

Executive Summary of the Supply and Cost of Alternatives to MTBE in Gasoline

In response to growing evidence that methyl tertiary-butyl ether (MTBE) is contaminating California's groundwater and surface water, Governor Gray Davis issued Executive Order D-5-99 calling for the phaseout of this gasoline additive. Appendix ES-A contains a copy of the complete Executive Order.

What are California Agencies Required to Do?

As part of the state's response to the potential environmental and public health risks, the Executive Order requires the California Energy Commission to evaluate California's potential to develop a "waste-based or other biomass ethanol industry" and evaluate "what steps, if any, would be appropriate to foster waste-based or other biomass ethanol development in California should ethanol be found to be an acceptable substitute for MTBE."

In addition, the Executive Order requires other state agencies to undertake a series of activities to mitigate the environmental effects of MTBE and examine the fuel supply, environmental, and health implications of ethanol use in place of MTBE.

Since the other investigations that bear on the role ethanol might ultimately play in California's gasoline supply are ongoing, this evaluation of in-state ethanol supply potential does not assume any particular outcome that might be determined through these other related studies.

What is the Federal Government Doing to Promote a Biomass-to-Ethanol Industry?

The federal government has a long history of supporting research, development and commercialization activities for converting biomass to ethanol. On August 12, 1999, President Clinton signed an executive order to develop and promote bio-based products such as ethanol and bioelectricity. The President also directed several federal agencies to work together to modify federal programs toward the goal of tripling the national use of bio-based products and bio-energy by 2010. Appendix III-D contains the full text of the President's Executive Order.

Major Findings and Conclusions

The Energy Commission staff's analysis shows that ethanol fuel produced from waste and residual materials offers potential for meeting the state's oxygenated gasoline needs. As a renewable fuel, biomass-to-ethanol fuel production offers a number of potential energy, environmental and economic benefits.

Creating a viable in-state ethanol industry to capture these benefits, however, poses major challenges. The cost of producing ethanol remains high, requiring continued government price support to make it a competitive fuel additive. Developing a California ethanol industry will also require a state government role to overcome economic, technical, and institutional barriers and uncertainties. California-produced ethanol fuel will face stiff competition from out-of-state ethanol supplies and in-state petroleum products.

Commercializing new technologies for converting biomass to ethanol raises uncertainties and presents challenges that must be overcome to foster and nurture a commercial ethanol industry in California.

The lack of commercial experience with biomass-to-ethanol conversion in California and elsewhere suggests that the state would be prudent to co-fund the first several production facilities as part of a near-term demonstration effort. A demonstration would be particularly valuable to gain insight into the actual benefits and drawbacks to siting, building, and operating such facilities in California.

In addition, developing a clear biomass-to-ethanol state policy to guide and coordinate actions can help reduce the many challenges that exist to developing this industry. Supporting activities to encourage the production and use of ethanol fuel as a renewable energy source complements California's ongoing efforts to develop transportation energy alternatives.

Past Efforts on Biomass-Based Ethanol Production in California

The Energy Commission and other state agencies began work on biomass-based ethanol production and its use in transportation nearly two decades ago.

Beginning in 1980, several demonstration projects were conducted to investigate the practicality and cost effectiveness of alcohol motor fuels. While this early work showed that ethanol production was potentially viable in the state, it became evident that the economics for in-state production were not competitive with corn-derived ethanol from the Midwest.

More recent work at the Energy Commission has identified a wide variety of biomass resources in California that may be suitable feedstocks for ethanol production.

Biomass-to-Ethanol Production in the United States and California

Nearly all the ethanol used as fuel in the United States today is produced from corn-based facilities in the Midwest. Currently, one small ethanol facility in California is operating, using beverage industry waste, with a capacity of 6 million gallons of ethanol a year.

Government Incentive Programs

The economics of ethanol fuel in the United States are influenced by favorable federal tax provisions, which effectively reduce the retail price of ethanol by 54 cents per gallon. A federal small producer's income tax credit is also in place, and a number of states offer additional state tax incentives. Without these tax provisions, ethanol would probably not be produced at today's quantities in the United States motor fuel market.

