-4 as the dashed line representing the long run supply curve for ethanol with the new domestic capacity in place.

The values in Figure V-4 represent a cost supply curve developed for estimated near-term and long-term production capacity. The long-term case represents all of the ethanol production facilities that would be available in the U.S. with 1 billion gallons of additional capacity. The price represents the delivered cost to California including an estimated $0.15 transportation cost from the Midwest (ESAI, 1999). The curve increases with additional sources of supply as these are more costly. In some instances, ethanol is sold in states where it is subsidized, if used in that state. If this ethanol were used in Calfornia, the cost of the subsidy would need to be included in the price in order to bid the ethanol away from those states.

In the near-term, capacity was estimated to be limited and the price of ethanol would be higher under a demand scenario corresponding to a U.S. ban on MTBE. Ethanol prices around $2.10 per gallon would attract imports from Brazil, even though this fuel is subject to a $0.54/gallon import tariff. However, that potential availability of near-term supply from Brazil may not limit price spikes in the event of unforseen shortages.

For the purposes of this study, producing ethanol in California was assumed to reduce wholesale prices by $0.10/gal due to competition with Midwest suppliers. A change in supply of 200 million gallons per year in the long-term cost supply curve in Figure V-4 results in a $0.10/gallon price change. The actual effect of California ethanol production would depend on the cost of production and other factors such as state support.

As discussed in Chapter III, the demand generated by oxygenate requirements in California could be well over 600 million gallons per year. Additional California capacity could help reduce demand induced price increases.

How Does the Price of Gasoline Affect the Ethanol Industry?

Ethanol prices are influenced by several key factors, tax incentives, demand for ethanol to meet refinery octane and oxygenate requirements, as well as gasoline prices. As MTBE is removed from gasoline, ethanol is expected to be a blending component. Several California refineries are proceeding with modifications to blend ethanol with gasoline.

Once refineries are using ethanol, the price of ethanol is generally related to the price of gasoline. Depending upon market conditions, there may be a premium for oxygenate and octane requirements or a discount if refineries do not need ethanol to meet their blending requirements. This price relationship was analyzed by ESAI for the California Energy Commission (CEC, 1999).

The relationship between fuel ethanol prices and wholesale gasoline prices is shown in Figure V-5. The price of ethanol shipped to California depends upon its alternative use as a gasoline blending component in the Midwest. As gasoline prices rise, the price that must be paid for ethanol also rises if refineries are able to use ethanol. The “bid away” prices correspond to the price that would be needed to purchase ethanol from the Midwest and ship the fuel to California. The high and low range correspond to the extent of California demand and reflect long term production capacity. High demand with near term capacity would result in higher prices shown in Figure V-5. In instances where refineries are not blending with ethanol, a surplus of ethanol would exist and prices would be lower than those indicated in the Figure V-5. As recently as one year ago, ethanol prices have been below the shaded area in Figure V-5 with prices around $1.00/gallon. Ethanol has been in a surplus situation where refiners have had other options for meeting oxygenate requirements (MTBE). The gasohol market alone was not sufficient to support the price of ethanol.

In the near-term, the price of ethanol is expected to be much higher if MTBE is banned in the U.S. and ethanol becomes the substitute oxygenate. Under these circumstances, demand for ethanol could result in volumes approaching U.S. capacity thus placing upward pressure on prices.

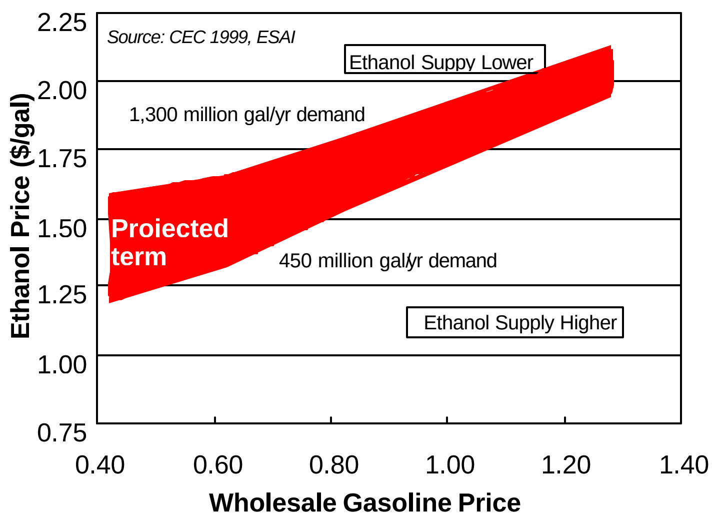


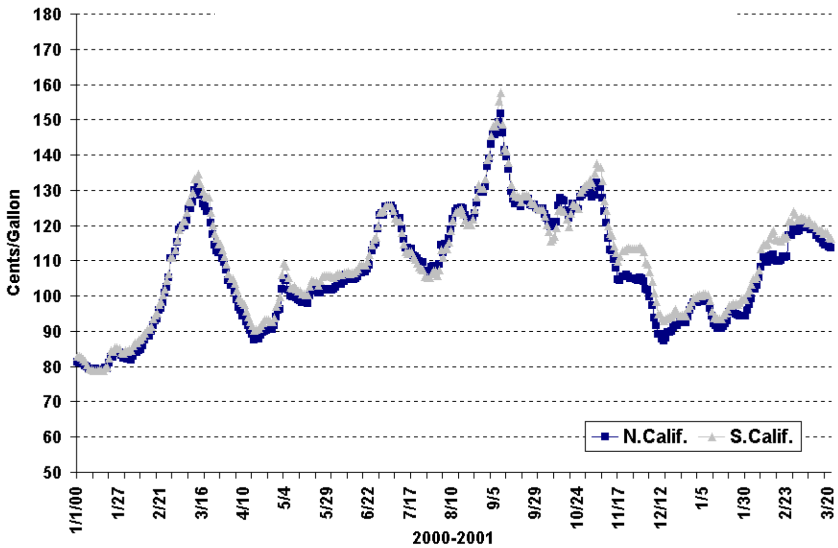
Figure V-5. Projected Long-Term Ethanol and Gasoline Price Correlation

The viability of ethanol plants is driven by the sales price of ethanol. Depending upon the cost of feedstock, plant size, production technology and other cost factors (CEC, 1999), cellulosic-based ethanol plants can operate economically with ethanol prices ranging from $1.30 to $1.70 in the near term and possibly below $1/gal for longer term plants that operate more efficiently.

The price of gasoline tracks the price of oil and is also affected by refinery capacity and gasoline demand. The importance of refinery capacity and gasoline distribution is reflected in the history of gasoline prices. Gasoline prices went up with refinery fires in California and pipeline disruptions in the Midwest.

The recent history of gasoline prices is shown in Figure V-6. As indicated, the wholesale price of gasoline has ranged from $0.80 to $1.60/gal with recent prices being above $0.80/gal. At this gasoline price, the price required to import ethanol from the Midwest would be over $1.65/gal with an ethanol demand of 450 million gallons per year in the State. The price of imported ethanol would reflect the price that could be achieved for California ethanol. If wholesale gasoline prices were to drop, the potential selling price of ethanol would also be reduced.

In conclusion, a California ethanol industry would be more viable if gasoline prices remain high or if the price of ethanol can be assured though contracts with refineries or other mechanisms.



Source: Oil Price Information

Figure V-6. Wholesale Gasoline Prices

Would Ethanol FFVs Affect the Supply and Price of Ethanol?

A significant number of flexible fueled vehicles (FFVs) that can run on any mixture of ethanol and gasoline operate in California today. At this time, the number is estimated to be about 65,000 and growing to over 100,000 in 2001.

Ethanol in the form of E-85 (85% ethanol and 15% gasoline) for use in FFVs currently has a lower market value when compared to ethanol's value as a gasoline blending component. The existing fuel tax structure favors blending ethanol in gasoline where it receive a tax exemption valued at $0.53 per gallon of ethanol. When used as an FFV fuel E-85 would receives a tax credit estimated to be worth about $0.35 per gallon of ethanol to producers.

FFV's could provide an important market for ethanol. The curent federal tax incentives are scheduled to expire in 2007. If the tax credit expires, ethanol will be much less attractive in the gasohol market as a substitute product for gasoline. However, requirements for oxygenates may still provide a substantial market for ethanol. As the outlook for continuation of the federal tax incentive is uncertain, an FFV market may be an important potential demand for a California ethanol industry.

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CHAPTER VI

EFFECTS OF CALIFORNIA ETHANOL PRODUCTION ON THE ENVIRONMENT

VI. Effects of California Ethanol Production on the Environment

A biomass-based ethanol industry in California has both positive and negative effects on the environment. Many of the effects are related to the removal of biomass from California forests. They vary from reduced forest fire risk due to pre-fire management thinning to possible habitat alteration. Effects may also be felt due to reduced open burning and more landfill diversion. This chapter discusses these and other effects on air quality, forest health, and water resources.

In the interest of understanding the costs and benefits of environmental effects, it is worth explaining that some effects can be valued according to their “use-value” and others require alternative valuation. For example, one “use-value” of slash removal would be the avoided costs of conducting prescribed burns. Control of invasive plant species or incremental additions of carbon to the forest floor, on the other hand, are “non-use” values that are difficult to monetize. Although methods exist for valuation of these “non-use” services, they require a level of analysis beyond the scope of this study. Previous cost and benefit analyses of environmental effects have also avoided monetization of “non use” services unless the specific purpose of the study was to do so (Burtraw, 1998). As a result, this chapter discusses both types of environmental effects, but does not attempt to monetize all environmental impacts.

VI.1 Emission Impacts of Ethanol Plant Operation

There will be positive and negative emission impacts due to ethanol production in California, although the net effect is positive. Forest wildfire, prescribed burning, and open burning of orchard material are all reduced by diversion of biomass to ethanol production. This results in a decrease in emissions of nitrogen oxides (NO_x), particulates (PM_{10}, from here referred to as PM), hydrocarbons (HC), and carbon monoxide (CO). On the other hand, there is new combustion of by-product lignin, transportation of some feedstocks to plants, and ethanol transportation to terminals. These activities add to statewide emissions of NO_x, PM, HC, CO, and fossil fuel CO_2. Due to the magnitudes of emissions from these various sources, the result is a net decrease in emissions for NO_x, PM, HC, CO, and fossil fuel CO_2. The extent of the impacts and their costs to California and beyond are discussed below.

Emission Sources under Zero California Ethanol Production Scenario

The case in which no ethanol is produced in California includes emissions from several types of sources. It is very important to note that the analysis only covers emissions that would be affected by the establishment of an ethanol production industry. For example, biomass power plants that operate under both scenarios are not considered. Table VI-1 shows emission sources when no California ethanol is produced. Table VI-2 shows how those emission sources change when California produces ethanol.

In Scenario 1, the five power plants converted to collocated ethanol plants would have been burning biomass anyway.

Table VI-1. Emission Assumptions for Zero California Ethanol

Emissions Source	Explanation
Biomass Combustion	In Scenario 1, five biomass power plants are operating which would be converted to collocated ethanol plants.
Prescribed Burn	0.01-0.02% of California forest undergoes prescribed burns in order to improve forest health, reduce the risk of wildfire, and provide firebreaks and fire fighting zones (CDF, 2000).
Wildfire	Approximately 0.5 percent of California forests burn due to wildfires each year (CDF, 2000). For this study, only areas at risk for wildfire and resulting emissions are areas that would undergo pre-fire management by reducing fuel loading for ethanol production.
Open Burn	Orchard prunings are burned.
Transportation	Emissions in California due to transport of ethanol from other states by rail and marine vessel; also emissions from feedstock transport for biomass power plants operating.
Total CO_2	Ethanol imported to California from other states causes CO_2 emissions (see Chapter V.3, Petroleum Use).

Table VI-2. Emission Assumptions for California Ethanol Production

Emissions Source	Explanation
Biomass by-product combustion	Forest material and agricultural residues produce lignin, which can be burned in a power plant.
Prescribed Burn	Prefire management by fuel loading removal replaces prescribed burns.
Wildfire	Wildfire emissions reduced significantly: reductions range from 3.5 lbs NO_x/bone dry ton biomass removed to 430 lbs CO/bone dry ton removed (ARB, 2000; see Appendix VI-C).
Open Burn	Agricultural residue diverted from open burning to ethanol feedstock.
Transportation	Feedstock transport by truck; ethanol transported by combination of truck and railroad (see Chapter III.4 for discussion of railroad infrastructure).
Total CO_2	Ethanol production in California produces CO_2; ethanol produced from corn becomes available for use in other states causing a reduction in gasoline-related fuel production emissions when those other states displace gasoline with ethanol (see Chapter V.3)

Emissions by Feedstock Source

The methods to obtain feedstock for ethanol and the various uses for by-products discussed in Chapter III.5 result in emission impacts. Since forest material, agricultural residues, and urban waste have different processes causing emissions, they are each discussed below.

<u>Forest Material</u>

Thinning and removing slash from dense forests will reduce prescribed burns and the severity of wildfires, thereby vastly reducing emissions of CO and PM. By thinning small areas or removing slash each year, those areas plus adjacent ones face a reduced risk of wildfire over several years. The time periods range from less than one year to 20 years or more, depending on the vegetation type. Although the emissions do not occur in highly populated areas, their transport does affect the forest ecosystem, nearby communities, and large populations further away.

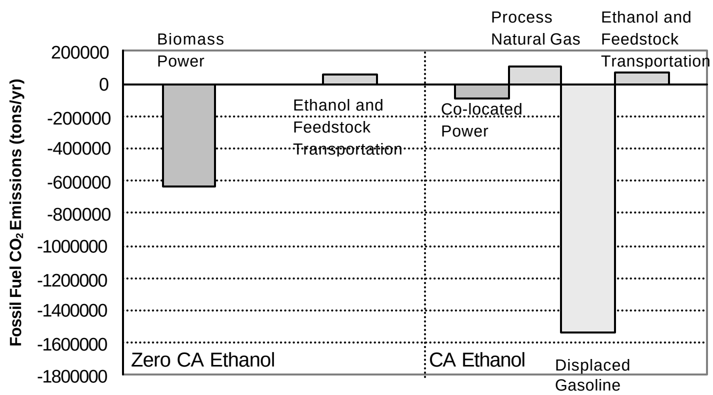
The level of emission reduction that can be expected from avoidance or less severe wildfires occurring in the areas that are treated is based on the California Air Resources Board (ARB) emission factors. These ARB factors enable analysis of the avoided wildfire emissions per ton of biomass removed. Unfortunately, little is known about the emissions from fires specifically in thinned areas (Forrest). As a result, this study relied on the average values reported by the ARB. As indicated in Figures VI-2 through VI-5, the emissions avoided by removing forest material are shown as emissions incurred in absence of treatment. In other words, the wildfire emissions are not zero in the California Ethanol production case, but are shown as avoided emissions in the Zero California Ethanol production case.

Despite emission reductions, there is a shift from one pollutant to another when the biomass is processed for ethanol rather than open burned. For example, reducing PM and HC emissions caused by biomass combustion in wildfires increases NO_x emissions. This is due to by-product lignin combustion in ethanol collocated power plant boilers, which produces more NO_x than a wildfire. See Appendix VI-B for forest material emission factors used in this study. Note that the emission factors suggest higher NO_x for open burns than for combustion in a boiler. The application of these factors should be further evaluated.

Although NO_x emissions from greater quantities of biomass increase due to the combustion of lignin in a boiler, there are also expected NO_x emission reductions. These are due to biomass power plant conversion to ethanol production. In the California Ethanol production case (Scenario 1) five operating biomass power plants will convert to ethanol production. Since the amount of feedstock required from forest materials in the base case is one million BDT/yr, this study assumes that one of the biomass power plants converts to an ethanol plant that uses much greater quantities of forest material than it did previously. Other ethanol plants using forest material are expected to use comparable amounts of biomass. Since the plants use the feedstock for ethanol rather than combustion for electricity, NO_x emissions are reduced.

Because some ethanol production will require new removal and hauling of biomass and all ethanol facilities will require transport of the product, the transportation emissions are greater in the California Ethanol production case than in the Zero Ethanol case, as seen in Figure VI-2 for NO_x. Transportation emissions and emission factors are discussed in detail later in this section.

Ethanol production from forest material and agricultural residue will increase emissions of fossil fuel CO_2. This is because diversion of biomass from power production to ethanol will result in increased fossil fuel electricity production elsewhere. The exception is if non-fossil fuels are used for electricity production. In addition, the ethanol production process from urban waste requires natural gas, which produces fossil fuel CO_2 emissions, as seen in Figure VI-1.



Note: Positive numbers indicate production of fossil fuel CO_2 while negative numbers indicate fossil fuel CO_2 emissions avoided

Figure VI-1. Fossil Fuel CO_2 Emissions in Zero CA and CA Ethanol Production Cases

If Scenario 2 is considered, in which only one forest material power plant converts to ethanol production, the fossil fuel CO_2 is reduced due to natural gas power being displaced by electricity from lignin combustion. This report, however, has focused on the likelihood that biomass power plants will be operating prior to ethanol production.

In either scenario, ethanol displaces CO_2 emissions related to gasoline and its fuel production cycle. As discussed in Chapter V.3, this is due to increased ethanol sales in other states, which displaces gasoline use. These avoided fossil fuel emissions are much greater than the CO_2 related to California Ethanol production, as seen in Figure VI-1. The CO_2 released from forest or other biomass combustion or ethanol is not shown because it is a short term storage in the atmosphere and because policy makers are generally more focused on the CO_2 production from fossil fuels.

Agricultural Residues

Diverting biomass for ethanol will reduce open burning of orchard prunings. The use of prunings for ethanol production feedstock will directly reduce this open combustion, which produces high emissions of CO, as seen in Figures VI-2 through VI-5 (see Appendix VI-B for agricultural residue emission factors).

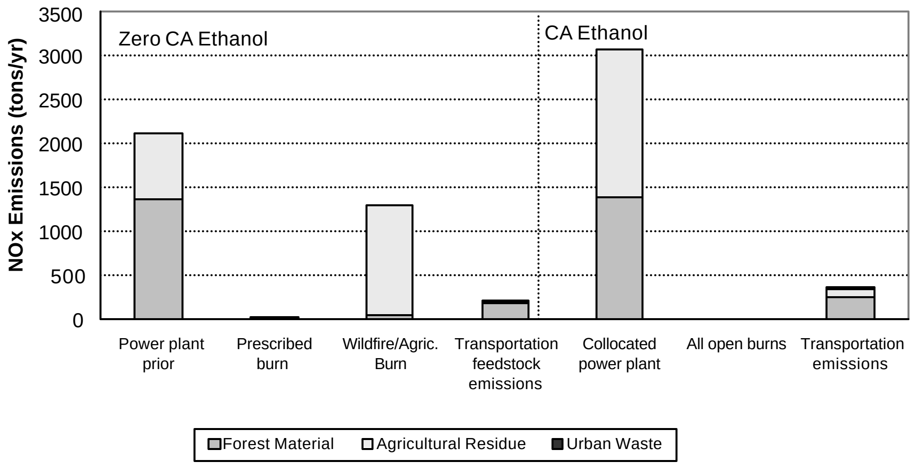


Figure VI-2. NO_x Emissions in Zero CA and CA Ethanol Production Cases

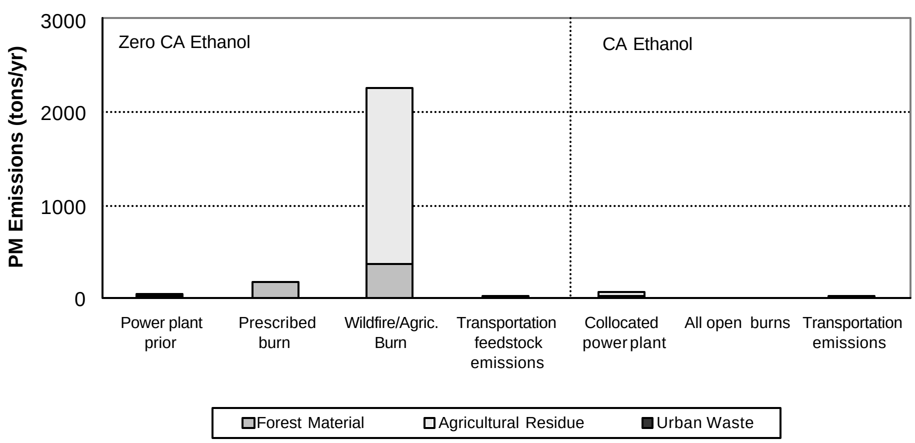


Figure VI-3. PM Emissions in Zero CA and CA Ethanol Production Cases

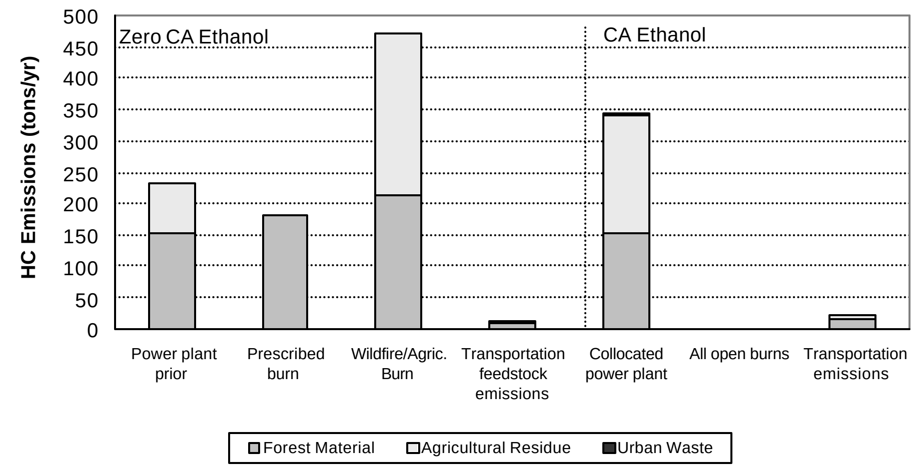


Figure VI-4. HC Emissions in Zero CA and CA Ethanol Production Cases

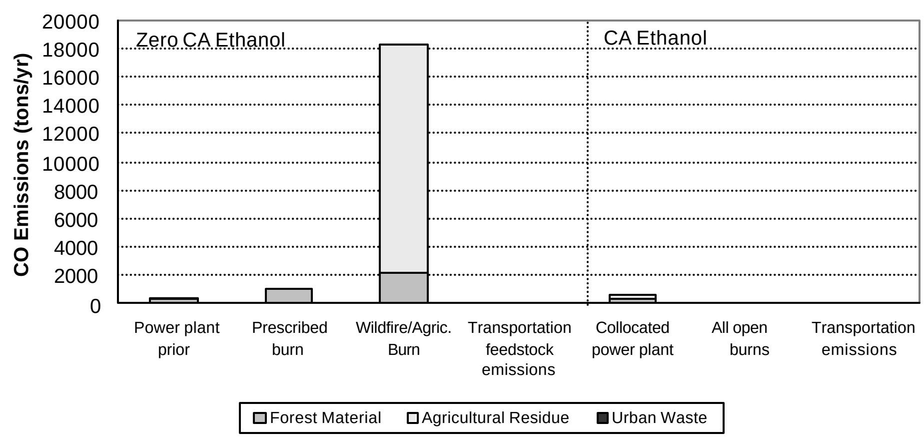


Figure VI-5. CO Emissions in Zero CA and CA Ethanol Production Cases

Ethanol also provides a disposal option to help the rice industry reduce the economic impacts with the air quality regulations. Nevertheless, this study does not take credit for air pollution reductions that might occur if rice straw burning were reduced.