California has several state programs that impact the use of certain waste feedstocks. The Rice Straw Utilization Tax Credit Program provides a tax credit to farmers who divert rice straw from open-field burning. The program offers a \$15 per ton (of rice straw) tax credit, capped at \$400,000 annually. In addition, the Rice Straw Demonstration Project Fund provides cost-sharing grants for promising projects to utilize rice straw.

For the conversion of municipal solid waste (MSW) to energy, a limited (non-financial) diversion credit is available through the California Integrated Waste Management Act (1989) to assist local municipalities in meeting their 50 percent waste reduction goals.

MTBE Phaseout and Demand for Ethanol in California

With the phaseout of MTBE, ethanol may be required as a gasoline additive to meet federal and state clean-burning gasoline requirements. Regulatory agency decisions in progress will likely affect the use of ethanol in the future.

As displayed in Figure ES-1, if ethanol is used to replace MTBE, estimated California demand for ethanol may be as low as 148 million gallons of ethanol in 2003 or as high as 1.15 billion gallons a year. Three California projects are in the active planning stages and, if constructed, could produce about 44 million gallons of ethanol a year by 2004. Thus, if ethanol is used to replace MTBE, most of it will initially be supplied from out-of-state sources, primarily corn-based ethanol from the Midwest.

California's Biomass Resources

California generates an estimated 51 million bone dry tons of gross waste and residual biomass resources annually from its large agricultural industry, forests and large volumes of municipal solid waste materials, that offer potential supply sources for producing ethanol.

Several factors affect how much of California's biomass resources will be available commercially. These factors include the high costs to collect and transport some feedstocks and their existing markets. The amount of feedstocks economically available to produce ethanol will change with market conditions.

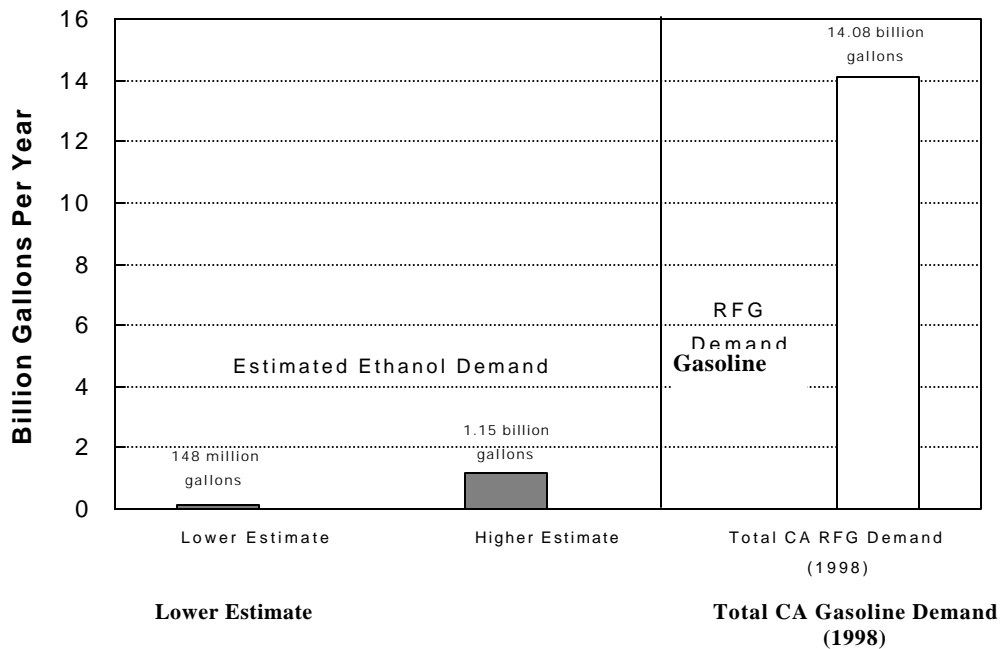


Figure ES-1. Range of Estimated Ethanol Demand for Use in California Gasoline

Other biomass resources to produce ethanol may exist, such as substantial livestock manure resources and out-of-state residues. These resources, however, will require additional study to determine their viability in this application.