In this analysis, agricultural residues are used in conjunction with seasonal rice straw in ethanol plants, although it may be possible to store rice straw and use it throughout the year. As is much the case with forest materials, the burning of agricultural residue lignin shifts emissions from PM, CO, and HC to NO_x. Figures VI-2 through VI-5 illustrate this effect.

Urban Waste

Urban waste disposal is likely to produce comparable emissions whether or not the material is used as feedstock for ethanol production. This is because the transportation emissions under the California Ethanol production case are comparable to conventional waste disposal since transport from the waste sources to a MRF is needed in both cases. It is assumed that the ethanol facilities are collocated with MRFs. Finally, the increased NOx experienced with other feedstocks due to by-product electricity production is not applicable to urban waste. No by-product combustion is assumed to be allowed in an urban waste-to-ethanol facility due to air pollution concerns and difficulty in siting a new combustion source.

The inability to combust by-products for steam and electricity creates a need for imported electricity and other process fuels, which leads to an increase in fossil fuel CO_2. The increases in other pollutants are not significant, as seen in Figures VI-2 through VI-5. As a result, increased fossil fuel CO_2 is the greatest emission impact of ethanol from urban waste.

Transportation Emissions

Ethanol feedstock and fuel transportation emissions are much less than the emissions from co-product combustion or open burning. Nevertheless, the truck, rail, and marine transport do contribute to pollution levels and have therefore been quantified in this study. Table VI-3 shows the estimated emissions of CO_2, NO_x, PM, HC, and CO under the California Ethanol production scenario.

Transportation emissions result from a combination of trucks, rail, and marine vessels, as discussed in Chapter III.4. In the Zero California Ethanol production scenario, rail and marine vessels transport ethanol from out-of-state, as shown in Figure VI-6. The emissions are counted once the rail cars or marine vessels are within the State boundaries, except for CO_2, which has global accounting due to its global effects.

If California produces 200 million gallons of ethanol from a resource mix of forest material, agricultural residue, and urban waste, the transportation requirements are different from the imported ethanol case. The emissions, in this case, are due to trucks bringing feedstock to ethanol plants, and trucks and locomotives transporting ethanol to distribution terminals. The transportation of the ethanol is shown in Figure VI-7. The emission factors used for this analysis are shown in Appendix VI-B.

Table VI-3. Transportation Emissions for 200 Million Gallons of Ethanol Transported to Terminals and Feedstock Movement Activities (tons/yr)

Production Case	NO_x	HC	PM	CO	CO_2
California Ethanol Production	**353**	**23**	**13**	**35**	**66,400**
Forest Material	256	17	10	27	45,000
Agricultural Residue	81	5	3	7	17,000
Urban Waste	16	1	0.4	1	4,000
Zero California Ethanol Production	**99**	**9**	**4**	**11**	**65,000**
Feedstock Transport	72	5	3	7	39,000
Ethanol Transport	28	4	1	3	26,000

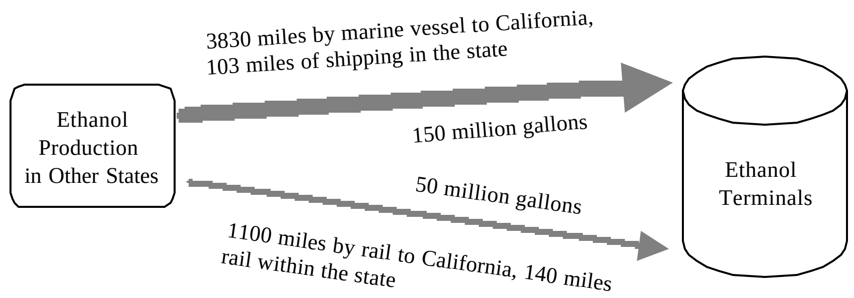


Figure VI-6. Transportation Scheme If California Produces No Ethanol

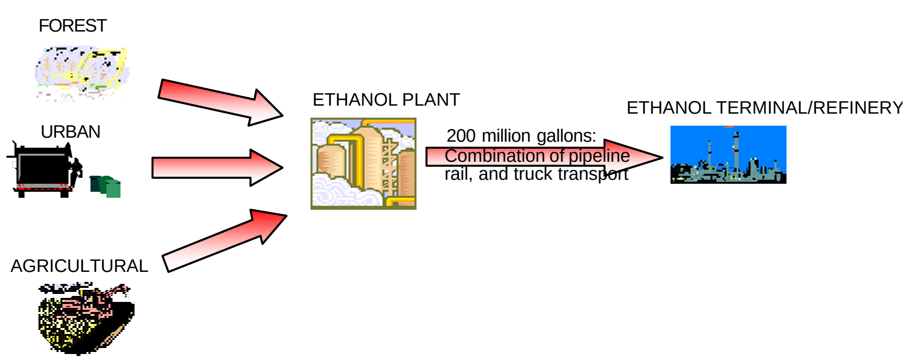


Figure VI-7. Transportation Segments of California Ethanol Production

The greatest transportation requirements are in the forest biomass sector, since nearly half of the ethanol will be from forest biomass plants that are fairly remote. Table VI-3 above shows that this leads to the highest emissions from transport of forest materials and their ethanol product. Although a portion of the total transportation emissions occurs in urban areas, the configuration of a greater number of smaller ethanol plants prevents longer truck travel in these regions. As a result, the transportation emissions related to urban waste-based ethanol are small, and the urban waste ethanol emissions are not noticeably greater than urban waste disposal emissions in a zero California ethanol case.

The comparison of CO_2 emissions from ethanol transportation from the Midwest and within the State revealed that emissions are slightly greater when California imports ethanol. This difference is not significant, however, especially because transport within the corn states was not considered.

Although the transportation emissions for other pollutants in a California ethanol production case are greater than in the zero ethanol production case, the previous section discussing ethanol plant emissions and Figures VI-2 through VI-5 demonstrated that the alternative feedstock burning produces emissions several magnitudes higher. As a result, the transportation emissions do not play a major role in determining the benefit of supporting an ethanol industry.

VI.2 Impacts of Biomass Harvest on Forest Health and Water Resources

This section summarizes the key assumptions and issues related to the potential impacts and risks to forest health and water resources when biomass is removed from managed forests for use in ethanol production. With the wide range of harvesting methods and frequencies available, the nature of potential adverse and beneficial ecological impacts to forests and associated water resources will vary significantly from site to site. To concisely summarize potential watershed-level impacts on forest health, water quality and biological communities, key assumptions must be made for a narrowly-defined biomass harvesting scenario, regarding the forest management practices to be used and compliance with environmental regulations governing those practices. Since the 13 million acres of commercial timberland in California that might benefit from thinning is dominated by coniferous tree species, this assessment of watershed-scale ecological impacts of biomass harvesting focuses exclusively on these coniferous forests.

While a diversity of forest and other plant communities could potentially provide biomass for ethanol production, the ethanol plant locations presented in this study would primarily draw material from Northern Sierra Nevada forests. The forest material primarily consists of mixed conifers and firs. The location of these ethanol plants corresponds to existing biomass power plants in forested regions of the State. It is assumed that forest material will primarily be obtained within the vicinity of the ethanol plant, as hauling the material long distances increases transportation costs.

Three principal types of forest material collection operations would be likely in Northern Sierra Nevada forests. Timber stand improvement refers to the thinning of forest to reduce fire risk and improve tree growth. Fuel reduction activities take place in sparsely populated areas to reduce risk to houses. Finally, lower branches can be removed from trees along roads and landings ("take slash").

Large areas of forest could be thinned in timber stand improvement operations (Cromwell), although only a small portion of these lands might be within hauling distance of the mill locations. Both private forestland and federally managed forests (National Forest), could be candidates for timber stand improvement. Forest management and fuel reduction activities do occur in National Forests, but the extent to which these can contribute to the feedstock in a stable long term manner is uncertain. Therefore, private lands are the most likely source of forest material from timber stand improvement operations. This type of forest thinning is intended to remove fuel to eliminate fire risk and to provide for improved forest health and management. Whether forest thinning for timber stand improvement is conducted on federal or private lands, the activity would require environmental review. The kind of review depends on whether the activity is on public or private land. Biomass harvested on public land would be subject to federal laws and process. Biomass harvested on private lands would be under California's Forest Practice Act. This law requires that timber operations be conducted to an approved timber harvesting plan or otherwise meet regulations that control the harvesting operation. A timber harvest plan would require the analysis of potential impacts to the forest, including impacts on endangered species and watershed. Any adverse impacts would need to be mitigated so that they are not significant.

Removals of forest material at the interface of populated areas many not require timber harvest plans, but must provide appropriate documentation and follow regulations designed to reduce the impacts of timber harvesting to an insignificant level. The California Department of Forestry and Fire Protection has developed the California Fire Plan. This plan is designed to reduce the damages and costs from wildfire. Under the plan, CDF cooperates with homeowners, community groups, and local governments to carry out projects to reduce fuels. These projects also follow practices that mitigate adverse environmental impacts. One by-product of such projects often is biomass that can be a source of ethanol feedstock.

Biomass Harvest Scenarios

Current and projected demand for forest biomass for ethanol production can be met partially by slash created during ongoing timber harvesting in California. Ecologically responsible removal of slash from logged areas can be targeted at a subset of the most accessible, economic, and least ecologically sensitive forest units being harvested on normal rotation. Slash and small tree removal for ethanol production could be integrated with slash removals for the purposes of fire prevention and forest sanitation (i.e., disease and insect control). Logging and slash treatment on private lands will conform to California's Forest Practice Rules (Title 14, California Code of Regulations, Chapters 4 and 4.5) and that the principles of ecological and water resources protection incorporated into these rules also will be used to focus selective removal of slash on the least vulnerable sites and forests. On federally owned forest lands subject to any type of timber harvesting, USDA Forest Service and USDI Bureau of Land Management regulations apply.

Under existing State and Federal regulations, slash removals can reasonably be expected not to occur, on steep slopes or other highly erodible soils, in riparian zones and headwaters of trout streams, in habitats of any protected species whose habitat or food supply may be damaged or undermined by slash removals, or in other specially sensitive areas. Similarly, timber harvests will be planned to mitigate adverse biomass losses from slash removal and soil erosion by leaving even more snags and fallen logs than the minimum extent required by the forest practice rules.

For slash removal, it is assumed that plans for pre-commercial and commercial forest thinning need not be altered/expanded and thinning rotations need not be shortened to a frequency greater than once a decade for any forest unit, to meet the current and projected demand for thinning residues targeted for ethanol production. All of the same assumptions made for harvest and slash removal, regarding conformance of silvicultural operations with the California Forest Practice Rules and ecological protection efforts such as minimizing or mitigating thinning impacts to the most sensitive forest units, are made when evaluating potential impacts of forest thinning. The removals of thinning residues for ethanol production could be planned to serve the collateral goals of enhancing timber yield and quality, insect/disease control, and fire prevention. Based on the type of forests and existing harvesting practices and forest roads in Northern California it appears that biomass removal from pre-commercial thinning operations will be allowed only in the most accessible watersheds, forests, and sites that already have roads and are least vulnerable with respect to soil compaction, erosion, nutrient depletion, downstream flooding from increased surface runoff, stream siltation and water quality degradation.

Compliance with California Forest Practice Rules

Many ecological impacts to forests and associated aquatic ecosystems can and must be mitigated to comply with environmental laws and regulations, such as the California Forest Practice Rules. These rules are designed to avoid or minimize adverse impacts of silvicultural and timber harvest practices on soils, carbon and nutrient cycles, forest productivity, biological diversity, wildlife and endangered species habitat, site hydrology, downstream flooding, stream siltation, water quality, and fisheries. Biomass-harvesting scenarios would need to fully comply with these rules. Given the location of where it is proposed to use forest biomass as ethanol feedstock and the extensive nature of the forest practice rules and agency review, it seems reasonable to expect that adverse impacts would be mitigated.

The nature of potential adverse and beneficial ecological impacts to forests and associated water resources will vary from site to site. Ecological impacts would be minimized if removal of slash from logged areas can be targeted at the most accessible, economic, and least ecologically sensitive forest units. Slash removal for ethanol production would be integrated with slash removal for the purposes of forest management, fire prevention and forest sanitation, as in disease and insect control. Insect and disease control are a cyclical concern in Northern California forests. For insect control, removal of dead trees and further thinning of healthy trees may be required to enhance the ability of the remaining trees to withstand damage.

Figure VI-8. Logging Operations

Hydrology and Flooding

Soil compaction from harvesting and thinning machinery often decreases rain and snowmelt infiltration (Rhodes and Purser, 1998). Logging road cuts can intercept shallow subsurface ground water flows, thus acting as tributaries that increase the diversion to streams of overland, sheet-flow runoff that otherwise would infiltrate forest soils. However, such impacts are much less significant for thinning operations, especially when no new road construction is required.

Food Chain, Fish, and Wildlife Impacts

Biomass removal of organic matter reduces the leaf litter, twigs, and other nutrients on the forest floor available to decomposers such as invertebrates, beneficial insects, and fungi. These form the foundation of forest nutrient cycles and food chains that support local wildlife. Logs, snags, and living trees targeted for biomass removals can harbor disease and increase fire risk but also provide habitat for wildlife and their prey (see Figure VI-9). These impacts are typically considered as part of evaluation of the potential impacts of the biomass operation by the regulating governmental agencies.

Figure VI-9. Examples of Biomass/Fuel Accumulation in Hardwood (right) and Unthinned Spruce (left) Forests

Potential Beneficial Forest Impacts

Reduced Damage from Fires and Fire Fighting

Potential wildfire damages to forest health and associated aquatic ecosystems include direct damage to flora and fauna and indirect fire impacts such as reduced soil quality, death of soil organisms and seeds, floristic changes, habitat loss, and impaired nutrient and water cycles (e.g., Chabot and Mooney, 1985; CBEA, 1997; Morris, 1998; Neary et al., 1999). Fire fighting activities (e.g., road cuts, fire breaks, stream water removals) and post-burn timber salvage operations exacerbate the direct impacts with further disturbance of the fire-damaged soils, forest hydrology, and habitat/water quality of associated aquatic habitats (e.g., Beschta et al., 1995; Frost, 1995; Rhodes and Purser, 1998). Silvicultural methods such as slash removal can reduce fire intensity without significantly disrupting nutrient cycles at all but the most nutrient-limited sites (e.g., Stephens, 1998; Monleon and Cromack, 1996). As a result, the prevention of intense fires by removals of slash, thinnings, and diseased trees/snags/logs from fire-prone areas will have the benefit of reducing direct and indirect damages to forested watersheds.

Optimized Carbon Assimilation and Growth

Photosynthesis, carbon assimilation, and growth of the desired/retained trees result from their sudden release from competition for sun, water, and soil nutrients with vegetation being removed. Competition for soil nutrients is reduced significantly by pre-commercial and commercial thinning. So the slight incremental increase in nutrient losses from the forest caused by removal of slash or thinned tree trunks is negligible. In most situations, thinning will enhance carbon gain, growth, and wood formation by the retained trees, despite the removal of additional nutrients as biomass used for ethanol purposes.

Improved Timber Yield and Quality

Thinning provides greater light availability and increased spacing that allow trees to attain their full genetic potential for optimal wood production and quality. Figure VI-11 illustrates a managed pine forest that has been thinned to enhance timber quality and yield per tree. Biomass removal should be targeted at forest stands that would not suffer a decline in wood production due to even very small removals of nutrients or other adverse effects of mechanized thinning, such as soil compaction and scarification.

Figure VI-11. Example of a Managed Forest

Better Forest Sanitation and Insect and Disease Control

Pine and spruce bark beetles and other insects damage trees directly and may transmit tree diseases, such as pitch canker disease in pines, leading to tree death and the resultant buildup of fuel as standing dead wood. Since the only known control for this fungal disease is forest sanitation, removals of infested trees, slash, and other biomass for use in ethanol production can help reduce disease outbreaks. Insect and other disease infestations and epidemics are exacerbated by drought, which can render even healthy trees susceptible to infection. As a result, removal of biomass, which leaves remaining trees with more water resources, can prevent infection.

Sudden Oak Death, caused by a combination of beetles and the fungus *Hypoxylon*, poses a threat to California's limited oak forests and also increases the risk of fire from increased amounts of fuel contributed by the dead trees (Figure VI-12). Slash and other small tree removal needed for the combined purposes of disease control, fire prevention, and ethanol production should be timed to precede drought conditions to optimize this preventative measure. Removal of diseased trees/biomass also can reduce the risk of fire-mediated disease transmission to healthy forests, because spores of pathogenic fungi can be entrained in smoke and carried considerable distances without losing their viability. While the species discussed here are generally candidates for thinning in Northern California forests, they may be available for ethanol facilities in other parts of the State.

Figure VI-12. Fruiting Bodies of Hypoxylon Fungus (left) and Oak Ambrosia Beetle (right)

Control of Invasive Plant Species

Thinning of forests can remove undesirable species of trees, shrubs, and herbs, including introduced species of noxious, invasive weeds. At the same time, it can enhance the growth of native species of shrubs and herbs that promote biodiversity but do not significantly compete with the timber trees for root space, water, light, or nutrients. Since undesirable weeds more easily invade a forest after high intensity fires, slash removals for use as biomass can reduce the risk of fire-potentiated invasions of forests by non-native plants.

Hydrology, Flooding, and Water Quality

By reducing the severity of forest damages from fires, insects, and disease, periodic removals of infected and combustible biomass will indirectly reduce erosional and combustion losses of soil organic matter and nutrients. These losses collectively reduce the water holding capacity of soil and undermine soil stability, thus increasing peak surface runoff rates and exacerbating downstream flooding. Therefore, efforts to reduce the frequency and intensity of forest fires, such as biomass removal, can benefit forest hydrology, flood control, water quality, and the health of aquatic ecosystems and their resident fish communities.

Summary of Forest Impacts

As described above, harvesting of forest biomass has a number of potential significant environmental impacts. Potential significant adverse environmental impacts of these activities are conducted in conformance with the California Forest Practice Rules and federal regulations, and employ ecological impact mitigation measures designed for site-specific conditions. In this situation, it is expected that biomass removals should tend to result in a beneficial impact on the health of forests. When compared to the ecological impacts of normal forest management and harvesting activities, the incremental impact from biomass removals of slash and thinnings are small. The extent of the damage to forests caused by intense fires and disease epidemics often justifies removals of biomass for the dual purposes of fire prevention, and pest control. The above discussion is a general evaluation of potential forest impacts, primarily with reference to the geographic area that would provide forest-related biomass feedstock. Further studies are required to determine site specific conclusions or broader regional conclusions.

VI.3 Landfill Diversion: The Value of Preserving Intangible Resources

Some research has been done in the academic field to determine whether people may place some monetary value on intangible environmental benefits. Such intangible benefits include the value that people may place on the knowledge that pristine undeveloped areas are preserved in their natural state, or that an outdoor area is not converted into landfill. See Appendix VI-A for discussion of valuation. It is possible to report these values and attempt to incorporate them into more conventional accounting methods. Unfortunately, none are known to specifically address the value of leaving the option for later use of land now being converted to landfill. Nevertheless, some people do place monetary value on these types of intangible environmental benefits, even though they may not receive any direct or tangible benefit.

As some people currently pay a premium for the provision of "green power" to their homes, so they may pay a premium on their garbage collection bill to support landfill diversion efforts. Some members of the public might be willing to subsidize the production of ethanol from MSW or other feedstocks in this manner. Therefore, an environmental economic study could be conducted to monetize the consumer value of landfill diversion. One method of valuation is a survey that could be employed to quantify the dollar amount of the subsidy that residents would support, as well as the percentage of residents that would be willing to participate. While choosing a method and carrying out a study to value this service is beyond the scope of this report, an additional study could determine the degree to which the public supports landfill diversion with ethanol production.

Another possible indication of the monetary value that California places on such environmental benefits is the amount of money appropriated by the legislature in recent years to subsidize activities and business that contribute to "green" power generation and landfill longevity. In 1999, in AB1890, the California Legislature appropriated a total of $540 million to subsidize the production of electricity by renewable means. Of that total, $135 million specifically was used to support the biomass and solar thermal industries. Since one of the rationales for providing this support to the biomass industry was to help divert solid waste from the State's landfills, this bill may give some indication of the monetary value that the public sector places on the environmental benefit of solid waste diversion.

VI.4 Costs and Benefits of Environmental Impacts

As discussed earlier, it is not possible in this study to place monetary value on all environmental impacts. This study does monetize the emission impacts associated with an ethanol industry based on several types of feedstocks. Other studies have attempted to evaluate the economics associated with emission reductions, changes to water resources, and fire risk reduction due to removal of biomass from forests and agricultural residues. These studies focused on these feedstocks because they were conducted primarily for evaluation of biomass-based power industries.