The three primary categories of waste and residual biomass resources in California include forest wastes (42 percent), municipal solid wastes (31 percent) and agricultural residues (27 percent).

California's Potential Biomass Energy Crops

Biomass energy crops, grown for their energy value, represent another approach to supplying feedstocks for ethanol production. While waste-based feedstocks receive greater attention for proposed near-term ethanol production, energy crops represent a potentially larger source of longer-term supplies for ethanol production, but high costs must be overcome.

Currently, there are no plans in evidence to produce ethanol from California-grown energy crops. Limited studies of energy crops have identified sweet sorghum and eucalyptus as possible future supply sources.

Regulatory Requirements for Siting a Biomass-to-Ethanol Facility in California

Siting a biomass-to-ethanol facility in California is a complex process, which can take 12 to 18 months or longer. The location of the site and its size will determine who has jurisdiction and the responsibility as lead agency for preparing an environmental impact report and determining whether the project complies with the California Environmental Quality Act.

Ethanol Production Potential from Biomass Resources

The estimated physical upper limit for ethanol produced from California's wastes and residues exceeds 3 billion gallons a year. The actual amount of residues available, however, will be significantly lower once economic, technological, and institutional factors are considered.

Studies of biomass-to-ethanol projects were previously undertaken in California. Most did not advance beyond the feasibility phase, although a few demonstrations were conducted. Several promising technologies to convert biomass-to-ethanol, electricity and other products are being developed, and significant improvements in ethanol production costs are expected as the technologies mature.

Biomass-to-Ethanol Project Economics

The economics of biomass-to-ethanol projects are difficult to assess completely because biomass-to-ethanol technologies have yet to be demonstrated or commercially applied.

High capital costs associated with the non-commercial status of cellulosic biomass-to-ethanol technologies contribute to high risk financing. Feedstock costs represent the largest portion of the total costs, and thus the availability of low cost feedstocks is critical for producing ethanol competitively. Other project economics are subject to many unknowns and will vary with plant size, location, and other variables.

A collocated ethanol production facility and biomass power plant offer several economic advantages. Both facilities share the cost of processing feedstocks. The ethanol facility can contract with the biomass power plant to manage feedstock procurement and inventory, which reduces the fixed operating costs for both facilities. The ethanol plant can also process feedstocks that would be burned in the biomass power plant and provide lignin as fuel for the power plant (lignin is a by-product of converting biomass to ethanol). Ethanol production cost savings up to 20 percent are possible with collocation of a biomass power plant with an ethanol facility.

Ethanol's value in the gasoline blending market is determined by the price of competing gasoline (or oxygenates), its octane value, and tax incentives provided at the federal and state level. Thus, as gasoline prices in each state change, and as tax credits vary, the price of ethanol will also vary.

Potential Public Benefits from a Biomass-to-Ethanol Industry

A number of potential public benefits may be derived from a biomass-to-ethanol industry in California.

Ethanol is an alternative fuel because it is not derived from petroleum sources. As an alternative fuel, ethanol can help California meet state and federal energy security goals, as outlined in the National Energy Policy Act of 1992. Furthermore, ethanol is a renewable fuel, and offers an effective option for reducing greenhouse gases that may contribute to global climate change.

Studies have shown that greenhouse gas reductions are possible with ethanol produced from biomass, as compared to non-renewable fuels, on a full fuel cycle basis. Based on Argonne National Laboratory analyses, ethanol in the form of E85 (85 percent ethanol blended with 15 percent gasoline) derived from cellulosic biomass (e.g., agricultural residues) can reduce carbon emissions in the range of 80 to 85 percent. In contrast, current corn-derived ethanol, in the form of E85, achieves about a 22 percent reduction in carbon emissions.

The traditional means of disposing of large quantities of agricultural and forest wastes has been open-field burning, which impacts air quality. Because of this concern, open-field burning of rice straw is being phased out. The state is seeking alternatives to open-field burning, such as converting the rice straw to ethanol, thereby reducing or eliminating this practice.