The range of benefits for wildfire risk reductions reported by previous studies is large due to the varying valuation and monetization methods. Some studies include avoided fire protection costs and asset losses while others include only avoided fire protection costs in the value of reduced wildfire risk. The ranges of values for impacts are shown below in Table VI-4.

Table VI-4. Economic Values for Various Environmental Impacts

Impact	Economic Value ($/BDT removed)	Economic Value (Million $/yr)[a]	Sources
Open Burn Emission Reduction	2-50	2-50	CBEA/Cal EPA 1997; NRSS/CEC 1997
Wildfire Emission Reduction	0.27-50	0.2-38	CBEA/Cal EPA 1997; NRSS/CEC 1997
Greenhouse Gas Reductions	33	55	CBEA/Cal EPA 1997
Wildfire Risk Reduction	3-36	2-27	CBEA/Cal EPA 1997; NRSS/CEC 1997; FRA/NREL 1997
Forest Health Improvement	0.07	0.05	NRSS/CEC 1997
Increased Water Assets	unclear - 3	unclear - 2	CBEA/Cal EPA 1997; FRA/NREL 1997

[a]Economic value based on biomass removals in the California Ethanol case.

Note that the report by Natural Resources Strategic Services, which describes the benefits of biomass power in California (1997), found forest health improvement to be less than one dollar. Other studies did not attempt to determine this value. Further studies are necessary to evaluate the costs and benefits to the forest due to biomass removal.

The range of values for emission benefits in Table VI-4 are close to those calculated in this study. This study chose to place a monetary value on emission reductions based on the history of society's willingness to pay for better air quality (see Appendix VI-A for more discussion). In particular, the study chose an avoided cost method, one of several types of valuation, to monetize the emission levels from ethanol production discussed in Chapter VI.1 and summarized in Table VI-5. Since the State and many air districts are making an effort to reduce air pollution through control measures, it is appropriate to value the emission impacts according to avoided control costs for particular pollutants and sources. This type of valuation employs average rates for emission trading credits or reduction effectiveness factors and is commonly used to determine the value of pollution reductions in the State. They take into account the marginal costs for incremental environmental improvements, such as road dust reduction for PM, gasoline car emission reductions for HC, fuel economy improvements for CO_2, and power plant emission reductions for NO_x.

Although other costing methods are sometimes used to evaluate the economics of pollution impacts, it is most appropriate to use the avoided cost of emission offsets since the market trades the same pollutants as those impacted by ethanol production.

California average trading factors for NO_x, PM, CO, and HC in 1999 are listed in Table VI-5. These factors are the average of actual prices paid throughout California in 1999 for permits to pollute (California Air Resources Board, 2000). In addition, CO_2 is worth approximately $25 per ton. Although CO_2 is not a traded pollutant, its value is associated with the cost to reduce CO_2 emitted from power plants.

Table VI-5. Values of Emission Benefits of Ethanol Production

Pollutant	NO_x	PM	HC	CO	CO_2
Cost for Offset ($/ton)	$13,884	$10,400	$6,579	$3,033	$25
Tons of Reductions per year	200	2,400	1000	19,000	870,000
Estimated Value of Ethanol Production over Zero CA Ethanol per year	$3 million	$25 million	$6 million	$58 million	$22 million
Estimated Value of Ethanol Production over Zero CA Ethanol per BDT of feedstock	$1	$9	$2	$21	$8

Total Estimated Value per year	$114 million

Table VI-6. Major Assumptions that Affect Environmental Impacts of Ethanol Production

Attribute	Value Used in This Study	Source
Tons of biomass burned per acre in a prescribed burn	4 tons/acre	—
Tons of biomass burned per acre in a forest fire	15 tons/acre	California Department of Forestry, ARB
Tons of biomass removed per acre in thinning operations	12.5 tons/acre	Quincy Library Group
Number of years of forest fire protection afforded by thinning and slash removal operation	10 years	—

The economic benefits can be calculated using these factors and the emission differences between the zero California ethanol case and the California ethanol case, as seen in Table VI-5. The total value for emission changes from wildfires, open burns, power plants, and transportation add up to approximately $40/BDT. This is within the ranges found in other studies shown in Table VI-4.

The emissions reported above and those shown in Figures VI-2 through VI-5 rely on emission factors for wildfires, prescribed burns, and biomass power plants. This study made an effort to choose the most appropriate emission factors. Appendix VI-B shows the variety of emission factors available, particularly values chosen for this analysis.

Several assumptions about forest wildfire and control activities shown in Table VI-6, above, have an effect on the values in Table VI-4. A sensitivity analysis ideally is required to determine the possible range of estimated emissions. For example, the study required values for the amount of biomass removed per acre during prescribed burns and forest management thinning. Since a previous study by the Quincy Library Group found the average thinning in similar forests to be an average of 12.5 tons per acre, this value was applied to the analysis (NREL, 1997). This value was also in the range of 7-15 tons per acre used for ongoing studies (Forrest). Unfortunately, no data was available for average density of biomass removed by prescribed burns, especially since vegetation and site-specific characteristics vary widely. Therefore, this study chose a conservative estimate based on the assumption that more material is left in the forest after a prescribed burn than a forest thinning treatment.

If the assumption for prescribed burn removal is too low and more material is removed, the emissions from the prescribed burn combustion will be greater, driving the zero California ethanol scenario emissions higher. As a result, the reduction in PM, HC, and CO emissions from the zero ethanol case to the California ethanol case will be more profound. In the same situation, the negative NO_x impact caused by burning biomass in a boiler rather than in an open burn will be less significant because the zero ethanol scenario emissions will be higher.

In order to verify the forest management estimates in Table VI-6, the study's assumptions need to be re-addressed as more information is known about the density and vegetation characteristics of the forest locations being considered for ethanol feedstock. The affected areas either need to be visited for this purpose by forestry experts, or detailed Forest Service and CDF geographic information system maps must be consulted to determine the assumptions appropriate for each particular region.

The effects of other assumptions used in this study on the overall impacts of a California ethanol industry are outlined in the "Sensitivity Analysis" in the following chapter.

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CHAPTER VII

TOTAL IMPACTS AND SENSITIVITY ANALYSIS

VII. Total Impacts and Sensitivity Analysis

Sensitivity to Economic Assumptions

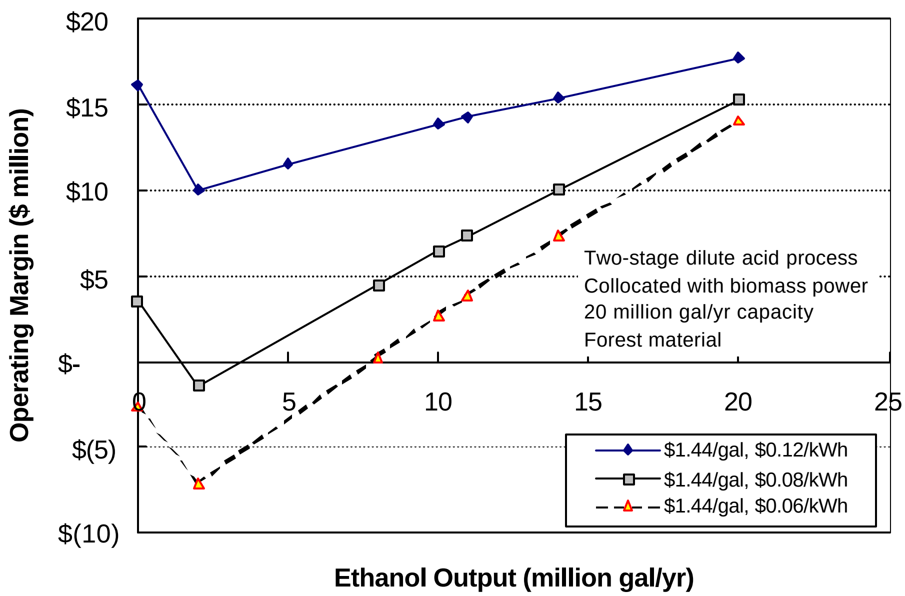
The costs and benefits of a California ethanol production industry depend upon several key parameters. The relationship between assumptions and the outcome of the study are shown in Table VII-1.

Table VII-1. Effect of Assumptions

Assumption	Effect on Economic Impacts
Viability of biomass power (economic impacts)	A long-term viable biomass power industry presents a baseline where significant amounts of forest material and agricultural residue would be power plant fuel. Scenario 1 in Chapter V (see Figure V-1). In Scenario 2 (see Figure V-1), the power produced by the ethanol industry will increase total electricity supply if long-term biomass power production is not viable.
Viability of biomass power (environmental, resource impacts)	A long-term viable biomass power industry would result in similar forest fire reduction, forest health, and air pollution reduction benefits. Ethanol plant operation would result in lower NO_x emissions as some of the feedstock would be converted to ethanol rather than burned.
Ethanol price/ market risk	Uncertainties in the ethanol market affect investors' willingness to provide funds for an evolving industry. Once an industry is established, ethanol prices affect the economic impacts of an ethanol industry. Low ethanol prices reduce income to a California ethanol industry and potentially reduce ethanol production. However, low ethanol prices also reflect savings in consumer fuel prices.
Electricity price	For power prices above $0.10/kWh biomass power appears economically viable. Ethanol investment could be utilized less.
Feedstock cost	High feedstock costs reduce the amount of biomass power and ethanol that would be produced. At higher ethanol prices, higher cost feedstocks can be utilized.
Support for ethanol industry	Depending upon the ethanol market, outlook for oxygenates, perceived technology risk, and other factors, state outlays may be necessary.
Federal oxygenate requirement	Oxygenate requirement results in 700 million gallons/year demand in California and contributes to national demand. Results in potentially higher ethanol prices in the near-term. Air quality attainment outside California may reduce U.S. oxygenate based demand.
Federal ethanol tax credit	Reducing or eliminating the federal tax credit reduces the demand for ethanol. More supply would be available and provide competition to California-based ethanol. Without the tax credit, ethanol would be more expensive to refiners and ethanol required as an oxygenate would add cost to gasoline.

The effect of these parameters on the economic costs and benefits to the State requires the examination of additional scenarios that take into consideration the possible energy prices in California as well the potential fate of the biomass power industry. The economics of ethanol production as well as the potential costs and benefits depend on the operating margin for ethanol and biomass power plants.

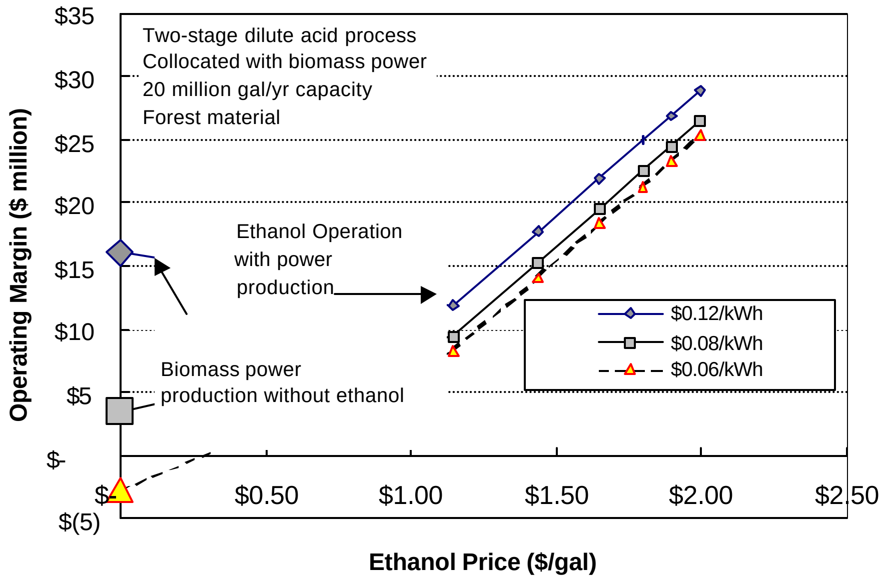
An important consideration in assessing the outlook for an ethanol industry is the alternative for producing electric power from feedstocks such as forest material and orchard prunings. Figure VII-1 illustrates the effect of ethanol plant operating capacity on the operating margin for a collocated biomass ethanol plant. The example for a two-stage dilute acid facility is intended to illustrate the effect of operating parameters rather than provide an analysis of the feasibility of a particular process. The operating margin takes into account the Federal small producer credit which provides an additional $0.10/gal for the first 10 million gallons of production capacity. This analysis also includes a hypothetical $0.20/gal producer payment as a basis for examining costs to the State. The results of the analysis indicate that ethanol production appears more attractive than power production (assuming a $0.20/gal producer payment) when power prices are below $0.10/kWh. In a situation with very high power prices capital investments may not be fully utilized. In the event of future high power prices, operating support such as producer payments would not result in a cost to the State if no ethanol were produced.



( ) Indicates negative values

Figure VII-1. Effect of Ethanol Production Capacity on Collocated Ethanol Plant Operating Margin

Similarly, Figure VII-2 illustrates the effect of ethanol prices on the operating margin for a biomass power/ethanol plant. A sales price of $1.44/gal is necessary to recover investment for the facility considered in this analysis. However, the facility may still produce ethanol at lower prices. The operating margin that would be achieved by burning the feedstock to produce biomass power is shown for comparison (with large symbols).



( ) Indicates negative values

Figure VII-2. Effect of Ethanol Sales Price on Collocated Plant Operating Margin

Given the range of assumptions that could affect the outcome of a California ethanol industry, the potential economic costs and benefits were evaluated over a range of assumptions. The assumptions for the baseline analysis (base case) and alternative assumptions are shown in Table VII-2.

Table VII-2. Sensitivity Assumptions

Parameter	Assumption
Ethanol demand	300 million gallons usage per year, over 20 years.
Low demand	CA ethanol drops to zero after 10 years
California production	200 million gallons per year
High California production	Economic effects would track fuel output. Feedstock resources identified (Appendix III).
Power price	$0.08/kWh average price
High power price	$0.12/kWh, reduces ethanol output but feedstocks are still utilized
Environmental, resource valuation	Count avoided cash costs to the State. Do not include indirect or induced impacts.
Ethanol price	Moderate ethanol price, CA industry has no impact on consumer fuel prices
High ethanol price	Assume that competition from CA industry reduces ethanol prices by $0.10/gal. Ethanol prices are over $1.80/gal
State support	Assume a 10% of capital and $0.20/gal producer payment
Higher State support	Assume a 20% of capital and $0.40/gal producer payment

Total Economic Impacts

The economic impacts that were quantified in this study include the following:

- Economic activity related to construction of production facilities, ethanol storage, and feedstocks collection equipment as well as ethanol plant operation, marketing, and feedstock handling
- State funds that might be required to support an ethanol industry
- Wildfire risk reduction, savings in forest fire fighting cost, improved forest health, and related resource impacts
- Air emission impacts from reduced wildfires, open field burning, and controlled burns, feedstock transportation, and ethanol plant operation
- Impacts on consumer fuel prices

Figure VII-3 illustrates the impacts of a California ethanol industry that were measured in this study. The economic benefits and state costs correspond to the base case analyses presented in Chapter IV. The State cost is assumed to be sufficient to incentivize an ethanol industry;

however, the structure and extent of the support requires further evaluation. In addition to the impacts that are internal to the ethanol industry, the potential avoided cash costs for forest fire impacts and air emission reductions are included. The forest benefits correspond to $25/ton, which is within the range of values presented in Chapter VI. The value of NO_x and PM emission reductions is also included as these reductions in these pollutants are currently purchased with state funds. The benefits of CO, HC, and CO_2 emission reductions is not shown in this figure as the valuation of these reductions is less certain since the State does not purchase reductions in these pollutants.

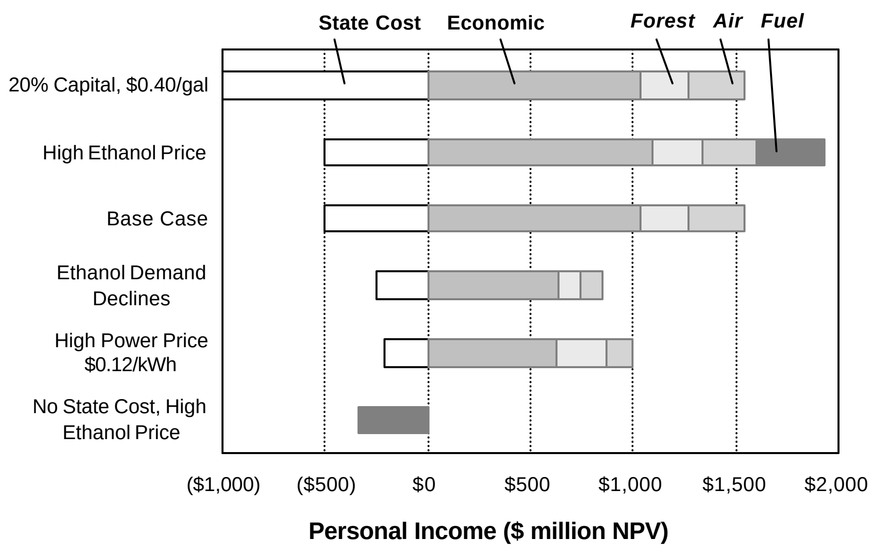


Figure VII-3. Total Costs and Impacts of a California Ethanol Industry

The effect of a California ethanol industry on consumer fuel prices is also illustrated in this figure. Under a scenario of high ethanol prices, California ethanol production was assumed to result in a $0.10/gal reduction in the price of ethanol. In practice, a shortage of ethanol would not result in a constant $0.10/gal increase in prices but rather higher prices in the near-term until additional capacity is added in response to higher prices. However, the effect of shortages is difficult to predict and the $0.10/gal estimate provides a benchmark estimate. This estimate is consistent with the supply curves presented in Chapter V. The cost to transport Midwest ethanol to California is about $0.15/gal. The effect of no California industry and high ethanol prices is also shown. Under this scenario, no ethanol would be produced in California and consumer fuel prices would be impacted if ethanol prices are high.

The cost of a higher level of state support was also evaluated. In this case the capital and producer payments are doubled for 200 million gallons of production capacity. The economic impacts of the higher California ethanol production case (400 million gallons per year) are not presented here as the cost and benefits would double if other assumptions were held constant. Uncertainties in the structure of state support, mix of plants, production technologies, feedstock cost, and other factors limits the value of comparing economic impacts and state costs for different levels of production. However, Appendix III does provide a Scenario for 400 million gallons of production in California that is consistent with available resources.

The scenario for ethanol production was also not presented in the context of a guaranteed 700 million gallon per year demand that would be required to meet oxygenate requirements. If such a demand were a certainty, one element of risk for ethanol production would be eliminated.

Declining ethanol output would affect the analysis of an ethanol industry. Figure VII-3 shows the impact of reduced ethanol sales after 10 years of operation. This could occur for a variety of reasons that are not explored here. As an example, the Federal tax incentive may change at some point in the future. In the case of declining ethanol demand, the State's cost would be limited if support is largely in the support of a producer payment. Similarly, high power prices may lead collocated ethanol production facilities to produce power instead of ethanol. Again, if state support is focused on producer payments, the potential cost to the State would be limited.

In conclusion, the economic benefits of a California ethanol industry are greater than the benchmark levels of state support analyzed in this study. The requirements and level of state support are uncertain and require further analysis.

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APPENDICES
COSTS AND BENEFITS OF A BIOMASS-TO-ETHANOL PRODUCTION INDUSTRY IN CALIFORNIA

COMMISSION REPORT

MARCH 2001
P500-01-002A

Gray Davis, *Governor*

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TABLE OF CONTENTS

Appendix III-A

Direct Impacts

The cases described in this work were generated using several inputs. The California gasoline energy demand was established using 1999 gasoline consumption data. The gasoline pool was then decomposed into three separate component volumes: conventional gasoline, MTBE, and RFG gasoline void of MTBE. The total energy contained in these fuel components is held constant across all scenarios.

With historical gasoline components identified, the amount of ethanol required by the state of California was calculated based on Federal oxygenate levels for ozone non-attainment, and the fraction of California gasoline consumed in ozone non-attainment regions. For the purposes of the study, it is assumed that the Federal oxygenate standard for ozone non-attainment in California is 2% by weight, and that 80% of California gasoline is used in ozone non-attainment regions. The Federal oxygenate standards required are in motion, however, California has applied for a waiver to lower Federal oxygenate standards. The actual percentage of gasoline consumed in ozone non-attainment regions is similarly fluid, as attainment status is under review, particularly that of the San Joaquin Valley. If the San Joaquin region is found to be in ozone non-attainment, as expected, 80% of California gas is anticipated to be consumed in ozone non-attainment regions.

With total ethanol demand established, several scenarios were created to examine potential outcomes in terms of ethanol usage. It is worth noting that a fraction of the pentane hydrocarbons present in gasoline must be removed for ethanol-gasoline blending, to meet Reid Vapor Pressure (RVP) requirements for evaporative emissions. With the removal of pentanes from the fuel inventory – and the associated decrease in transportation fuel energy – it is assumed that additional gasoline will be consumed to compensate for any energy shortfall.

In several scenarios outlined in the appendix, ethanol is blended without pentane extraction. This is not an omission, despite the caveat listed above regarding RVP standards. For relatively low volumes of ethanol-gasoline blending, it is believed that a “split pool” strategy can be employed. Using this approach, pentanes are extracted from any gasoline to be blended with ethanol and reincorporated into the balance of the gasoline pool. This strategy effectively extends the transportation fuel pool, as both pentanes and ethanol can be used without the exclusion of the other.

With ethanol demand defined, the appendix develops production scenarios in terms of biomass-to-ethanol plants and jobs associated with these enterprises. Two major economic implications come from this examination: capital investment and employment impacts. These factors are quantified based on plant construction costs and estimated work force requirements for ethanol production facilities. These factors become inputs for the economic Input-Output (IO) model used to quantify the general equilibrium economic costs and benefits that stem from biomass-to-ethanol conversion. Another input to the IO model is the tax revenue and sales due to ethanol consumption. These impacts are quantified in this appendix.

The final major component of the scenarios is the quantification of the biomass required to achieve listed ethanol output. The types of biomass, and the feedstocks needed for each plant are also developed. Using specific plant locations, feedstock collection regions and the transportation required to move this biomass is also developed to complete the biomass analysis as it pertains to ethanol production.

Other factors considered within this appendix are electricity production due to displaced (or augmented) biomass power production, differential natural gas consumption to compensate for marginal power requirements, and electricity co-production from biomass-to-ethanol conversion.

Appendix III-B

Model Inputs

This appendix contains tables of inputs for the cost benefit analysis.

Summary of Feedstocks for Ethanol Production Cases

Plants Used	**ZERO CA ETOH** 1,3,4,7,8 (biomass power only) [c]	**CA ETOH** 1,3,4,7,8, 12-21[a]	**HIGH CA ETOH** All
Ethanol Cap. (M Gal/yr)	0	200	400
Forest Materials (BDT/yr)	723,514	1,033,592	2,067,183
Agricultural Residues (BDT/yr)	400,000	1,273,231	2,196,308
Urban Waste (BDT/yr)	—	404,040	1,010,101

a - Any four plants to be chosen from the lot of plants 12 through 21
b - Any eight plants to be chosen from the lot of plants 12 through 21
c - Plants 1, 7 and 8 will use only 40% of biomass when operating without a collocated ethanol plant

Agricultural Residue Plants and Feedstocks

Type	Rice Straw	Rice Straw	Ag Residue Orchard pruning	Ag Residue Orchard pruning	Ag Residue Orchard pruning
Plant ID	7	8	9	10	11
Ethanol Cap. (M Gal/yr)	40	40	20	20	20
Capital (M $)	120	120	60	60	60
Rice Straw Feed (EtOH %) - a	41	41			
Consumption (tons/yr) - b	368,000	368,000			
Consumption (BDT/yr)	276,000	276,000			
Ag. Residue Feed (EtOH %) - c	59	59	100	100	100
Consumption (tons/yr) - b	480,821	480,821	410,256	410,256	410,256
Consumption (BDT/yr)	360,615	360,615	307,692	307,692	307,692
Total Agricultural Residues, BDT/yr	636,615	636,615	307,692	307,692	307,692

a - Based on available rice straw information gathered from industry stakeholders
b - Consumption data calculated from ethanol yield data shown in Plant Parameters Table in this Appendix
c - Based on availability data from CEC 1999 report "Evaluation of Biomass-to-Ethanol Potential."

Urban Waste Plants and Feedstocks

Type	Urban Waste	Urban Waste	Urban Waste	Urban Waste	Urban Waste
Plant ID	12	13	14	15	16
Ethanol Cap. (M Gal/yr)	10	10	10	10	10
Capital (M $)	45	45	45	45	45
Waste Paper Feed (EtOH %) - a	60	60	60	60	60
Consumption (tons/yr) - b	63,796	63,796	63,796	63,796	63,796
Consumption (BDT/yr)	60,606	60,606	60,606	60,606	60,606
Other Waste (EtOH %) - a	40	40	40	40	40
Consumption (tons/yr)	42,531	42,531	42,531	42,531	42,531
Consumption (BDT/yr)	40,404	40,404	40,404	40,404	40,404
Tree Prunning Feed (EtOH %)	0	0	0	0	0
Consumption (tons/yr)	0	0	0	0	0
Consumption (BDT/yr)	0	0	0	0	0
Construction Material (EtOH %)	0	0	0	0	0
Consumption (tons/yr)	0	0	0	0	0
Consumption (BDT/yr)	0	0	0	0	0
Total Urban Waste, (BDT/yr)	101,010	101,010	101,010	101,010	101,010

a - Data inferred from discussions with Material Recycling Facilities operators, Ventura County, and California Integrated Waste Management Board.
b - Consumption data calculated from ethanol yield data shown in Plant Parameters Table in this Appendix

Urban Waste Plants and Feedstocks (cont.)

Type	Urban Waste	Urban Waste	Urban Waste	Urban Waste	Urban Waste
Plant ID	17	18	19	20	21
Ethanol Cap. (M Gal/yr)	10	10	10	10	10
Capital (M $)	45	45	45	45	45
Waste Paper Feed (EtOH %) - a	60	60	60	60	60
Consumption (tons/yr) - b	63,796	63,796	63,796	63,796	63,796
Consumption (BDT/yr)	60,606	60,606	60,606	60,606	60,606
Other Waste (EtOH %) - a	40	40	40	40	40
Consumption (tons/yr)	42,531	42,531	42,531	42,531	42,531
Consumption (BDT/yr)	40,404	40,404	40,404	40,404	40,404
Tree Prunning Feed (EtOH %)	0	0	0	0	0
Consumption (tons/yr)	0	0	0	0	0
Consumption (BDT/yr)	0	0	0	0	0
Construction Material (EtOH %)	0	0	0	0	0
Consumption (tons/yr)	0	0	0	0	0
Consumption (BDT/yr)	0	0	0	0	0
Total Urban Waste, (BDT/yr)	101,010	101,010	101,010	101,010	101,010

Forest Material Plants and Feedstocks

Type	Forest Materials	Forest Materials	Forest Materials	Forest Materials	Forest Materials	Forest Materials
Plant ID	1	2	3	4	5	6
Ethanol Cap. (M Gal/yr)	40	40	20	20	20	20
Capital (M $) - c	90	90	60	60	60	60
Forest Thinning/Slash Feed (EtOH %) - a	87	87	87	87	87	87
Consumption (tons/yr) - b	642,303	642,303	321,152	321,152	321,152	321,152
Consumption (BDT/yr)	449,612	449,612	224,806	224,806	224,806	224,806
Lumbermill Waste Feed (EtOH %) - a	13	13	13	13	13	13
Consumption (tons/yr) - b	89,578	89,578	44,789	44,789	44,789	44,789
Consumption (BDT/yr)	67,183	67,183	33,592	33,592	33,592	33,592
Total Forest Materials, BDT/yr	516,796	516,796	258,398	258,398	258,398	258,398

a - Assumption based on various reports and communications
b - Consumption data calculated from ethanol yield data shown in Plant Parameters Table in this Appendix
c - Landucci, R., Proforma Systems, “Evaluation of Ethanol Production Costs, Appendix VII-B, in Evaluation of Biomass to Ethanol Fuel Potential in California,” California Energy Commission Report P500-99-022A, December 1999.

Plant Parameters [a]

Biomass Type	Moisture (%)	Ethanol Yield (Gal EtOH/BDT)	Collocated Plant Electricity Production (kWh/gal)	Collocated Plant Net Electricity Production (kWh/gal)	Equivalent NG required for electricity in ethanol plant[b] (kBtu/gal)	Equivalent NG required for electricity in ethanol plant (scf/gal)
Forest Materials						
Forest Slash/Thinnings	30	77.4	3.2	2	-	-
Lumbermill Waste	25	77.4	3.2	2	-	-
Agricultural Residues						
Rice Straw	25	60	0	-1.3	-	-
Ag. Residue	25	65	3.2	2	-	-
Urban Waste						
Waste Paper	5	81.7	0	-1.1	9.900	9.61
Other Waste	30	65	0	-1.1	9.900	9.61
Tree Prunnings	30	65	0	-1.1	9.900	9.61
Construction Materials	30	65	0	-1.1	9.900	9.61

Assumed NG Elec. Conversion	Btu/kWh	9000
NG Volume	Btu/scf	1030
NG Price	$/MMBtu	3
Biomass Power Heat Rate	Btu/kWh	17,000
Biomass Heating Value	Btu/lb (HHV)	8500

a - Plant parameters data was provided by Mr. Ron Landucci, ProForma Systems
b- Assume rice straw does not use natural gas but uses additional agricultural residue to provide the required electricity

Rice Straw Burn Scenarios

Bone Dry Tons, BDT

	Total Rice Straw Produced	Reincorporated into soil	Available for ethanol	Total Burned	Alternate markets	Ethanol production (mill gal)	Rice straw available for bailing
	BDT	**BDT**	**BDT**	**BDT**	**BDT**	**(Million Gal)**	**BDT**
Zero CA Ethanol	840,000	696,360	-	126,000	17,640	-	588,000
CA Ethanol	840,000	126,000	570,360	126,000	17,640	34.22	588,000

Assumption: legislation states the lesser of 25% or 125,000 acres may be burned

No-burn days also limit the ability to burn rice straw to approximately 15% of acreage.

Available for baling	70%	
Yield (gal/BDT)	60	<-- Based on Proforma Systems data
Moisture	30%	<-- Based on Proforma Systems data
Alternate markets	3%	(assumes growth of current market which is less than 2%)
Rice straw density (tons/acre)	2	<-- based on a range of 1 to 2.5 by Ken Collins, Rice Straw Cooperative
Total acres	600,000	<-- Paul Buttner, CARB

ETHANOL TRANSPORTATION											
Plant ID		1	2	3	4	5	6	7	8	9	10
Ethanol Production Capacity	M Gal/yr	40	40	20	20	20	20	40	40	20	20
	K Gal/day	110	110	55	55	55	55	110	110	55	55
	ton/day	723,288	723,288	361,644	361,644	361,644	361,644	723,288	723,288	361,644	361,644
Ethanol Movement											
Truck (7.8 K Gal/trk)	Trucks/day	14	14	7	7	7	7	14	14	7	7
Railcar (29 K Gal/railcar)	Railcar/day	4	4	2	2	2	2	0	0	0	0
Nearest Ethanol Unloading Point											
Truck											
Location		Marysville	Dunsmuir	Reno	Redding	Reno	Redding	Marysville	SAC	Fresno	Fresno
Distance	Miles	100	10	40	10	60	20	10	20	40	5
Total Truck Miles (one-way)	Miles	1405	140	281	70	421	140	140	281	281	35
Railcar											
Location		SAC/STK	SAC/STK	SAC/STK	SAC/STK	SAC/STK	SAC/STK	SAC/STK	—	SAC/STK	SAC/STK
Distance	Miles	50	250	100	200	100	200	50	—	200	200
Total Railcar Miles (one-way)	Miles	50	250	100	200	100	200	50	—	200	200

SAC - Sacramento Terminals
STK - Stockton Terminals
LAP - Los Angeles Port Terminals

ETHANOL TRANSPORTATION												
Plant ID		11	12	13	14	15	16	17	18	19	20	21
Ethanol Production Capacity	M Gal/yr	20	10	10	10	10	10	10	10	10	10	10
	K Gal/day	55	27	27	27	27	27	27	27	27	27	27
	ton/day	361,644	180,822	180,822	180,822	180,822	180,822	180,822	180,822	180,822	180,822	180,822
Ethanol Movement												
Truck (7.8 K Gal/trk)	Trucks/day	7	4	4	4	4	4	4	4	4	4	4
Railcar (29 K Gal/railcar)	Railcar/day	0	0	0	0	0	0	0	0	0	0	0
Nearest Ethanol Unloading Point												
Truck												
Location		LAP	LAP	LAP	LAP	LAP	LAP	Crockett	Crockett	LAP	LAP	LAP
Distance	Miles	40	30	40	40	40	100	50	50	10	100	100
Total Truck Miles (one-way)	Miles	281	105	140	140	140	351	176	176	35	351	351
Railcar												
Location		—	—	—	—	—	—	—	—	—	—	—
Distance	Miles	—	—	—	—	—	—	—	—	—	—	—
Total Railcar Miles (one-way)	Miles	—	—	—	—	—	—	—	—	—	—	—

SAC - Sacramento Terminals
STK - Stockton Terminals
LAP - Los Angeles Port Terminals

FEEDSTOCK TRANSPORTATION

Plant ID		1	2	3	4	5	6	7	8	9	10
Ethanol	Gal/BDT	77	77	77	77	77	77	65	65	65	65
Feedstock	BDT/day	1,423	1,423	712	712	712	712	1,686	1,686	843	843
Truck Capacity	BDT/Truck	22	22	22	22	22	22	14	14	14	14
Truck trips per day	Trucks/day	65	65	32	32	32	32	120	120	60	60
Trucks trips	Truck Trips/MGal	590	590	590	590	590	590	1,099	1,099	1,099	1,099
Average One-way Distance per trip	miles/trip	40	40	25	25	25	25	25	25	25	25
Average Speed	miles/hr	40	40	40	40	40	40	40	40	40	40
Average #of hour loading/unloading	hr/trip	2	2	2	2	2	2	2	2	2	2
Number of trips by truck (10-hr days)	trips/day	3	3	3	3	3	3	3	3	3	3
Load per truck per day	BDT/truck/day	55	55	68	68	68	68	43	43	43	43
Number of trucks per day	Trucks/day	26	26	11	11	11	11	39	39	20	20
Number of trucks	Trucks/MGal	0.6	0.6	0.5	0.5	0.5	0.5	1.0	1.0	1.0	1.0

Plant ID		11	12	13	14	15	16	17	18	19	20	21
Ethanol	Gal/BDT	65	78	78	78	78	78	78	78	78	78	78
Feedstock	BDT/day	843	354	354	354	354	354	354	354	354	354	354
Truck Capacity	BDT/Truck	14	25	25	25	25	25	25	25	25	25	25
Truck trips per day	Trucks/day	60	14	14	14	14	14	14	14	14	14	14
Trucks trips	Truck Trips/MGal	1,099	516	516	516	516	516	516	516	516	516	516
Average One-way Distance per trip	miles	25	20	20	20	20	20	20	20	20	20	20
Average Speed	miles/hr	40	40	40	40	40	40	40	40	40	40	40
Average #of hour loading/unloading	hr	2	2	2	2	2	2	2	2	2	2	2
Number of trips by truck (10-hr days)	trips/day	3	3	3	3	3	3	3	3	3	3	3
Load per truck per day	BDT/truck/day	43	83	83	83	83	83	83	83	83	83	83
Number of trucks per day	Trucks/day	20	4	4	4	4	4	4	4	4	4	4
Number of trucks	Trucks/Mgal	1.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4

Appendix IV-A

Economic Evaluation

IV-A-1 Total Economic Impacts

Total economic impacts were estimated for a moderate demand California Ethanol case (200 million gallons/year produced in California) and a high demand California Ethanol case (400 million gallons/year produced in California). Direct impacts are based upon a comparison with a Zero California Ethanol case in which California imports and consumes 300 million gallons/year or 600 million gallons/year in the high demand case. The direct impacts were then used as inputs to IMPLAN (a regional economic input-output model) to estimate the secondary economic impacts on the California economy (see detailed discussion below). Impacts were estimated for different time periods depending on the type of impact. Impacts due to construction activity were specified to occur between 2001 and 2008. Recurring impacts due to California ethanol production occur between 2004 (when the first plant begins operations) and 2029 (when the last plant is shut down). The positive and negative direct and indirect impacts were then summed by year to produce a total benefit stream for each case. A net present value analysis is used to compare these benefit streams with estimated government outlays (in the form of personal income losses).

The following table presents the main assumptions associated with each case analyzed.

Table IV-1. Changes in Key Variables Used to Define Each Case

Variable	CA Ethanol Case	High CA Ethanol Case
Change in CA Ethanol Production (M gal/yr)	200	400
Change in Ethanol Imports (M gal/yr)	-200	-400
Change in Pentane Extraction (M gal/yr)	0	264
Change in CA Gasoline Production (M gal/yr)	0	-32
Change in Gasoline Imports (M gal/yr)	0	-33
Change in Total Fuel Volume (M gal/yr)	0	122
Change in Electricity Peak Production (GW)	0	0
Change in Electricity Production (GW-hr)	-510	-383
Change in Process Natural Gas (M ef/yr)	2,000	4,000

M = million
GW = Giga Watt

IV.A.1.1 Overview of Approach

Overview of Approach

The economic impacts of an ethanol industry are estimated using a regional economic impact model. This model is used to estimate the indirect and induced impacts in California.

Possible Methods to Estimate Economic Impacts

- Economic Base
- Input-Output
- RIMS II
- IMPLAN
- REMI
- CGE

Types of Economic Impacts

Most economic stimuli generate three types of impacts: direct impacts, indirect impacts, and induced impacts. Direct impacts generally refer to those impacts that occur first in the economy. These first round effects are often associated with changes in employment (these impacts can be measured in different metrics: e.g., employment, output, income, value added, etc.) in an industry or institution. For example, assume that a significant rise in the price of forest products causes paper manufactures to use relatively more recycled paper in their production process. Two direct impacts ensue. Employment falls in the forest products industry and increases in the paper recycling industry.

Indirect and induced impacts occur after the direct impacts and are often referred to as secondary impacts. Indirect impacts reflect changes in downstream support industries. Continuing the example, the forest products industry utilizes fuel for its trucks; employment in the petroleum products industry, therefore, would probably decline due to the reduced demand for forest products. The increased demand for recycled paper, on the other hand, would give rise to additional demand for chemicals used in the deinking process. As a result, employment in the chemical manufacturing industry would increase.

Induced impacts are the result of employees spending their disposable income. Changes in expenditure levels generate related employment changes in the manufacture and distribution of consumer products. For example, total earnings in both the recycled paper industry and the chemical industry would increase as a result of the increased demand for recycled paper. Part of these increased earnings would be spent on clothing, which would generate employment in its manufacture and distribution.

Model Selection and Overview

Calculating all of these impacts requires an economic model that can appraise impacts through multiple tiers of expenditures. There are a number of different models that could be used for this purpose: e.g., IMPLAN, REMI, or RIMS II. IMPLAN was used for several reasons. First, IMPLAN is both easier to understand and is much less expensive than the REMI model. Second, to improve the accuracy of the impact estimates it is desirable to create custom multipliers based upon the specifics of the California economy and the ethanol industry being evaluated. This is not possible with RIMS II but, as discussed later, can easily be done with IMPLAN.

IMPLAN uses input-output analysis (a method of examining relationships between producers and consumers in an economy) to analyze the effects of an economic stimulus on a specified economic region. IMPLAN provides data at three geographic levels: national, state, and county. These geographic units can be combined to construct any regional grouping the user desires. The ease with which alternative regional aggregations can be constructed while preserving critical trade flow information is a principal advantage of IMPLAN.

There are two major components in the IMPLAN model: a descriptive model and a predictive model. The descriptive model is represented by accounting tables that describe the trade flows between producers and consumers in the region. The trade flows detail not only intra-regional flows but also flows between the study area and the "rest of the world". The descriptive model also incorporates Social Accounting Matrices (SAMs), which show money flows between institutions: e.g., taxes paid by consumers to governments and transfer payments from governments to businesses and households.

The predictive model consists of a set of multipliers that can be used to forecast changes in the economy. Multipliers are the means by which the initial change is translated into direct, indirect, and induced impacts. Thus, IMPLAN can be used to predict the regional economic repercussions due to changes in supply or demand or due to changes in model parameters (e.g., income tax rate).

The IMPLAN multipliers are based on the descriptive model and are computed only after the regional economic accounts have been completely defined. This is an important advantage of IMPLAN. In the descriptive model, all of the model parameters can be changed to reflect a particular scenario or situation. Consequently, the resulting multipliers embody such changes. Examples of parameters that can be changed include regional purchase coefficients, margin rates, and production coefficients. Some regional models, such as RIMS II, only provide the multipliers for evaluating economic impacts and do not provide the descriptive accounts that can be used to developed custom multipliers. Since they are not able to incorporate specific conditions in a local economy, the impacts predicted by these models are usually less accurate than impacts predicted by models such as IMPLAN.

IMPLAN conducts its analysis for 528 industrial sectors, primarily a mix of 4-digit and 3-digit SIC sector detail. This highly detailed sectoring plan is critical in input-output modeling, where the production function determines the indirect impacts associated with increased output in an industry. In a highly aggregated sectoring plan (for example, 2-digit SIC level) the production function coefficients and impact multipliers are averaged over all the different firms that comprise each 2-digit SIC group. Therefore, a specific facility of interest may have a production process that differs substantially from that represented at the 2-digit SIC level. Modeling impacts at the 4-digit level reduces the inaccuracies associated with industry aggregations.

The model is stimulated using estimates of the direct impacts. All direct impacts are defined in terms of the differences between the "with" and "without" scenarios.

These impacts are estimated outside of the model. These first round effects can be measured in different metrics: e.g., employment, output, income, or value added. After a model scenario has been run, results are available for all metrics and type of impact (direct, indirect, and induced).

Estimation of Indirect Impacts

Operations

Two approaches can be used to estimate the economic impacts associated with ethanol production operations. The easiest approach is simply to stimulate the output of those industries that are directly impacted. As noted above, there are problems with this approach due to how industries are aggregated in IMPLAN (or any other regional model). For example, IMPLAN's transportation sector consists of numerous industries with very different production processes. Note that the transportation production function represents an average of all of these different industry production processes. If the focus of analysis is on only one of these transportation industries, stimulating the entire transportation sector may lead to large inaccuracies if that industry's production process is very different from the average sector production process.

The ability to group events in IMPLAN is an important feature that can be used to deal with these type of aggregation problems. Stimulating a sector's output is an individual event in IMPLAN, so multiple sectors can be stimulated simultaneously. Rather than stimulating the output of the directly impacted industry, sometimes it is better to simultaneously stimulate the sectors associated with the inputs to that industry. To some extent, this helps circumvent the aggregation problem.

To carry out this approach, it is first necessary to determine the production function of the directly impacted industry. Data is gathered on the inputs into ethanol production. A concordance between the data's sectoring plan and IMPLAN's industry scheme is developed. Knowledge of SIC coding is used whenever possible. In some cases there may not be a one-to-one correspondence, and the data may have to be aggregated or split accordingly.

The next step is to determine the output in the industries directly impacted by the stimulus. These figures are multiplied by the production coefficients (estimated in the first step), yielding estimates of the total cost of each input used.

Finally, the total cost associated with each input is used to stimulate a sector in IMPLAN. At this point, note that only the costs of intermediate inputs are being stimulated. However, the impacts resulting from payroll expenditures will also be estimated; the procedure for doing so is described below under "Induced Impacts".

Investment

It should be noted that the production equations in an input-output model do not include capital investment (rather, capital depreciation is included with value added). While data on employment/output and intermediate inputs allows us to estimate the impacts resulting from current operations, they do not allow us to estimate those impacts associated with initial investments. Such investments include purchases of machinery and equipment (e.g., bailers and sorters) and purchases of construction services if new structures have to be built. This issue is relevant since we are evaluating different growth scenarios for the ethanol production industry. Industry growth depends upon these types of investments.