Similarly, forest residues are being open-field burned. In an effort to improve forest health and reduce the risk of catastrophic wildfires, forests are being mechanically thinned. The conversion of forest residues to ethanol provides a potentially viable alternative to burning.

Converting MSW (including paper waste, yard waste, etc.) to ethanol would reduce the volume of waste streams that are now deposited in landfills. In addition to other diversion strategies, such as recycling and composting, waste-to-ethanol may be an attractive option.

Another benefit that could arise if a biomass-to-ethanol industry develops in California is the creation of a new industry that could provide jobs and increased tax revenues for the state.

Potential Investment Risks

A number of risks exist that could impact the development of a biomass-to-ethanol industry in California.

The rate at which cellulosic biomass conversion technologies advance will impact ethanol production costs. California-based ethanol project proposers are looking at converting cellulosic feedstocks, using technologies that differ from traditional starch and sugar conversion technologies. Consequently, if cellulosic conversion technologies advance slowly, higher ethanol production costs will likely affect a California biomass ethanol industry adversely. The reverse is also true.

Delivered feedstock prices have a significant impact on the cost to produce ethanol. Higher feedstock prices could make California biomass ethanol less competitive with other sources of ethanol (i.e., Midwest corn-based) and restrict the size of a California industry.

Regulatory decisions, both by the State of California and the federal government, also will impact the ethanol market. In particular, reconsideration of the current federal mandate for oxygenates in gasoline will substantially impact the size and duration of a California ethanol market. Without clear evidence of a significant ethanol market, production plant financing will be difficult to obtain.

Recommendations to Foster Biomass-to-Ethanol Development in California

Based on the evaluation of biomass-to-ethanol fuel potential in California, the Energy Commission recommends that the state take several actions to develop a longer-term state policy, and other strategies.

These actions are divided into four categories as follows: (1) policy, (2) research, development and demonstration (RD & D), (3) market development and commercialization, and (4) further study needs. These actions represent a prudent approach to formulating a policy to guide state investment in this industry, which is now in the embryonic stage.

With regard to policy steps, California should adopt a biomass-derived transportation fuels energy policy that is consistent with Energy Commission programs and goals for the transportation sector. In addition, an interagency task force should be convened to establish and implement an integrated California biomass policy in response to several issues that go beyond the agenda of the California Energy Commission. The Governor, the California Resources Agency, or California Environmental Protection Agency should identify appropriate agencies and convene this task force.

An Interagency Biomass Group consisting of a broad cross-section of state agencies and departments has been meeting for several months to share information about biomass-related interests and activities. This group is currently working to develop a vision to better focus activities affecting the utilization of biomass. This work should provide a good platform for developing a comprehensive statewide biomass policy developed through interagency cooperation.

With regard to RD&D, California should support demonstrations of several biomass-to-ethanol facilities to establish the technical and economic feasibility of the new technologies. Further, the state should support RD& D to improve biomass feedstock collection, conversion and utilization. The appropriate financial mechanisms and extent of funding need to be determined.

With regard to market development and commercialization, California should study and determine the appropriate forms of state financial and non-financial assistance to support commercialization of the industry, should demonstration projects prove successful.

Finally, with regard to further study needs, California needs to assess and quantify the public benefits associated with the emergence of a biomass-to-ethanol industry to provide the rationale for public policy and public resource commitments in the longer-term.

How Was This Report Reviewed?

This report was reviewed by a technical peer review group of experts who reviewed an earlier working draft version of this report. Appendix ES-D provides a list of the technical peer review group members. The technical experts represent a diverse panel of individuals with particular knowledge and involvement in the field of biomass, ethanol and alternative fuels.

A public workshop was held on September 10, 1999 at the California Energy Commission. The Energy Commission staff received comments and input on the report and recommendations were discussed. More than 40 people attended the event, and 18 presentations were delivered. Appendix ES-B-1 summarizes comments received at this workshop.

On November 19, 1999, a public hearing was held at the Energy Commission to receive comments on the draft report. Approximately 40 interested parties attended the hearing and 12 speakers delivered comments. Appendix ES-B-2 summarizes comments received at the public hearing.