The procedure used to estimate the economic impacts associated with capital investment is similar to the one used for operations. First, total investment needs to be allocated to equipment and structures. Total equipment investment then needs to be further allocated to the different types of equipment that will be purchased. Next, the investment categories are mapped to the relevant IMPLAN sectors. For example, investment in conveyors would be mapped to IMPLAN sector 315 (Conveyors and Conveying Equipment). The output of these IMPLAN sectors is then stimulated with the respective investments. Investment or industrial margins (primarily transportation) are applied to each stimulated sector; regional purchase coefficients are also assigned to take into account purchased equipment and machinery that are manufactured out of the state.

Estimation of Induced Impacts

As pointed above, induced effects are the result of employees spending their disposable income. The estimation of these impacts entails a three stage process. First, employee earnings for each impacted industry are converted into disposable income using assumed tax rates and savings rates. Disposable income is then allocated to income groups using data on consumption expenditures by income group, which are available from secondary data sources. Finally, personal consumption expenditure (PCE) vectors for each income group are stimulated in IMPLAN using the above disposable income estimates. Household margins are applied to these expenditures to ensure that the wholesale trade, retail trade, and transportation sectors are appropriately stimulated.

Estimation of Tax Revenue Impacts

The total economic impacts, defined in terms of changes in total personal income (TPI), are used to estimate the annual gains in tax revenues. The estimates are based upon ratios of tax revenues to TPI developed using data for California. State and local government tax revenues are provided by the U.S. Census Bureau. These revenues include property taxes, sales and gross receipts, and other tax revenues. TPI by state is furnished by the U.S. Bureau of Economic Analysis.

IV.A.1.2 Direct Impacts

Direct economic impacts were defined and estimated for different types of events that would result from the establishment of a California ethanol production industry. For example, two events that were considered were (1) reduced ethanol imports and (2) increased sales of California produced ethanol. Several direct impacts were associated with each event. For example, the reduction in imports would negatively impact both the wholesale trade and fuel transportation sectors in California. Each of these was defined as a direct impact. Offsetting these negative impacts were positive impacts on the wholesale and fuel transportation sectors due to the increase in California ethanol production.

All direct impacts were measures in terms of changes in industry output or commodity demand.

Capital Investments

Capital investments include purchases and installation of equipment, construction costs, and other minor expenses. Acquisition of land is not included in the analyses, since those purchases represent an economic transfer. The analyses consider investments in ethanol plants/biomass power facilities and in truck fleeting needed to transport feedstock and distribute ethanol to storage terminals.

The manufacture of the equipment and the construction of the facilities create jobs and positive economic impacts over short periods of time. However, since the proposals under consideration do not affect the cost of capital, total capital expenditures are assumed to remain the same in the U.S. and abroad. This means the investments displace investments that would have occurred both in California and outside of the state. Displaced investment that would have occurred outside of the state is considered a benefit since it represents positive economic growth in California that otherwise would not have occurred. Based on the amount of manufacturing investment that takes place in California relative to the U.S., it is assumed in this report that 11% of the total capital investment would have occurred in California in the reference case. Therefore, 89% of the principal represents new investment in California.

Plant Construction and Modification

New plant investment was allocated to those economic sectors involved in building the plants. Based upon engineering cost estimates, the following percentages were used to carry out the allocation:

Construction Services:	32.9%
Cost of Equipment:	39.5%
Equipment Installation (Labor):	19.7%
Engineering/Architectural Services:	7.9%

The following table presents the results of the allocation. Note that expenditures for labor will be assigned to IMPLAN's personal consumption expenditure vector. In addition, the "New Investment in California" figures do not necessarily represent the total direct impact on the California economy. For example, some of the purchased equipment is manufactured in other states. During the model runs, IMPLAN's regional purchase coefficients were used to assign portions of the direct expenditures to California. Finally, the table presents the total amount of investment planned for each scenario. These investments will take place gradually over a construction phase. The timing of these investments and their associated economic impacts are taken into account in the present value analysis.

Table IV-2. Capital Investment in Ethanol Plant and Biomass Power Facilities (in million dollars)

Investment	CA Ethanol	High California Ethanol
Total Investment	660	1,426
New Investment in California	587	1,269
Construction	193	418
Equipment Manufacturing	232	501
Personnel Consumption Expenditures (labor)	116	250
Engineering/Architectural Services	46	100

Truck Fleet Investment

Ethanol Distribution

Additional truck fleeting will be required to distribute the ethanol. Ethanol produced in California will have to be carried by rail or truck from the production sites to wholesalers and blending points. It is assumed that imported ethanol will be carried by ship or rail to these distributors.

The calculations to estimate the additional trucks consist of several steps. First, annual California ethanol production was converted into daily demand by dividing it by a capacity factor (360 days). Next, this demand was divided by the average truck tank size to estimate the number of truck trips per day. The number of truck-trips per day was then divided by an estimate of daily trips per truck[1], yielding the actual number of trucks needed to deliver the product. Auxiliary trucks were added to this number to take into account overhauls and other major downtime. Finally, the total fleet size was multiplied by the estimated truck purchase price to yield the total capital investment.

Table IV-3 presents the parameters used in the calculations. Table IV-4 presents the results of the calculations and the required capital investment. These figures were used to stimulate IMPLAN sector 384 (Motor Vehicles). It is assumed that the trucks will be not be manufactured exclusively in California; therefore, the investments do not represent the total direct impact on the California economy. During the model runs, IMPLAN's regional purchase coefficients were used to assign portions of these direct expenditures to California.

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[1] Estimates of daily trips per truck are based on assumptions about round-trip mileage per trip, average travel speed, loading and unloading time, and the number of hours each truck is used.

Table IV-3. Parameters Used to Estimate Fleet Investment

Transportation Parameter	Value
Tank size (Gal)	10,000
Truck Price ($)	100,000
Miles per Trip (Roundtrip)	120
Capacity (days)	360
Average Speed (mph)	40
Downtime per trip (hr)	2
Travel Time per Trip	3
Total Trip Time	5
Hours per Day	16
Trips per Truck per Day	3.2
Reserve Adjustment	1.2

Table IV-4. Investment in Truck Fleet for Fuel Distribution

Distribution of CA Ethanol Production to Storage Terminal	CA Ethanol Production	High CA Ethanol Production
Million Gallons Per Year	200	400
Gallons Per Day	556,000	1,110,000
Total Truck Trips Per Day	56	111
Additional Fleet Required	17	35
Total Fleet Required	21	42
Capital Investment ($)	2,083,000	4,167,000

Feedstock Transportation

Additional truck fleeting will be required to transport the feedstock. Table IV-5 presents the required capital investment for each case. Note that the estimates represent net new investment in California: i.e., the displaced capital has been subtracted from the total. The figures were used to stimulate IMPLAN sector 384 (Motor Vehicles). It is assumed that the trucks will be not be manufactured exclusively in California; therefore, the investments do not represent the total direct impact on the California economy. During the model runs, IMPLAN's regional purchase coefficients were used to assign portions of these direct expenditures to California.

Table IV-5. New Capital Expenditures for Feedstock Transportation Fleet

Case	Expenditures ($)
3	26,878,000
4	41,296,000
6	26,878,000
7	53,934,000

Finance

Given the fluidity of financial capital, it is assumed for this report that there would be no economic impact on California's investment banks or brokerage firms. Although the additional investment in ethanol production would occur in California, it is assumed that the borrowed funds used to pay for the purchases would be obtained from sources across the nation (e.g., consider a firm that issues stocks to pay for new investments). California currently accounts for 12.5% of U.S. personal income. Therefore, it is assumed in all scenarios that Californians would finance 12.5% of new investment in the U.S., regardless of where the investments actually takes place. In other words, it is assumed that the case definitions do not contain policy instruments that would give rise to additional investment by California residents or institutions.

Operating Expenditures and Other Recurring Impacts

Processing Materials Used in Ethanol Production

Because there are a number of industries that produce the non-feedstock materials used in ethanol production, it was necessary to distribute total expenditures on these materials to the various sectors that produce them. The primary materials used in ethanol production other than feedstock include sulfuric acid, lime, yeast, corn steep liquor solids, anhydrous ammonia, denaturant and zeolite. Tonnage figures for each plant and material were used to estimate the total quantity of each material required in the California Ethanol and the High California Ethanol cases. The material requirements were based on ProForma ethanol plant modeling. Shares for each case and material were contructed based upon the total tonnage of materials consumed in each case. Multiplying these shares by the total expenditures on processing materials produced the desired allocation. Note that the expenditure figures do not necessarily represent the direct impact on the California economy because some of the materials are manufactured in other states. During the model runs, IMPLAN's regional purchase coefficients were used to assign portions of the direct expenditures to California.

Table IV-6. Expenditures for Processing Materials ($)

Case	Total Cost	Sulfuric Acid	Lime	Yeast	Corn Steep Liquor	Anhydrous Ammonia	Denaturant (gasoline)	Zeolite
CA Ethanol	22,000,000	600,000	400,000	40	6,600,000	2,600,000	11,000,000	600,000
High CA Ethanol	44,000,000	1,200,000	800,000	80	13,200,000	5,200,000	22,000,000	1,200,000

Water Used in Ethanol Production

Expenditures for water were assigned to IMPLAN sector 445 (Water Supply and Sewage Systems) and are presented below for each case.

Table IV-7. Annual Ethanol Plant Operating Expenditures for Water

Case	Expenditures ($)
CA Ethanol	5,225,000
High CA Ethanol	10,450,000

General Maintenance of Ethanol Plants

Expenditures for maintenance was assigned to IMPLAN sector 472 (Services to Buildings). While ethanol plants may provide their own maintenance, it is assumed that the production function of this activity is similar to the production function of maintenance service companies. Expenditures for maintenance are presented below for each case.

Table IV-8. Annual Ethanol Plant Operating Expenditures for Maintenance

Case	Expenditures ($)
CA Ethanol	605,000
High CA Ethanol	1,200,000

Employee Compensation

The average annual salary for plant personnel is $37,573, based on ProForma statistics. Marketing personnel earn $74,107 per year on average based on Abbott, Langer & Associates, Inc. marketing and sales survey. When employees spend these earnings, additional economic impacts are generated. The number of items in the normal consumer basket is quite large, and it is not possible to enumerate all of them here. However, IMPLAN has a feature that distributes specified income into numerous personal consumption categories. Different expenditure patterns are provided for different income groups. Given the average salaries noted above, we chose to use the medium income group for plant personnel and the high-income group for marketing personnel. Table IV-9 below presents the total employee earnings that were used to stimulate IMPLAN's personal consumption expenditure (PCE) vectors.

Table IV-9. Annual Employee Earnings ($) for Ethanol Plant and Marketing Operations

Case	Plant Personnel	Marketing Personnel
CA Ethanol	8,453,952	2,000,880
High CA Ethanol	19,725,888	4,668,720

Ethanol Distribution Costs

In addition to plant operation and feedstock collection and production expenditures, an ethanol production industry would also give rise to growth in the transportation and trade sectors used to distribute the fuel. It is assumed that these impacts would occur exclusively within California.

The calculation of these impacts entailed several steps. First, production volumes were converted into revenues and then adjusted for Federal and State taxes. The adjusted sales figures were then allocated to industry sectors using margin percentages obtained from IMPLAN. We used the margin percentages associated with the petroleum-refining sector, which is dominated by the manufacture of gasoline. Margins associated with the sector, in which ethanol production is classified (190: Cyclic Crudes, Intermediate and Industrial Organic Chemicals) appeared to be heavily biased by output associated with non-fuel products. One adjustment was made to the petroleum sector's transportation margins: transportation expenditures for pipeline services were allocated to truck and rail sectors. Table IV-10 below presents the parameters used in the process, whereas Table IV-11 presents the resulting economic impacts associated with the distribution of California produced ethanol.

Table IV-10. Parameters Used to Calculate the Impacts of California Ethanol Distribution

Parameter	Value
Ethanol Price ($/gal)	1.44
Margin Percentages	
Manufacturing	65%
Rail	1%
Truck	2%
Wholesale Trade	15%
Regional Purchase Coefficients	
Manufacturing	100%
Rail	100%
Truck	100%
Wholesale Trade	100%

Table IV-11. Direct Impacts of Distributing California Ethanol Production

	CA Ethanol	High CA Ethanol
California Ethanol Production		
Volume (Gal/Yr)	200,000,000	400,000,000
Sales ($)	288,000,000	576,000,000
Margins ($)		
Manufacturing	203,580,000	407,160,000
Rail	3,132,000	6,264,000
Truck	6,264,000	12,528,000
Wholesale Trade	46,980,000	93,960,000
Service Station	53,244,000	106,488,000
Impacts on California Economy ($)		
Rail	3,132,000	6,264,000
Truck	6,264,000	12,528,000
Wholesale Trade	46,980,000	93,960,000
Service Station	53,244,000	106,488,000

Feedstock Collection

Transportation

Expenditures for feedstock transportation were assigned to IMPLAN sector 435 (Motor Freight Transport and Warehousing) and are presented below for each case. Note that these figures represent net increases in feedstock transportation costs relative to the case with no ethanol. It is assumed that the expenditure occurs entirely within California.

Table IV-12. Annual Expenditures for Feedstock Transportation

Case	Expenditures ($)
CA Ethanol	5,000,000
High CA Ethanol	10,000,000

Collection

Assumptions about feedstock collection efforts vary depending on the type of feedstock and the location of the plants. In the Zero California Ethanol case, some forest materials would be collected and used in biomass production facilities. Controlled burns would also be used to reduce the amount of forest residues in areas susceptible to fire damage. The alternative cases, on the other hand, would require an expansion of forest material collection efforts to feed the ethanol plants. As a result of relatively less forest residue, the need for controlled burns would decline. In all cases, it is assumed that expenditures on controlled burns would decline by $500,000 per year, based on a cost of $50-$70 per acre.

In the Zero California Ethanol case, some agricultural residues would be burned or collected for feedstock. Most of the rice straw would be tilled back into the ground. Collecting the straw for ethanol production would require additional manpower, but at the same time would reduce the need for tilling operations. It is assumed that the cost of reworking the straw into the ground is equal to labor expenditures for equipment operators involved in agricultural feedstock collection. To estimate this expense, we allocated total equipment operator earnings based on the ratio of the tons of agricultural and forest material feedstocks used in each case. These percentages are presented below.

Table IV-13. Ratios of Feedstocks Used to Allocate Equipment Operator Earnings

	CA Ethanol	High CA Ethanol
Forest Material Feedstocks	**44.8%**	**48.5%**
Forest Slash/Thinnings	39.0%	42.2%
Lumbermill Waste	5.8%	6.3%
Agricultural Residue Feedstocks	**55.2%**	**51.5%**
Rice Straw	23.9%	12.9%
Other Agricultural Residue	31.2%	38.6%

It is assumed that there is no net impact on feedstock collection efforts in urban areas.

Table IV-14 below presents the net impact on labor expenditures for harvesting personnel and equipment operators. The figures were used to stimulate IMPLAN's PCE vector.

Table IV-14. Net Labor Expenditures for Feedstock Collection

Case	Expenditures ($)
CA Ethanol	2,164,924
High CA Ethanol	5,788,979

Ethanol Imports

There are a number of industries associated with the importation of ethanol; therefore, any policy, which affects import levels, will have an impact on these sectors. After subtracting federal and state taxes, the price of ethanol can be divided into manufacturing costs, transportation costs for distribution, and trade margins. Regarding transportation margins, it is assumed that ethanol is brought into the state by rail and ship. Trade margins include wholesale blending services.

These activities do not take place entirely within California. Changes in activities that occur outside of the state do not represent an impact on the California economy. The manufacturing process was assumed to take place in the U.S. Midwest; therefore, the analysis does not address the changes in manufacturing output levels resulting from induced changes in California ethanol demand. Truck and wholesale margins, on the other hand, were assumed to take place entirely within California. Rail and ship margins include services provided both within California and outside of the state. Therefore, it was necessary to divide the expenditures for rail and ship into California services and out-of-state services.

The calculation of the impacts on the California economy entailed several steps. First, changes in import volumes were converted into revenue changes and then adjusted for Federal and State taxes. The adjusted sales figures were then allocated to industry sectors using margin percentages obtained from IMPLAN. We used the margin percentages associated with the petroleum-refining sector, which is dominated by the manufacture of gasoline. Margins associated with the sector in which ethanol production is classified (190: Cyclic Crudes, Intermediate and Industrial Organic Chemicals) appeared to be heavily biased by output associated with non-fuel products. Two adjustments were made to the petroleum sector's transportation margins. First, transportation expenditures for pipeline services were allocated to truck and rail sectors. We then slightly reapportioned the truck and rail expenditures. This adjustment was made because the IMPLAN margins are associated with California production, which is delivered primarily for domestic consumption; therefore, the relative relationship among the transportation margins presumably differ from those associated with imported fuel. Finally, a regional purchase coefficient was used to allocate a portion of the rail margin to California. Table IV-15 below presents the parameters used in the process, whereas Table IV-16 presents the resulting economic impacts associated with the considered changes in ethanol import volumes.

Table IV-15. Parameters Used to Calculate Impacts of Ethanol Imports

Parameter	Value
Ethanol Price ($/gal)	1.44
Margin Percentages	
Manufacturing	65%
Rail	2%
Truck	1%
Regional Purchase Coefficients	
Manufacturing	0%
Rail	50%
Truck	100%

Table IV-16. Direct Impacts of Changes in Ethanol Imports

	CA Ethanol	High CA Ethanol
Change in Ethanol Imports		
Volume (Gal/Yr)	(50,000,000)	50,000,000
Sales ($)	(72,000,000)	72,000,000
Margins ($)		
Manufacturing	(50,895,000)	50,895,000
Rail	(1,566,000)	1,566,000
Truck	(783,000)	783,000

Gasoline Imports

There are a number of industries associated with the importation of gasoline; therefore, any policy that affects import levels will have an impact on these sectors. After subtracting Federal and State taxes, the price of gasoline can be divided into manufacturing costs, transportation costs for distribution, and trade margins. Regarding transportation margins, it is assumed that imported gasoline is brought into the state by pipeline and then distributed to retail outlets by truck. Trade margins include wholesale services and retail services.

These activities do not take place entirely within California. Changes in activities that occur outside of the state do not represent an impact on the California economy. The manufacturing process takes place outside of the state; as a result, the analysis does not address the changes in manufacturing output levels resulting from changes in California gasoline imports. Truck, wholesale, and retail margins, on the other hand, were assumed to take place entirely within California. Pipeline margins include services provided both within California and outside of the state. Therefore, it was necessary to divide the expenditures for pipe transportation into California services and out-of-state services.

The calculation of the impacts on the California economy entailed several steps. First, changes in import volumes were converted into revenue changes and then adjusted for federal and state taxes. The adjusted sales figures were then allocated to industry sectors using margin percentages obtained from IMPLAN. We used the margin percentages associated with the petroleum-refining sector, which is dominated by the manufacture of gasoline. Two adjustments were made to the petroleum sector's transportation margins. First, all transportation margins were allocated to truck and pipeline service sectors. We then slightly reapportioned the truck and pipeline expenditures. This adjustment was made because the IMPLAN margins are associated with California production, which is delivered primarily for domestic consumption; therefore, the relative relationship among the transportation margins presumably differ from those associated with imported fuel. Finally, a regional purchase coefficient was used to allocate a portion of the pipeline margin to California. Table IV-17 below presents the parameters used in the process, whereas Table IV-18 presents the resulting economic impacts associated with the considered changes in gasoline import volumes.

Table IV-17. Parameters Used to Calculate Impacts of Gasoline Imports

Parameter	Value
Gasoline Price ($/gal)	1.9115
Margin Percentages	
Manufacturing	65%
Rail	2%
Truck	1%
Regional Purchase Coefficients	
Manufacturing	0%
Rail	50%
Truck	100%

Table IV-18. Direct Impacts of Changes in Gasoline Imports

	CA Ethanol	High CA Ethanol
Change in Gasoline Imports		
Volume (Gal/Yr)	—	(33,000,000)
Sales ($)	—	(63,079,500)
Margins ($)		
Manufacturing	—	(29,461,575)
Pipeline	—	(906,510)
Truck	—	(453,255)
Impacts on California Economy ($)		
Pipeline	—	(453,255)
Truck	—	(453,255)

California Gasoline and Pentane Production

In either case, positive economic impacts are projected for the petroleum-refining sector. Although motor fuel sales may drop, these revenue changes will be more than offset by sales of extracted pentanes.

To reduce the volatility of ethanol fuel products, pentanes are extracted from gasoline through an additional refining process. In the California Ethanol case, it is assumed the pentanes are not removed from the gasoline. As a result, costs associated with this activity in the alternative scenarios represent increased output for the petroleum refining industry (IMPLAN sector 210: Petroleum Refining). It is assumed that this activity occurs entirely within California.

To estimate the impact, the volume of pentanes produced was multiplied by the retail price of gasoline, which was assumed to be fairly close to the wholesale price of pentanes. The result was then distributed to industrial margins (manufacturing and transportation between the producer and wholesaler); since pentane is an industrial chemical used in other manufacturing processes, wholesale and retail margins were not added.

The two impacts were then added by sector to produce the net impact. For each case, the following table shows the resulting direct impacts.

Table IV-19. Net Impact ($) of Changes in Gasoline Production and Pentane Extraction on California's Petroleum Refining Sector

	CA Ethanol	High CA Ethanol
Petroleum Refining	251,218,804	474,884,483
Pipeline Transportation Services	1,967,777	3,511,659
Truck Transportation Services	3,935,554	7,023,319

Electricity

The net change in total electricity produced in the state was used to stimulate IMPLAN sector 443 (Electric Services). Depending on the operating characteristics of the ethanol plants, the net change could be positive or negative. Chapter V discusses the flexibilities in operating collocated ethanol plants and the energy environment that would lead to various ethanol and electricity production choices. The scenario used in the model assumed that forest material and agricultural biomass power plants were operating prior to the addition of ethanol facilities.

Consumer Expenditures for Fuel

Since the energy content of ethanol is lower than it is for gasoline, consumers will have to purchase more fuel to travel the same distance over the year. This fact combined with differences in prices between the two products could affect consumer purchasing power. To deal with this issue, it was assumed that the ratio of equilibrium prices for ethanol and gasoline would equate with the ratio of the energy content of the two products. This implies that consumer welfare would not change since they would be able to travel the same distance for the same cost. Given a retail price of $1.44 per gallon of ethanol, the equilibrium prices for gasoline was assumed to be $1.9115.

IV.A.1.2 Total Economic Impacts

The direct impacts associated with developing an ethanol production industry in California are defined below in Tables IV-22 through 24. They are associated with various events (e.g., reduced ethanol imports); they are defined for each case, and their measurement is based upon a comparison with the Zero California Ethanol case.

Table IV-20. Capital and Operations Direct Impacts

CAPITAL AND OPERATIONS DOLLAR INPUTS TO THE I/O ECONOMIC MODEL		
	CA ETHANOL	HIGH CA ETHANOL
Annual California Ethanol Production (Million gal)	200	400
Number of Plants	9	21
Total Capital Investment[a], TCI (Million $)		
Equipment Cost	$261	$563
Installation	$130	$281
Construction Totals	$217	$469
Engineering/Design/Architectural/Other Services	$52	$113
Total Capital Investment, TCI (Million $)	**$660**	**$1,426**

[a] TCI dollar amount derived from ProForma, Inc., collocated ethanol plant model

[b] Land (Acquisition of land is not included in the analyses since those reflect economic transfer

Construction also includes permitting and preparation costs.

[c] Other services include financing and related costs

Note 1 Ethanol storage terminal capital costs are included in the above costs and are approximately $1/gallon TCI for a 60-day storage capacity of 30,000,000 gallons.

Note 2 Co-product process equipment related costs are included in the above costs.

Table IV-21. Operating Cost Direct Impacts

Operating Costs ($/Year)	CA ETHANOL	HIGH CA ETHANOL
Feedstock Collection and Processing	$18,948,000	$32,588,758
Processing Materials	$19,645,040	$39,290,080
Maintenance	$605,497	$1,210,994
Ethanol Transport	$3,540,000	$7,080,000
Feedstock Transport	$4,738,708	$9,477,415
Total Operating Costs ($/yr)	$47,477,245	$89,647,247

Table IV-22. Employment Direct Impacts

Employment	CA # of	HIGH CA # of
Fleet	64	130
Feedstock Collection and	630	1,084
Processing	64	81
Maintenanc	21	42
Ethanol	34	68
Feedstock	46	91
Plant & Infrastructure	3,893	8,410

The direct impacts were then used as inputs into IMPLAN to estimate the secondary economic repercussions on the California economy. Separate runs were executed for each case and event listed below:

Plant Investment
Truck Fleet Investment
Usage of Processing Materials
General Maintenance Activities
Usage of Water
Compensation of Plant and Marketing Personnel
Distribution (trade and transportation) of Domestic Ethanol
Transportation of Feedstocks
Collection of Feedstocks
Production Electricity
Natural Gas Imports
Ethanol Imports
Gasoline Imports
California Petroleum Sector Output

For each case and event, the model generated the direct, indirect, and induced impacts on the California economy. The results were presented in several metrics including changes in output, changes in employment, changes in personal income, and changes in value added. Table IV-23 shows the multipliers used to calculate these impacts in various industry sectors.

The results were then scaled to take into account differences in activity levels at different time periods. Impacts due to construction activity were scaled based upon the projected capital outlays presented in Table IV-24. Construction activities are slated to occur between 2001 and 2008. Reoccurring impacts due to California ethanol production were scaled based upon the volumes of ethanol production forecast for each year. These volumes vary depending upon when plants first begin operations and when they shut down. Operations are expected to occur between 2003 and 2028. The factors used to scale the reoccurring impacts are shown in the following table.

Table IV-23. Indirect and Induced Impacts Multipliers

Industry Sectors	Metric	Direct	Indirect	Induced
Plant Investment	Output	1.00	0.35	0.38
	Employment	7.53E-06	3.80E-06	4.79E-06
	Personal Income	0.48	0.14	0.14
	Value Added	0.55	0.21	0.24
Fleet Investment	Output	1.00	0.30	0.41
	Employment	1.27E-05	2.91E-06	5.16E-06
	Personal Income	0.38	0.11	0.15
	Value Added	0.59	0.17	0.26
Processing Materials	Output	1.00	0.28	0.32
	Employment	4.02E-06	3.25E-06	4.06E-06
	Personal Income	0.26	0.13	0.12
	Value Added	0.62	0.17	0.20
Maintenance	Output	1.00	0.30	0.59
	Employment	3.44E-05	3.30E-06	7.43E-06
	Personal Income	0.58	0.12	0.22
	Value Added	0.69	0.18	0.37
Plant Earnings	Output	1	0.21	0.27
	Employment	2.41E-05	2.13E-06	3.39E-06
	Personal Income	1	0.08	0.10
	Value Added	1	0.12	0.17
Distribution	Output	1	0.63	0.46
	Employment	9.64E-06	6.01E-06	5.72E-06
	Personal Income	0.33	0.22	0.17
	Value Added	0.42	0.33	0.29
Feedstock Collection	Output	1	0.21	0.27
	Employment	3.33E-05	2.12E-06	3.42E-06
	Personal Income	1	0.08	0.10
	Value Added	1	0.12	0.17
Feedstock Transport	Output	1	0.63	0.46
	Employment	9.64E-06	6.01E-06	5.72E-06
	Personal Income	0.33	0.22	0.17
	Value Added	0.42	0.33	0.29
Ethanol Imports	Output	1	0.32	0.43
	Employment	5.4E-06	2.8E-06	5.4E-06
	Personal Income	0.39	0.12	0.16
	Value Added	0.67	0.64	0.18
Net Power	Output	1	0.07	0.19
	Employment	1.77E-06	6.97E-07	2.35E-06
	Personal Income	0.20	0.03	0.07
	Value Added	0.85	0.04	0.12
Corporate Income Tax	Output	1	0.21	0.27
	Employment	2.41E-05	2.13E-06	3.39E-06
	Personal Income	1	0.08	0.10
	Value Added	1	0.12	0.17

Table IV-24. Factors Used to Scale Impacts Due to Plant Operations

	CA Ethanol	High CA Ethanol
2002	0%	0%
2003	0%	0%
2004	30.00%	20.00%
2005	50.00%	40.00%
2006	60.00%	60.00%
2007	85.00%	75.00%
2008	90.00%	85.00%
2009	95.00%	92.50%
2010	100.00%	100.00%
2011	100.00%	100.00%
2012	100.00%	100.00%
2013	100.00%	100.00%
2014	100.00%	100.00%
2015	100.00%	100.00%
2016	100.00%	100.00%
2017	100.00%	100.00%
2018	100.00%	100.00%
2019	100.00%	100.00%
2020	100.00%	100.00%
2021	100.00%	100.00%
2022	100.00%	100.00%
2023	100.00%	100.00%
2024	70.00%	80.00%
2025	50.00%	60.00%
2026	40.00%	40.00%
2027	15.00%	25.00%
2028	10.00%	15.00%
2029	5.00%	7.50%

The direct, indirect, and induced impacts were then summed by year to produce a total benefit stream for each case. These are presented in Table IV-25 below. A net present value analysis is used to compare these benefit streams with estimated government outlays.

Table IV-24. Total Economic Impacts by Case, Metric and Year

Year	Output	Employment	Personal Income	Value Added	Output	Employment	Personal Income	Value Added
2002	128,347,268	1,196	56,918,832	74,102,576	170,871,944	1,592	75,777,471	98,654,620
2003	214,393,589	1,998	95,078,243	123,782,278	359,053,977	1,592	159,231,538	207,303,392
2004	159,127,255	1,669	73,242,750	95,883,506	530,591,805	2,478	187,596,242	272,816,725
2005	186,104,842	2,037	87,164,556	114,079,543	642,988,855	3,364	189,969,608	304,113,273
2006	184,135,030	2,076	87,299,186	114,243,558	774,440,728	4,250	200,793,315	346,411,312
2007	145,612,975	1,869	72,502,210	95,326,317	872,146,526	4,914	208,578,493	377,607,155
2008	148,568,888	1,922	74,404,886	97,657,125	930,198,868	5,357	210,646,330	394,307,932
2009	121,453,661	1,699	62,854,816	82,661,354	899,262,073	5,689	179,154,167	363,838,478
2010	94,338,434	1,476	51,304,746	67,665,584	868,764,279	6,022	147,827,175	333,631,394
2011	93,903,617	1,471	51,141,150	67,405,714	867,447,275	4,429	147,331,664	332,844,283
2012	92,025,545	1,442	50,118,327	66,057,600	867,447,275	4,429	147,331,664	332,844,283
2013	93,903,617	1,471	51,141,150	67,405,714	867,447,275	4,429	147,331,664	332,844,283
2014	93,903,617	1,471	51,141,150	67,405,714	867,447,275	4,429	147,331,664	332,844,283
2015	93,903,617	1,471	51,141,150	67,405,714	867,447,275	4,429	147,331,664	332,844,283
2016	93,903,617	1,471	51,141,150	67,405,714	867,447,275	4,429	147,331,664	332,844,283
2017	93,903,617	1,471	51,141,150	67,405,714	867,447,275	4,429	147,331,664	332,844,283
2018	93,903,617	1,471	51,141,150	67,405,714	867,447,275	4,429	147,331,664	332,844,283
2019	93,903,617	1,471	51,141,150	67,405,714	867,447,275	4,429	147,331,664	332,844,283
2020	93,903,617	1,471	51,141,150	67,405,714	867,447,275	4,429	147,331,664	332,844,283
2021	93,903,617	1,471	51,141,150	67,405,714	867,447,275	4,429	147,331,664	332,844,283
2022	93,903,617	1,471	51,141,150	67,405,714	867,447,275	4,429	147,331,664	332,844,283
2023	93,903,617	1,471	51,141,150	67,405,714	867,447,275	4,429	147,331,664	332,844,283
2024	65,732,532	1,030	35,798,805	47,184,000	693,957,820	3,543	117,865,332	266,275,426
2025	46,951,808	735	25,570,575	33,702,857	520,468,365	2,658	88,398,999	199,706,570
2026	37,561,447	588	20,456,460	26,962,286	346,978,910	1,772	58,932,666	133,137,713
2027	14,085,543	221	7,671,173	10,110,857	216,861,819	1,107	36,832,916	83,211,071
2028	9,390,362	147	5,114,115	6,740,571	130,117,091	664	22,099,750	49,926,642
2029	4,695,181	74	2,557,058	3,370,286	65,058,546	332	11,049,875	24,963,321

IV.A.2.3 Present Value Analysis

In this section, the methodology described in Section IV.3.5 is used to compare the ethanol production benefits with the costs to the State. It should be noted that the assignment of economic benefits depends on the vantage point of the interested party. Given that government investments are funded in one way or another by the public, it is assumed that the California public is the correct perspective to use. This means that benefits cannot be defined simply in terms of government revenues.

The costs and benefits associated with the proposals will occur over different periods of time. Subsidized capital outlays may be financed. The construction phase of the projects will create jobs and income for a short period of time (2001-2008). Plant operations will result in reoccurring economic benefits over the lives of the ethanol plants (each plant is assumed to operate for twenty years).

Three considerations had to be addressed to compare these different cost and benefit streams. First, all costs and benefits have to be reported in the same metric. For example, it is not possible to compare employment data with dollar figures. Since costs are defined in terms of dollars spent, it was necessary to define the benefits on a dollar basis. Second, to remove the effects of inflation from the analyses, all costs and benefits were defined in terms of constant 2000 year dollars. Finally, we had to take into account the fact that a $100 benefit twenty years in the future is not equal to $100 received today. For example, if you received $100 today and invested it for twenty years, you would have more than $100 at the end of the time period. To deal with this issue, we discounted all future benefits and costs using a rate of return on government investments of similar risk.

Calculate Cost Vectors

Opportunity costs are associated with funds used to subsidize government programs. Regardless of funding source (e.g., bonds or taxes), the true opportunity cost of all government revenues is assumed to be taxpayer income. Reductions in personal income to cover the cost of a government program result in lower consumer spending; hence, additional losses in income accrue through secondary economic repercussions.

Capital Subsidy

It was assumed that the state would fund 10% of the initial investments required to construct or modify the ethanol plants. According to the construction schedule shown in Table IV-26, annual capital outlays are projected to occur between 2001 and 2008, with each plant taking two years to build. Table IV-27 shows the total capital outlays and State's portion that are projected to occur.

Table IV-25. First Year of Construction by Plant ID

Year	CA Ethanol	High CA Ethanol
2002	4, 7	4, 5, 7
2003	8	6, 8, 9
2004	3	2, 3, 10
2005	1, 12	1, 12, 16
2006	13	11, 13, 17
2007	14	14, 18, 20
2008	15	15, 19, 21

Table IV-26. Capital Outlays for Plant Construction with 10% Government Subsidy

(Millions of Constant 2000 Dollars)				
	CA Ethanol		High CA Ethanol	
Year	Total	State	Total	State
2002	91.3	9.1	121.4	12.1
2003	152.5	15.3	255.1	25.5
2004	91.3	9.1	251.2	25.1
2005	97.8	9.8	207.8	20.8
2006	90.3	9.0	177.9	17.8
2007	45.3	4.5	155.5	15.6
2008	45.3	4.5	135.8	13.6
2009	22.6	2.3	67.9	6.8
Total	636	64	1373	137

It is assumed the state would finance these outlays for twenty years (the expected life of the plants) at a 5.77% interest rate. This rate is the average rate over the last 12 months for state and local government obligation bonds maturing in twenty years (obtained from the *Federal Reserve Bulletin* published by the Board of Governors of the Federal Reserve System).

The state would presumably obtain the funds through the issuance of bonds. Both California residents and non-California residents would be able to purchase the bonds. These bond purchases would come at the expense of other investments made since the case definitions do not contain policy instruments that would give rise to additional investment by California residents. In other words, it is assumed that bond purchases by California residents would not come at the expense of personal consumption.

In subsequent years, the state would have to cover the cost of the annual bond payments. These could be financed by additional taxes, use of government surpluses, budget diversions, or some other mechanism. In all cases, it is assumed the payments would come at the expense of personal income, which would lead to a resulting decline in personal consumption expenditures over the entire bond period.

Although annual dividends would lead to increased personal consumption in years after the bonds were sold, it is assumed in the reference case that California residents would receive such income from other investments. Therefore, no economic impact ensues.

Table IV-28 shows the annual bond reimbursements the state would have to make to finance its investment in ethanol production capital (shown in the columns labeled "Direct") The payments represent the annual opportunity cost to the taxpayer in terms of lost income. These figures were used to stimulate IMPLAN's PCE vectors to estimate the total economic repercussions.

Table IV-27. Annual Cost to the State of Subsidizing 10% of Initial Capital Investment in Ethanol Plants

Year	CA Ethanol Production				High California Ethanol Production			
	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total
2002	($770,458)	($61,140)	($78,135)	($909,733)	($1,024,388)	($81,290)	($103,887)	($1,209,564)
2003	($2,057,446)	($163,269)	($208,653)	($2,429,367)	($3,176,938)	($252,106)	($322,184)	($3,751,228)
2004	($14,827,904)	($1,176,668)	($1,503,748)	($17,508,320)	($5,296,733)	($420,322)	($537,160)	($6,254,215)
2005	($23,652,788)	($1,876,966)	($2,398,710)	($27,928,464)	($7,050,276)	($559,474)	($714,993)	($8,324,743)
2006	($28,414,698)	($2,254,847)	($2,881,632)	($33,551,177)	($8,551,801)	($678,628)	($867,267)	($10,097,696)
2007	($38,796,609)	($3,078,703)	($3,934,497)	($45,809,808)	($9,864,281)	($782,780)	($1,000,371)	($11,647,431)
2008	($41,178,519)	($3,267,719)	($4,176,054)	($48,622,293)	($11,010,013)	($873,699)	($1,116,563)	($13,000,276)
2009	($43,369,475)	($3,441,582)	($4,398,247)	($51,209,304)	($11,582,879)	($919,159)	($1,174,659)	($13,676,698)
2010	($45,369,475)	($3,600,292)	($4,601,074)	($53,570,841)	($11,582,879)	($919,159)	($1,174,659)	($13,676,698)
2011	($45,369,475)	($3,600,292)	($4,601,074)	($53,570,841)	($11,582,879)	($919,159)	($1,174,659)	($13,676,698)
2012	($44,569,475)	($3,536,808)	($4,519,943)	($52,626,226)	($11,582,879)	($919,159)	($1,174,659)	($13,676,698)
2013	($45,369,475)	($3,600,292)	($4,601,074)	($53,570,841)	($11,582,879)	($919,159)	($1,174,659)	($13,676,698)
2014	($45,369,475)	($3,600,292)	($4,601,074)	($53,570,841)	($11,582,879)	($919,159)	($1,174,659)	($13,676,698)
2015	($45,369,475)	($3,600,292)	($4,601,074)	($53,570,841)	($11,582,879)	($919,159)	($1,174,659)	($13,676,698)
2016	($45,369,475)	($3,600,292)	($4,601,074)	($53,570,841)	($11,582,879)	($919,159)	($1,174,659)	($13,676,698)
2017	($45,369,475)	($3,600,292)	($4,601,074)	($53,570,841)	($11,582,879)	($919,159)	($1,174,659)	($13,676,698)
2018	($45,369,475)	($3,600,292)	($4,601,074)	($53,570,841)	($11,582,879)	($919,159)	($1,174,659)	($13,676,698)
2019	($45,369,475)	($3,600,292)	($4,601,074)	($53,570,841)	($11,582,879)	($919,159)	($1,174,659)	($13,676,698)
2020	($45,369,475)	($3,600,292)	($4,601,074)	($53,570,841)	($11,582,879)	($919,159)	($1,174,659)	($13,676,698)
2021	($45,369,475)	($3,600,292)	($4,601,074)	($53,570,841)	($11,582,879)	($919,159)	($1,174,659)	($13,676,698)
2022	($44,599,016)	($3,539,153)	($4,522,939)	($52,661,108)	($10,558,492)	($837,869)	($1,070,773)	($12,467,133)
2023	($43,312,029)	($3,437,024)	($4,392,421)	($51,141,474)	($8,405,942)	($667,053)	($852,475)	($9,925,470)
2024	($30,541,570)	($2,423,625)	($3,097,325)	($36,062,520)	($6,286,146)	($498,837)	($637,500)	($7,422,483)
2025	($21,716,687)	($1,723,327)	($2,202,363)	($25,642,377)	($4,532,604)	($359,685)	($459,667)	($5,351,955)
2026	($16,954,777)	($1,345,445)	($1,719,442)	($20,019,664)	($3,031,079)	($240,531)	($307,392)	($3,579,002)
2027	($6,572,866)	($521,589)	($666,577)	($7,761,032)	($1,718,598)	($136,379)	($174,289)	($2,029,266)
2028	($4,190,955)	($332,573)	($425,019)	($4,948,547)	($572,866)	($45,460)	($58,096)	($676,422)

Appendix V-A

Energy Impacts

The following table shows the power production assumptions for a California Ethanol industry that are discussed in Chapter V.

		BIOMASS POWER PRODUCTION			ETHANOL PRODUCTION					
Plant ID	**Feedstock**	**GWh/yr**	**BDT/yr**	**BTU/lb**	**Feedstock BDT/yr**	**Ethanol Cap., MGal**	**Lignin (tons/yr)**	**Power Consumption (GWh/yr)**	**Power Production from Lignin (GWh/yr)**	**Net Power Production (GWh/yr)**
1	Forest Matl	210	210,000	8,500	520,000	40	160,000	50	200	150
3	Forest Matl	260	260,000	8,500	260,000	20	80,000	20	100	80
4	Forest Matl	260	260,000	8,500	260,000	20	80,000	20	100	80
7	Ag Residue	200	200,000	8,500	640,000	40	190,000	50	230	180
8	Ag Residue	200	200,000	8,500	640,000	40	190,000	50	230	180
12 through 15	Urban Waste					40		50	0	-50
Total		**1,130**						**240**	**860**	**620**

Unnasch, S., Browning, L., “Fuel Cycle Energy Conversion Efficiency, Status Report, “Prepared for California Energy Commission and California Air Resources Board, May 2000.

Appendix VI-A

Environmental Valuation

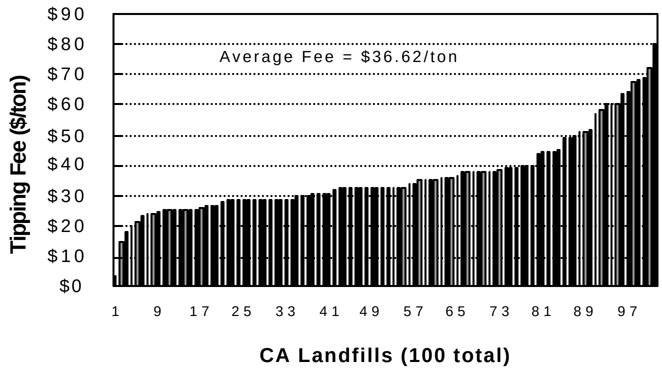
Monetizing Economic Valuation of Landfill Diversion:

When a particular parcel of land is being considered for a new use, one way to measure the value people have for that land is to measure the "option value." This refers to the premium that people are willing to pay to preserve the parcel over and above the use-value of the parcel. In essence, how sure are they that even though they have little use for it now, they won't need the piece of land later. This is an appropriate method to assess the value of landfill diversion and avoidance of new landfills but it is difficult to measure.

In addition to the option value for avoiding landfilling, the value of not landfilling materials is reflected in a cost saving to the materials recovery facilities (MRFs). Currently, MRFs sort materials that are considered recyclable from those for which there is not a developed recycling or transformation market (residual). Part of this MRF residual consists of paper products that are not considered suitable for recycling by paper mills. Once this residual is sorted at a MRF, a municipality usually incurs two additional costs to dispose it. One, the cost of transporting the residual to a landfill, and, two, the cost of depositing the residual into a landfill (otherwise known as a landfill "tipping" fee). Statewide, about 10% of all the waste that is placed in landfills consists of such post-MRF waste paper residual (over 3.5 million tons/year).

The cost of disposing of this residual in landfills thus varies from jurisdiction to jurisdiction depending on two things: the distance that residual must be transported from the MRF to the landfill (with longer transport distances resulting in higher transport costs); and, the tipping fee charged by the landfill. The range of the tipping fees that are currently being charged by California landfills is shown below. As the chart indicates, these costs range from less than $10/ton to about $80/ton, with the state average being about $36.

California Landfill Tipping Fees Per Ton



The cost of transporting waste paper from a MRF to a landfill ranges from about $3.30 ton to $12.30 per wet ton for distances of 5 and 50 miles, respectively. Thus, the total cost per ton of transporting waste paper residual from a MRF and placing it into a landfill ranges from about $10 to $90 per wet ton. The benefit of land-filling materials is -$10 per ton. This benefit is within (and internal to) the cost of ethanol production. Consequently, the cost of ethanol production decreases by $10 per ton when ethanol production uses landfill materials.

Monetizing Economic Valuation of Air Pollution:

The economics of air pollution are based upon the marginal value of clean air. This has been established through legislation, such as the Clean Air Act, which supports the philosophy that society is willing to pay the costs for cleaner air because it receives benefits from cleaner air. At a more tangible level, in order to achieve acceptable air quality or mitigate new growth, local air quality management districts limit emissions but allow trading of surplus credits. Sources that emit less pollution than is required of them may sell their surplus rights to pollute. The marginal value for the offsets (they offset emissions from other sources) are based on the supply and demand of permits, such that the last few available permits are likely to be the most expensive. Thus the value for reducing air pollution in other ways, such as ethanol production, is equal to the marginal willingness to pay for an offset.

This study has chosen to monetize cleaner air with the avoided cost of other air pollution reduction mechanisms because it is an accepted practice in California. Using this method also avoids analyses of revealed or stated consumer preferences, which require further studies specifically designed for the tradeoffs related to ethanol production.

Appendix VI-B

Emissions

This appendix contains tables of emission factors and results of the ethanol production analysis.

Biomass Power Emission Factors

	Wood (g/gal) from Greet	Biomass (lb/MMBtu) from Acurex	Biomass (lb/wet ton) from AP42*	Biomass (lb/wet ton) NRSS**	Biomass (lb/MMBtu) NRSS	For study: biomass plant, (lb/wet ton)	For study: biomass plant (lb/MMBtu)	Diesel (lb/MMBtu) from Acurex	Diesel (g/gal) from Acurex	Lignin factors assumed from biomass (lb/MMBtu)
NO_x	12.036	0.12	1.5			2	0.222	4.41	0.40	0.222
CO	8.388	0.04				1.4		0.95	0.09	0.040
CH_4	0.893	0.003	0.1			0.1	0.011			0.011
Fugitives		0.000						0.36	0.03	
Combust NMOG	1.199	0.003	0.22			0.22	0.024	0.07	0.01	0.024
NMOG		0.003	0.22			0.22	0.024	0.43	0.04	0.024
PM	1.56		8.8	0.06	13.3	0.04	0.004	0.31	0.03	0.004
CO_2 Vent	1.93									
Fossil Fuel CO_2								164	14.70	

*AP 42 assumptions: wet ton 4500btu/lb, 50% moisture
8.8 lb/wet ton for PM is for an uncontrolled wood boiler. For comparison, a boiler with electrostatic precipitator is 0.04 lb/wet ton.
**Natural Resource Strategic Services

Emissions due to lignin and diesel combustion, and ethanol production process

(lb/ton biomass)	**Biomass power plant only**	**Collocated midterm large plant Forest or Ag Material**		**Urban Waste Stand Alone**
	power plant	power plant	ethanol plant	
NO_x	4	3		0.04
CO	0.7	0.5		
CH_4	0.2	0.1		
NMOG	0.4	0.3		0.03
PM	0.08	0.05		0.04
Fossil Fuel CO_2 (diesel)	0	0	3	486

Emission Factors continued

Avoided Emissions from Ag Open Burn

Pollutant	CBEA lb/wet ton (100% orchard)	NRSS lbs/ton	For this study: ARB lb/BDT (100% orchard, 28.8% moisture)
NO_x	4.3	3.1-5.6	7.3
SO_2	0.6		0.1
CO	31.9		92.7
NMOG	4.2	4.2-5.4	8.8
PM	2.5	2.5-3.2	11

Rice Straw Emissions		AP-42 (lb/wet ton)	For Study (lb/wet ton)
30% Moisture Rice Straw			
	NO_x		23
	PM	29	29
	CO	181	181
	NMOG	23	23

Wildfires

	CBEA lb/acre (35 tons/acre)	AP-42 kg/hectare (18 tons/acre)	NRSS lbs/ton (25 tons/acre)	CDF, CARB lb/ton (15 tons/acre)	For this study: CDF, CARB lb/acre	For this study: Avoided emissions lb/ton removed	For this study: avoided prescribed burn lb/ton removed
NO_x	140	81		4	60	0.24	1.28
SO_2	140						
CO	4899	2830		260	3900	15.6	83.2
ROC	840	485		25	375	1.5	8
PM	594	343	6	42	630	2.52	13.44

Transportation NOx Emissions Sources	**NOx Emissions due to feedstock transport - two way (tons/yr)**							**Note: Case is 1,3,4,7,8,12-15**			
Plant ID	1	2	3	4	5	6	7	8	9	10	11
	FM	FM	FM	FM	FM	FM	RC/AR	RC/AR	AR	AR	AR
Forest Slash/Thinnings	86	74	43	32	43	43	0	0	0	0	0
Lumbermill Waste	0	0	0	0	0	0	0	0	0	0	0
Rice Straw	0	0	0	0	0	0	12.8	12.8	0	0	0
Agricultural Residues	0	0	0	0	0	0	19.7	19.7	16.8	16.8	16.8
Waste Paper	0	0	0	0	0	0	0	0	0	0	0
Other Urban Waste	0	0	0	0	0	0	0	0	0	0	0
Tree Prunnings	0	0	0	0	0	0	0	0	0	0	0
Construction Materials	0	0	0	0	0	0	0	0	0	0	0
	NOx Emissions due to ethanol transport - two way (tons/yr)										
Forest Material	60	12	12	24	16	25					
RS/AR							13	3	27	24	3
UW											
Total Transportation Emissions	146	86	55	56	59	68	46	35	44	41	19

Transportation NOx Emissions Sources										
Plant ID	12	13	14	15	16	17	18	19	20	21
Forest Slash/Thinnings	0	0	0	0	0	0	0	0	0	0
Lumbermill Waste	0	0	0	0	0	0	0	0	0	0
Rice Straw	0	0	0	0	0	0	0	0	0	0
Agricultural Residues	0	0	0	0	0	0	0	0	0	0
Waste Paper	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
Other Urban Waste	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Tree Prunnings	0	0	0	0	0	0	0	0	0	0
Construction Materials	0	0	0	0	0	0	0	0	0	0
Forest Material										
RS/AR										
UW	1	1	1	1	3	2	2	0	3	3
Total Transportation Emissions	4	4	4	4	6	4	4	3	6	6

Transportation HC Emissions Sources	HC Emissions due to feedstock transport - two way (tons/yr)						Note: Case is 1,3,4,7,8,12-15				
Plant ID	1	2	3	4	5	6	7	8	9	10	11
	FM	FM	FM	FM	FM	FM	RC/AR	RC/AR	AR	AR	AR
Forest Slash/Thinnings	4	3	2	1	2	2	0	0	0	0	0
Lumbermill Waste	0	0	0	0	0	0	0	0	0	0	0
Rice Straw	0	0	0	0	0	0	0.56	0.56	0	0	0
Agricultural Residues	0	0	0	0	0	0	0.86	0.86	0.73	0.73	0.73
Waste Paper	0	0	0	0	0	0	0	0	0	0	0
Other Urban Waste	0	0	0	0	0	0	0	0	0	0	0
Tree Prunnings	0	0	0	0	0	0	0	0	0	0	0
Construction Materials	0	0	0	0	0	0	0	0	0	0	0
	HC Emissions due to ethanol transport - two way (tons/yr)										
Forest Material	6	1	1	3	2	3					
RS/AR							1	0	3	3	0
UW											
Total Transportation Emissions	10	5	3	4	4	5	3	2	4	3	1

Transportation HC Emissions Sources										
Plant ID	12	13	14	15	16	17	18	19	20	21
Forest Slash/Thinnings	0	0	0	0	0	0	0	0	0	0
Lumbermill Waste	0	0	0	0	0	0	0	0	0	0
Rice Straw	0	0	0	0	0	0	0	0	0	0
Agricultural Residues	0	0	0	0	0	0	0	0	0	0
Waste Paper	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Other Urban Waste	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Tree Prunnings	0	0	0	0	0	0	0	0	0	0
Construction Materials	0	0	0	0	0	0	0	0	0	0
Forest Material										
RS/AR										
UW	0	0	0	0	0	0	0	0	0	0
Total Transportation Emissions	0.22	0.25	0.25	0.25	0.44	0.28	0.28	0.15	0.44	0.44

Transportation PM Emissions Sources	PM Emissions due to feedstock transport - two way (tons/yr)							Note: Case is 1,3,4,7,8,12-15			
Plant ID	1	2	3	4	5	6	7	8	9	10	11
	FM	FM	FM	FM	FM	FM	RC/AR	RC/AR	AR	AR	AR
Forest Slash/Thinnings	2.2	1.9	1.1	0.8	1.08	1.08	0	0	0	0	0
Lumbermill Waste	0	0	0	0	0	0	0	0	0	0	0
Rice Straw	0	0	0	0	0	0	0.32	0.32	0	0	0
Agricultural Residues	0	0	0	0	0	0	0.49	0.49	0.42	0.42	0.42
Waste Paper	0	0	0	0	0	0	0	0	0	0	0
Other Urban Waste	0	0	0	0	0	0	0	0	0	0	0
Tree Prunnings	0	0	0	0	0	0	0	0	0	0	0
Construction Materials	0	0	0	0	0	0	0	0	0	0	0
	PM Emissions due to ethanol transport - two way (tons/yr)										
Forest Material	4	1	1	2	1	2					
RS/AR							1	0	2	2	0
UW											
Total Transportation Emissions	6	3	2	2	2	3	2	1	2	2	0.49

Transportation PM Emissions Sources										
Plant ID	12	13	14	15	16	17	18	19	20	21
Forest Slash/Thinnings	0	0	0	0	0	0	0	0	0	0
Lumbermill Waste	0	0	0	0	0	0	0	0	0	0
Rice Straw	0	0	0	0	0	0	0	0	0	0
Agricultural Residues	0	0	0	0	0	0	0	0	0	0
Waste Paper	0.04	0.04	0.04	0.04	0.042	0.042	0.042	0.042	0.042	0.042
Other Urban Waste	0.03	0.03	0.03	0.03	0.028	0.028	0.028	0.028	0.028	0.028
Tree Prunnings	0	0	0	0	0	0	0	0	0	0
Construction Materials	0	0	0	0	0	0	0	0	0	0
Forest Material										
RS/AR										
UW	0.026	0.034	0.034	0.034	0.085	0.043	0.043	0.009	0.085	0.085
Total Transportation Emissions	0.095	0.103	0.10	0.10	0.15	0.11	0.11	0.08	0.15	0.15

Transportation CO2 Emissions Sources	CO2 Emissions due to feedstock transport - two way (tons/yr)							Note: Case is 1,3,4,7,8,12-15			
Plant ID	1	2	3	4	5	6	7	8	9	10	11
	FM	FM	FM	FM	FM	FM	RC/AR	RC/AR	AR	AR	AR
Forest Slash/Thinnings	20465	17805	10233	7572	10233	10233	0	0	0	0	0
Lumbermill Waste	0	0	0	0	0	0	0	0	0	0	0
Rice Straw	0	0	0	0	0	0	3048	3048	0	0	0
Agricultural Residues	0	0	0	0	0	0	4699	4699	4009	4009	4009
Waste Paper	0	0	0	0	0	0	0	0	0	0	0
Other Urban Waste	0	0	0	0	0	0	0	0	0	0	0
Tree Prunnings	0	0	0	0	0	0	0	0	0	0	0
Construction Materials	0	0	0	0	0	0	0	0	0	0	0
	CO2 Emissions due to ethanol transport - two way (tons/yr)										
Forest Material	4344	869	869	1738	1843	2063					
RS/AR							1194	649	2387	1819	649
UW											
Total Transportation Emissions	24,810	18,674	11,102	9,310	12,076	12,295	8,941	8,397	6,397	5,828	4,659

Transportation CO2 Emissions Sources										
Plant ID	12	13	14	15	16	17	18	19	20	21
Forest Slash/Thinnings	0	0	0	0	0	0	0	0	0	0
Lumbermill Waste	0	0	0	0	0	0	0	0	0	0
Rice Straw	0	0	0	0	0	0	0	0	0	0
Agricultural Residues	0	0	0	0	0	0	0	0	0	0
Waste Paper	395	395	395	395	395	395	395	395	395	395
Other Urban Waste	263	263	263	263	263	263	263	263	263	263
Tree Prunnings	0	0	0	0	0	0	0	0	0	0
Construction Materials	0	0	0	0	0	0	0	0	0	0
Forest Material										
RS/AR										
UW	244	325	325	325	812	406	406	81	812	812
Total Transportation Emissions	902	983	983	983	1,470	1,064	1,064	739	1,470	1,470

Transportation CO Emissions Sources	CO Emissions due to feedstock transport - two way (tons/yr)							Note: Case is 1,3,4,7,8,12-15			
Plant ID	1	2	3	4	5	6	7	8	9	10	11
Forest Slash/Thinnings	7	6	4	3	3	4	0	0	0	0	0
Lumbermill Waste	0	0	0	0	0	0	0	0	0	0	0
Rice Straw	0	0	0	0	0	0	1.1	1.1	0	0	0
Agricultural Residues	0	0	0	0	0	0	1.7	1.7	1.4	1.4	1.4
Waste Paper	0	0	0	0	0	0	0	0	0	0	0
Other Urban Waste	0	0	0	0	0	0	0	0	0	0	0
Tree Prunnings	0	0	0	0	0	0	0	0	0	0	0
Construction Materials	0	0	0	0	0	0	0	0	0	0	0
	CO Emissions due to ethanol transport - two way (tons/yr)										
Forest Material	8	2	2	3	2	3					
RS/AR							1.8	0.2	3.5	3.3	0.2
UW											
Total Transportation Emissions	15	8	5	6	5	7	4	3	5	5	2

Transportation CO Emissions Sources										
Plant ID	12	13	14	15	16	17	18	19	20	21
Forest Slash/Thinnings	0	0	0	0	0	0	0	0	0	0
Lumbermill Waste	0	0	0	0	0	0	0	0	0	0
Rice Straw	0	0	0	0	0	0	0	0	0	0
Agricultural Residues	0	0	0	0	0	0	0	0	0	0
Waste Paper	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
Other Urban Waste	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Tree Prunnings	0	0	0	0	0	0	0	0	0	0
Construction Materials	0	0	0	0	0	0	0	0	0	0
Forest Material										
RS/AR										
UW	0.09	0.11	0.11	0.11	0.29	0.14	0.14	0.03	0.29	0.29
Total Transportation Emissions	0.32	0.35	0.35	0.35	0.52	0.37	0.37	0.26	0.52	0.52

NOx Emissions							
	Ethanol Plant Types	Forest Thinnings/ Lumbermill Waste Continued Operation	Forest Thinnings/ Lumbermill Waste Continued Operation	Forest Thinnings/ Lumbermill Waste Continued Operation	Forest Thinnings/ Lumbermill Waste Continued Operation	Forest Thinnings/ Lumbermill Waste Reopened	Forest Thinnings/ Lumbermill Waste Reopened
	Plant IDs	1	2	3	4	5	6
	EtOH Production (Mgallons/yr/plant)	40	40	20	20	20	20
	Yield (gal/BDT)	77.4	77.4	77.4	77.4	77.4	77.4
	Feedstock (BDT/yr/ plant)	516,796	516,796	258,398	258,398	258,398	258,398
Without Ethanol	Power plant (tons/yr)	390.47	390.47	488.08	488.08	-	-
	Prescribed burn (tons/yr)	17.36	17.36	-	-	14.47	14.47
	Wildfire/Agric. burn (tons/yr)	33.95	33.95	-	-	28.29	28.29
	Transportation feedstock emissions (tons/yr)	58.3	34.6	54.8	56	0	0
With Ethanol	Collocated power plant (tons/yr)	689.37	275.75	344.69	345	344.69	344.69
	All open burns (tons/yr)	-	-	-	-	-	-
	Transportation emissions (tons/yr)	146	86	55	56	59	68
	No EtOH: % at risk Wildfire/open burn	55%	55%	0%	0%	91%	91%
	No EtOH: % Prescribed Burn	5%	5%	0%	0%	9%	9%
	No EtOH: %Feedstock to Power Plant	40%	40%	100%	100%	0%	0%
	No EtOH: % feedstock other use	0%	0%	0%	0%	0%	100%
	Power plant prior (BDT/yr)	206,718.35	206,718.35	258,397.93	258,397.93	-	-
	Emissions Reduction (tons/yr)	(334.99)	114.14	143.40	143.40	(360.81)	(370.11)
	Tons of biomass at risk for wildfire	282,946	282,945.74	-	-	235,788	235,788
	Acres at risk for wildfire	18,863	18,863	-	-	15,719	15,719

NOx Emissions

	Ethanol Plant Types	Rice Straw/Ag Residue Continued	Rice Straw/Ag Residue Continue	Ag Residue Reopened	Ag Residue Continued Operation	Ag Residue Continued Operation
	Plant IDs	7	8	9	10	11
	EtOH Production (Mgallons/yr/plant)	40	40	20	20	20
	Yield (gal/BDT)	63	63	65	65	65
	Feedstock (BDT/yr/ plant)	634,921	634,921	307,692	307,692	307,692
Without Ethanol	Power plant (tons/yr)	377.78	377.78	-	377.78	377.78
	Prescribed burn (tons/yr)	-	-	-	-	-
	Wildfire/Agric. Burn(tons/yr)	628.17	628.17	1,123.08	393.08	393.08
	Transportation feedstock emissions (tons/yr)	10.6	10.6	-	26.74	12.67
With Ethanol	Collocated power plant (tons/yr)	846.94	846.94	410.44	410.44	410.44
	All open burns (tons/yr)	-	-	-	-	-
	Transportation emissions (tons/yr)	46	35	44	41	19
	No EtOH: % at risk Wildfire/open burn	27%	27%	100%	35%	35%
	No EtOH: % Prescribed Burn	0%	0%	0%	0%	0%
	No EtOH: %Feedstock to Power Plant	32%	32%	0%	65%	65%
	No EtOH: % feedstock other use	41%	41%	0%	0%	0%
	Power plant prior (BDT/yr)	200,000.00	200,000	-	200,000.00	200,000.00
	Emissions Reduction (tons/yr)	123.78	134.44	669.12	346.01	353.59

*372,100 BDT rice straw used for ethanol in plants 7 and 8

NOx Emissions											
	Ethanol Plant Types	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation
	Plant IDs	12	13	14	15	16	17	18	19	20	21
	EtOH Production (Mgallons/yr/plant)	10	10	10	10	10	10	10	10	10	10
	Yield (gal/BDT)	99	99	99	99	99	99	99	99	99	99
	Feedstock (BDT/yr/ plant)	101,010	101,010	101,010	101,010	101,010	101,010	101,010	101,010	101,010	101,010
Without Ethanol	Power plant (tons/yr)	0	0	0	0	0	0	0.00	0.00	0.00	0.00
	Prescribed burn (tons/yr)	-	-	-	-	-	-	-	-	-	-
	Wildfire/Agric. burn (tons/yr)	-	-	-	-	-	-	-	-	-	-
	Transportation feedstock emissions (tons/yr)	3.77	4.11	4.11	4.11	6.15	4.45	4.45	3.09	6.15	6.15
With Ethanol	Collocated power plant (tons/yr)	2	2	2	2	2	2	2	2	2	2
	All open burns (tons/yr)	-	-	-	-	-	-	-	-	-	-
	Transportation emissions (tons/yr)	4	4	4	4	6	4	4	3	6	6
	No EtOH: % at risk Wildfire/open burn	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	No EtOH: % Prescribed Burn	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	No EtOH: %Feedstock to Power Plant	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	No EtOH: % feedstock other use	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Power plant prior (BDT/yr)	-	-	-	-	-	-	-	-	-	-
	Emissions Reduction (tons/yr)	(2.05)	(2.05)	(2.05)	(2.05)	(2.05)	(2.05)	(2.05)	(2.05)	(2.05)	(2.05)

NOx Emissions					
	Ethanol Plant Types	Forest Material	Agricultural Residue	Urban Waste	Total
	EtOH Production (Mgallons/yr/plant)	80	80	40	200
	Yield (gal/BDT)	-	-	-	-
	Feedstock (BDT/yr/ plant)	1,033,592	1,269,841	404,040.4	2,707,473
Without Ethanol	Power plant (tons/yr)	1,367	756	0	2,122
	Prescribed burn (tons/yr)	17	0	0	17
	Wildfire/Agric. burn (tons/yr)	34	1256	0	1,290
	Transportation feedstock emissions (tons/yr)	169	21	16	206
With Ethanol	Collocated power plant (tons/yr)	1,379	1,694	8.191717	3,081
	All open burns (tons/yr)	-	-	-	-
	Transportation emissions (tons/yr)	256	81	16	353
	Total decrease (tons/yr)		202		

PM Emissions

	Ethanol Plant Types	Forest Thinnings/ Lumbermill Waste Continued Operation	Forest Thinnings/ Lumbermill Waste Continued Operation	Forest Thinnings/ Lumbermill Waste Continued Operation	Forest Thinnings/ Lumbermill Waste Continued Operation	Forest Thinnings/ Lumbermill Waste Reopened	Forest Thinnings/ Lumbermill Waste Reopened
	Plant IDs	1	2	3	4	5	6
	EtOH Production (Mgallons/yr/plant)	40	40	20	20	20	20
	Yield (gal/BDT)	77.4	77.4	77.4	77.4	77.4	77.4
	Feedstock (BDT/yr/ plant)	516,796	516,796	258,398	258,398	258,398	258,398
Without Ethanol	Power plant (tons/yr)	7.81	7.81	9.76	9.76	-	-
	Prescribed burn (tons/yr)	182.33	182.33	-	-	151.94	151.94
	Wildfire/Agric. Burn (tons/yr)	356.51	356.51	-	-	297.09	297.09
	Transportation feedstock emissions (tons/yr)	2.4	1.1	1.8	2.3	0.0	0.0
With Ethanol	Collocated power plant (tons/yr)	13.79	5.51	6.89	6.89	6.89	6.89
	All open burns (tons/yr)	-	-	-	-	-	-
	Transportation emissions (tons/yr)	6	3	2	2	2	3
	No EtOH: % at risk Wildfire/open burn	55%	55%	0%	0%	91%	91%
	No EtOH: % Prescribed Burn	5%	5%	0%	0%	9%	9%
	No EtOH: % Power Plant	40%	40%	100%	100%	0%	0%
	No EtOH: % feedstock other use	0%	0%	0%	0%	0%	100%
	Power plant prior (BDT/yr)	206,718.35	206,718.35	258,397.93	258,397.93	-	-
	Emissions Reduction (tons/yr)	529.29	539.55	2.87	2.87	440.20	439.51

PM Emissions

	Ethanol Plant Types	Rice Straw/Ag Residue Continued	Rice Straw/Ag Residue Continue	Ag Residue Reopened	Ag Residue Continued Operation	Ag Residue Continued Operation
	Plant IDs	7	8	9	10	11
	EtOH Production (Mgallons/yr/plant)	40	40	20	20	20
	Yield (gal/BDT)	63	63	65	65	65
	Feedstock (BDT/yr/ plant)	634,921	634,921	307,692	307,692	307,692
Without Ethanol	Power plant (tons/yr)	7.56	7.56	-	11.62	11.62
	Prescribed burn (tons/yr)	-	-	-	-	-
	Wildfire/open burn (tons/yr)	946.55	946.55	1,692.31	592.31	592.31
	Transportation emissions (tons/yr)	0.266	0.266	0.0	1.3	0.3
With Ethanol	Collocated power plant (tons/yr)	16.94	16.94	8.21	8.21	8.21
	All open burns (tons/yr)	-	-	-	-	-
	Transportation emissions (tons/yr)	2	1	2	2	0.5
	No EtOH: % at risk Wildfire/open burn	27%	27%	100%	35%	35%
	No EtOH: % Prescribed Burn	0%	0%	0%	0%	0%
	No EtOH: % Power Plant	32%	32%	0%	65%	65%
	No EtOH: % feedstock other use	41%	41%	0%	0%	0%
	Power plant prior (BDT/yr)	200,000.00	200,000.00	-	200,000.00	200,000.00
	Emissions Reduction (tons/yr)	935.82	936.55	1,682.09	595.04	595.55

PM Emissions											
	Ethanol Plant Types	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation
	Plant IDs	12	13	14	15	16	17	18	19	20	21
	EtOH Production (Mgallons/yr/plant)	10	10	10	10	10	10	10	10	10	10
	Yield (gal/BDT)	99	99	99	99	99	99	99	99	99	99
	Feedstock (BDT/yr/ plant)	101,010	101,010	101,010	101,010	101,010	101,010	101,010	101,010	101,010	101,010
Without Ethanol	Power plant (tons/yr)	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Without Ethanol	Prescribed burn (tons/yr)	-	-	-	-	-	-	-	-	-	-
Without Ethanol	Wildfire/open burn (tons/yr)	-	-	-	-	-	-	-	-	-	-
Without Ethanol	Transportation emissions (tons/yr)	0.09	0.10	0.10	0.10	0.15	0.11	0.11	0.08	0.15	0.15
With Ethanol	Collocated power plant (tons/yr)	2	2	2	2	2	2	2	2	2	2
With Ethanol	All open burns (tons/yr)	-	-	-	-	-	-	-	-	-	-
With Ethanol	Transportation emissions (tons/yr)	0.09	0.10	0.10	0.10	0.15	0.11	0.11	0.08	0.15	0.15
	No EtOH: % at risk Wildfire/open burn	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	No EtOH: % Prescribed Burn	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	No EtOH: % Power Plant	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	No EtOH: % feedstock other use	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Power plant prior (BDT/yr)	-	-	-	-	-	-	-	-	-	-
	Emissions Reduction (tons/yr)	(2.05)	(2.05)	(2.05)	(2.05)	(2.05)	(2.05)	(2.05)	(2.05)	(2.05)	(2.05)

PM Emissions

	Ethanol Plant Types	Forest Material	Agricultural Residue	Urban Waste	Total
	EtOH Production (Mgallons/yr/plant)	80	80	40	200
	Yield (gal/BDT)	-	-	-	-
	Feedstock (BDT/yr/ plant)	1,033,592	1,269,841	404,040	2,707,473
Without Ethanol	Power plant (tons/yr)	27	15	0	42
	Prescribed burn (tons/yr)	182	0	0	182
	Wildfire/open burn (tons/yr)	357	1,893	0	2,250
	Transportation emissions (tons/yr)	7	0.5	0.41	7
With Ethanol	Collocated power plant (tons/yr)	28	34	8	70
	All open burns (tons/yr)	-	-	-	-
	Transportation emissions (tons/yr)	10	2	0	13
	Total decrease (tons/yr)		2,399		

CO Emissions							
	Ethanol Plant Types	Forest Thinnings/ Lumbermill Waste Continued Operation	Forest Thinnings/ Lumbermill Waste Continued Operation	Forest Thinnings/ Lumbermill Waste Continued Operation	Forest Thinnings/ Lumbermill Waste Continued Operation	Forest Thinnings/ Lumbermill Waste Reopened	Forest Thinnings/ Lumbermill Waste Reopened
	Plant IDs	1	2	3	4	5	6
	EtOH Production (Mgallons/yr/plant)	40	40	20	20	20	20
	Yield (gal/BDT)	77.4	77.4	77.4	77.4	77.4	77.4
	Feedstock (BDT/yr/ plant)	516,796	516,796	258,398	258,398	258,398	258,398
Without Ethanol	Power plant (tons/yr)	70.28	70.28	87.86	87.86	-	-
	Prescribed burn (tons/yr)	1,128.68	1,128.68	-	-	940.57	940.57
	Wildfire/Agric. Burn (tons/yr)	2,206.98	2,206.98	-	-	1,839.15	1,839.15
	Transportation feedstock emissions (tons/yr)	6.2	3.2	5.2	5.9	0.0	0.0
With Ethanol	Collocated power plant (tons/yr)	124.09	49.63	62.04	62.04	62.04	62.04
	All open burns (tons/yr)	-	-	-	-	-	-
	Transportation emissions (tons/yr)	15	8	5	6	5	7
	No EtOH: % at risk Wildfire/open burn	55%	55%	0%	0%	91%	91%
	No EtOH: % Prescribed Burn	5%	5%	0%	0%	9%	9%
	No EtOH: % Power Plant	40%	40%	100%	100%	0%	0%
	No EtOH: % feedstock other use	0%	0%	0%	0%	0%	100%
	Power plant prior (BDT/yr)	206,718.35	206,718.35	258,397.93	258,397.93	-	-
	Emissions Reduction (tons/yr)	3,272.61	3,351.57	25.81	25.81	2,713.03	2,710.67

CO Emissions

	Ethanol Plant Types	Rice Straw/Ag Residue Continued	Rice Straw/Ag Residue Continue	Ag Residue Reopened	Ag Residue Continued Operation	Ag Residue Continued Operation
	Plant IDs	7	8	9	10	11
	EtOH Production (Mgallons/yr/plant)	40	40	20	20	20
	Yield (gal/BDT)	63	63	65	65	65
	Feedstock (BDT/yr/ plant)	634,921	634,921	307,692	307,692	307,692
Without Ethanol	Power plant (tons/yr)	68.00	68.00	-	104.62	104.62
	Prescribed burn (tons/yr)	-	-	-	-	-
	Wildfire/Agric. burn (tons/yr)	7,976.84	7,976.84	14,261.54	4,991.54	4,991.54
	Transportation emissions (tons/yr)	0.8872446	0.8872446	0.0	3.1	1.1
With Ethanol	Collocated power plant (tons/yr)	152.45	152.45	73.88	73.88	73.88
	All open burns (tons/yr)	-	-	-	-	-
	Transportation emissions (tons/yr)	4	3	5	5	1.6
	No EtOH: % at risk Wildfire/open burn	27%	27%	100%	35%	35%
	No EtOH: % Prescribed Burn	0%	0%	0%	0%	0%
	No EtOH: % Power Plant	32%	32%	0%	65%	65%
	No EtOH: % feedstock other use	41%	41%	0%	0%	0%
	Power plant prior (BDT/yr)	200,000.00	200,000.00	-	200,000.00	200,000.00
	Emissions Reduction (tons/yr)	7,888.79	7,890.32	14,182.73	5,020.62	5,021.70

CO Emissions											
	Ethanol Plant Types	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation
	Plant IDs	12	13	14	15	16	17	18	19	20	21
	EtOH Production (Mgallons/yr/plant)	10	10	10	10	10	10	10	10	10	10
	Yield (gal/BDT)	99	99	99	99	99	99	99	99	99	99
	Feedstock (BDT/yr/ plant)	101,010	101,010	101,010	101,010	101,010	101,010	101,010	101,010	101,010	101,010
Without Ethanol	Power plant (tons/yr)	0	0	0	0	0	0	0.00	0.00	0.00	0.00
	Prescribed burn (tons/yr)	-	-	-	-	-	-	-	-	-	-
	Wildfire/Agric. burn (tons/yr)	-	-	-	-	-	-	-	-	-	-
	Transportation emissions (tons/yr)	0.32	0.35	0.35	0.35	0.52	0.37	0.37	0.26	0.52	0.52
With Ethanol	Collocated power plant (tons/yr)	0	0	0	0	0	0	0	0	0	0
	All open burns (tons/yr)	-	-	-	-	-	-	-	-	-	-
	Transportation emissions (tons/yr)	0.32	0.35	0.35	0.35	0.52	0.37	0.37	0.26	0.52	0.52
	No EtOH: % at risk Wildfire/open burn	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	No EtOH: % Prescribed Burn	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	No EtOH: % Power Plant	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	No EtOH: % feedstock other use	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Power plant prior (BDT/yr)	-	-	-	-	-	-	-	-	-	-
	Emissions Reduction (tons/yr)	-	-	-	-	-	-	-	-	-	-

CO Emissions

	Ethanol Plant Types	Forest Material	Agricultural Residue	Urban Waste	Total
	EtOH Production (Mgallons/yr/plant)	80	80	40	200
	Yield (gal/BDT)	-	-	-	-
	Feedstock (BDT/yr/ plant)	1,033,592	1,269,841	404,040	2,707,473
Without Ethanol	Power plant prior (tons/yr)	246	136	0	382
	Prescribed burn (tons/yr)	1,129	0	0	1,129
	Wildfire/Agric. burn (tons/yr)	2,207	15,954	0	18,161
	Transportation emissions (tons/yr)	17	2	1	20
With Ethanol	Collocated power plant (tons/yr)	248	305	0	553
	All open burns (tons/yr)	-	-	-	-
	Transportation emissions (tons/yr)	27	7	1	35
	Total decrease (tons/yr)		19,103		

HC Emissions

	Ethanol Plant Types	Forest Thinnings/ Lumbermill Waste Continued Operation	Forest Thinnings/ Lumbermill Waste Continued Operation	Forest Thinnings/ Lumbermill Waste Continued Operation	Forest Thinnings/ Lumbermill Waste Continued Operation	Forest Thinnings/ Lumbermill Waste Reopened	Forest Thinnings/ Lumbermill Waste Reopened
	Plant IDs	1	2	3	4	5	6
	EtOH Production (Mgallons/yr/plant)	40	40	20	20	20	20
	Yield (gal/BDT)	77.4	77.4	77.4	77.4	77.4	77.4
	Feedstock (BDT/yr/ plant)	516,796	516,796	258,398	258,398	258,398	258,398
Without Ethanol	Power plant (tons/yr)	42.95	42.95	53.69	53.69	-	-
	Prescribed burn (tons/yr)	182.33	182.33	-	-	151.94	151.94
	Wildfire/Agric. Burn (tons/yr)	212.21	212.21	-	-	176.84	176.84
	Transportation feedstock emissions (tons/yr)	4.0	1.8	3.1	3.9	0.0	0.0
With Ethanol	Collocated power plant (tons/yr)	75.87	30.35	37.93	37.93	37.93	37.93
	All open burns (tons/yr)	-	-	-	-	-	-
	Transportation emissions (tons/yr)	10	5	3	4	4	5
	No EtOH: % at risk Wildfire/open burn	55%	55%	0%	0%	91%	91%
	No EtOH: % Prescribed Burn	5%	5%	0%	0%	9%	9%
	No EtOH: % Power Plant	40%	40%	100%	100%	0%	0%
	No EtOH: % feedstock other use	0%	0%	0%	0%	0%	100%
	Power plant prior (BDT/yr)	206,718.35	206,718.35	258,397.93	258,397.93	-	-
	Emissions Reduction (tons/yr)	312.63	361.48	(37.93)	(37.93)	287.33	286.32

HC Emissions							
	Ethanol Plant Types	Rice Straw/Ag Residue Continued	Rice Straw/Ag Residue Continue	Ag Residue Reopened	Ag Residue Continued Operation	Ag Residue Continued Operation
	Plant IDs	7	8	9	10	11
	EtOH Production (Mgallons/yr/plant)	40	40	20	20	20
	Yield (gal/BDT)	63	63	65	65	65
	Feedstock (BDT/yr/ plant)	634,921	634,921	307,692	307,692	307,692
Without Ethanol	Power plant (tons/yr)	41.56	41.56	-	63.93	63.93
	Prescribed burn (tons/yr)	-	-	-	-	-
	Wildfire/open burn (tons/yr)	129.08	129.08	230.77	80.77	80.77
	Transportation emissions (tons/yr)	0.4611915	0.4611915	0.0	2.1	0.6
With Ethanol	Collocated power plant (tons/yr)	93.21	93.21	45.17	45.17	45.17
	All open burns (tons/yr)	-	-	-	-	-
	Transportation emissions (tons/yr)	3	2	4	3	1.0
	No EtOH: % at risk Wildfire/open burn	27%	27%	100%	35%	35%
	No EtOH: % Prescribed Burn	0%	0%	0%	0%	0%
	No EtOH: % Power Plant	32%	32%	0%	65%	65%
	No EtOH: % feedstock other use	41%	41%	0%	0%	0%
	Power plant prior (BDT/yr)	200,000.00	200,000.00	-	200,000.00	200,000.00
	Emissions Reduction (tons/yr)	33.52	34.66	182.08	34.45	35.25

HC Emissions

	Ethanol Plant Types	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation
	Plant IDs	12	13	14	15	16	17	18	19	20	21
	EtOH Production (Mgallons/yr/plant)	10	10	10	10	10	10	10	10	10	10
	Yield (gal/BDT)	99	99	99	99	99	99	99	99	99	99
	Feedstock (BDT/yr/plant)	101,010	101,010	101,010	101,010	101,010	101,010	101,010	101,010	101,010	101,010
Without Ethanol	Power plant (tons/yr)	0	0	0	0	0	0	0.00	0.00	0.00	0.00
	Prescribed burn (tons/yr)	-	-	-	-	-	-	-	-	-	-
	Wildfire/open burn (tons/yr)	-	-	-	-	-	-	-	-	-	-
	Transportation emissions (tons/yr)	0.22	0.25	0.25	0.25	0.44	0.28	0.28	0.15	0.44	0.44
With Ethanol	Collocated power plant (tons/yr)	2	2	2	2	2	2	2	2	2	2
	All open burns (tons/yr)	-	-	-	-	-	-	-	-	-	-
	Transportation emissions (tons/yr)	0.22	0.25	0.25	0.25	0.44	0.28	0.28	0.15	0.44	0.44
	No EtOH: % at risk Wildfire/open burn	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	No EtOH: % Prescribed Burn	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	No EtOH: % Power Plant	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	No EtOH: % feedstock other use	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Power plant prior (BDT/yr)	-	-	-	-	-	-	-	-	-	-
	Emissions Reduction (tons/yr)	(1.64)	(1.64)	(1.64)	(1.64)	(1.64)	(1.64)	(1.64)	(1.64)	(1.64)	(1.64)

HC Emissions

	Ethanol Plant Types	Forest Material	Agricultural Residue	Urban Waste	Total
	Plant IDs				
	EtOH Production (Mgallons/yr/plant)	232	126	396	754
	Yield (gal/BDT)	1,033,592	1,269,841	404,040	2,707,473
	Feedstock (BDT/yr/ plant)	150	83	0	233
Without Ethanol	Power plant (tons/yr)	182	0	0	182
	Prescribed burn (tons/yr)	212	258	0	470
	Wildfire/open burn (tons/yr)	11	1	1	13
	Transportation emissions (tons/yr)	152	186	7	345
With Ethanol	Collocated power plant (tons/yr)	0	0	0	0
	All open burns (tons/yr)	17	4	1	23
	Transportation emissions (tons/yr)	1	1	0	1
	Total decrease (tons/yr)			987	

CO_2 Emissions

		Zero EtOHCase	CA EtOH Case	Difference
Ethanol Produced in California (Mgal)		-	200	
Electricity Produced (GWh)		1,124	163	
Process Gas Required (Mscf)		-	1,592	
Additional CO_2 from electricity	(tons/yr)	(643,700)	(93,176)	
Additional CO_2 from process gas	(tons/yr)	-	106,503	
Displaced CO_2 from reduced gasoline use	(tons/yr)	-	(1,541,850)	
CO_2 from ethanol and feedstock transportation	(tons/yr)	54,138	66,409	
CO_2 from ethanol transport	(tons/yr)	15,253	10,012	
CO_2 from feedstock transport	(tons/yr)	38,885	56,397	
Global Emissions Reduction	(tons/yr)			872,552

CO_2 from electricity (g/kWh)	520
CO_2 from process gas (lb/scf)	0.134
CO_2 from displaced gasoline (g/gal ethanol)	7000

Vehicle Emission Factors

Diesel Truck Emission Factors

	(g/mi)	(g/gal diesel)
NOx (a)	12	0.1
HC (b)	0.14	0.5
PM (a)	0.3	0.01
CO_2 (c)		11,500
CO (b)	1.01	

Source for g/mi: (a) Carl Moyer Program for MY 1998-2002
(b) EMFAC 2000 values for 2003
(c) ADL for ARB (fuel cycle analysis)

Locomotive Emission Factors (1973-2001 model years)

	(g/bhp-hr)	(g/ton-mile)
NOx	9.5	0.8265
HC	1	0.087
PM	0.6	0.0522
CO_2	687	59.769
CO	1.3	0.1131

Source: Carl Moyer Incentive Program

bhp-hr/ton-mile 0.087

Imported Ethanol Emission Factors

	Marine Emissions g/gal etoh	Rail Emissions g/gal etoh
NOx	0.0733	0.282
HC	0.0133	0.0412
PM	0.0057	0.004
CO_2		
CO	0.0034	0.0524

Imported Ethanol Emissions

For Marine and Rail Transport		Zero-ethanol case marine	Zero-ethanol case rail	Total zero-ethanol case in CA
Imported Ethanol	M Gal/yr	150	50	200
Transport in CA (one-way)	Miles in CA	103	140	-
Emissions (two-way)				
NOx	(ton/yr)	12.11	15.53	28
HC	(ton/yr)	2.20	2.27	4
PM	(ton/yr)	0.94	0.22	1
CO_2	(ton/yr)	0.00	0.00	0
CO	(ton/yr)	0.56	2.89	3

Transport of Ethanol by Truck: Emissions

Plant ID		1	2	3	4	5	6	7	8	9	10	
Ethanol Production Capacity	M Gal/yr	40	40	20	20	20	20	40	40	20	20	
Truck Transport (one-way)	Miles/yr	51,282	512,821	102,564	25,641	153,846	51,282	51,282	102,564	102,564	12,821	
Truck Fuel Economy	Mi/gal	4	4	4	4	4	4	4	4	4	4	
Emissions (two-way)												
Nox	(ton/yr)	1	14	3	1	4	1	1	3	3	0	
HC	(ton/yr)	0	1	0	0	0	0	0	0	0	0	
PM	(ton/yr)	0	0	0	0	0	0	0	0	0	0	
CO_2	(ton/yr)	325	3,247	649	162	974	325	325	649	649	81	
Plant ID		11	12	13	14	15	16	17	18	19	20	21
Ethanol Production Capacity	M Gal/yr	20	10	10	10	10	10	10	10	10	10	10
Truck Transport (one-way)	Miles/yr	102,564	38,462	51,282	51,282	51,282	128,205	64,103	64,103	12,821	128,205	128,205
Truck Fuel Economy	Mi/gal	4	4	4	4	4	4	4	4	4	4	4
Emissions (two-way)												
NOx	(ton/yr)	3	1	1	1	1	3	2	2	0	3	3
HC	(ton/yr)	0	0	0	0	0	0	0	0	0	0	0
PM	(ton/yr)	0	0	0	0	0	0	0	0	0	0	0
CO_2	(ton/yr)	649	244	325	325	325	812	406	406	81	812	812

Transport of Ethanol by Rail: Emissions

Plant ID		1	2	3	4	5	6
Ethanol Production Capacity	M Gal/yr	40	40	20	20	20	20
Rail Transport (one-way)	ton/day	362	362	181	181	181	181
	Rail Miles	250	50	100	200	100	200
	Ton-miles/yr	33,000,000	6,600,000	6,600,000	13,200,000	6,600,000	13,200,000
Emissions (two-way)							
NOx	(ton/yr)	60	12	12	24	12	24
HC	(ton/yr)	6	1	1	3	1	3
PM	(ton/yr)	4	1	1	2	1	2
CO_2	(ton/yr)	4344	869	869	1738	869	1738

Note: Only plants 1-6 involve transportation of ethanol by rail