How Is This Report Organized?

This report has been organized for a general audience, with the technical details and documentation for the Executive Summary and chapters in a separate volume of Appendices. The following describes the contents of each chapter:

Chapter I, “Steps to Foster Biomass-to-Ethanol Development in California,” examines optional steps in a “pro and con” format and identifies appropriate steps to foster biomass-to-ethanol development in California. Appendices I-A through I-D contain additional documentation for this chapter.

Chapter II, “Ethanol as a Fuel - Background,” summarizes the history of ethanol as a motor fuel and the role of federal and state tax incentives in fostering an ethanol market. This chapter also discusses federal and state air quality regulations affecting the use of ethanol, the current status of ethanol production and use, and the role of ethanol in the phaseout of MTBE. Appendices II-A and II-B contain additional documentation for this chapter.

Chapter III, “Waste Biomass Resources in California,” defines and describes biomass, waste biomass and residues identified as candidates for ethanol production. In addition, estimates of the physical resource potential in California for various wastes and residual biomass categories are discussed. The economic and environmental factors and challenges, including competing markets and alternative disposal options affecting the viability of ethanol production, are also examined. Appendices III-A through III-D contain additional documentation for this chapter.

Chapter IV, “Biomass Crop Resource Potential in California,” examines the potential for producing ethanol in California from energy crops. It identifies different types of crops that are candidate feedstocks for ethanol production, reviews previous studies of the potential for energy crop-based ethanol production in the state, and discusses key factors that affect the prospects for achieving this potential.

Chapter V, “Biomass Conversion,” describes the most competitive current technologies and probable improvements to increase the rate of conversion, yields and efficiency of ethanol production, electricity, and co-products from urban, agricultural, and forest wastes. The chapter also surveys the various technologies for converting biomass-to-ethanol, research on methods to improve them, and possible features of a mature bio-refinery industry, including opportunities to lower the costs of ethanol produced. Appendix V-A contains additional documentation for this chapter.

Chapter VI, “Biomass-to-Ethanol Production Potential in California,” develops estimates of the maximum ethanol production potential in California and what is producible after addressing key technological, economic, and institutional issues. Appendices VI-A through VI-D contain additional documentation for this chapter.

Chapter VII, “Economic Evaluation,” assesses the economics of biomass-to-ethanol production in California compared with obtaining ethanol from conventional sources. The analysis includes a number of different production scenarios, which incorporate different feedstocks, process options and facility size along with other considerations such as whether stand-alone or collocated with

biomass power facilities. Appendices VII-A through VII-D contain additional documentation for this chapter.

The appendices provide additional information and technical details of key topics. Because of the size and number of appendices, they have been printed separately from the main body of the report. The appendices are listed here for reference:

Appendix ES-A	Governor Davis' Executive Order D-5-99
Appendix ES-B-1	Summary of September 10, 1999 Staff Workshop
Appendix ES-B-2	Summary of November 19, 1999 Public Hearing
Appendix ES-C	Glossary of Terms
Appendix ES-D	Peer Review List
Appendix I-A	State Alternative Fuel Incentives and Initiatives
Appendix I-B	Minnesota's Ethanol Incentive Program
Appendix I-C	A Producer Payment Incentive Scenario for California
Appendix I-D	California Energy Commission Alcohol Fuels Policy Resolution (1980)
Appendix II-A	Current Production Capacity
Appendix II-B	Estimates of Ethanol Demand for Use in California Gasoline
Appendix III-A	Information on Forest and Crop Residues
Appendix III-B	Summary of Biomass-Derived Transportation Fuels and Conversion Processes
Appendix III-C	State Rice Straw Utilization
Appendix III-D	President Clinton's Executive Order on Biomass Utilization
Appendix V-A	Biomass-to-Ethanol Process Technologies
Appendix VI-A	Composition and Yields of Biomass Resources
Appendix VI-B	Location of Some Solid Waste Handling Facilities in California
Appendix VI-C	Biomass Power Plants in California
Appendix VI-D	Requirements for Siting a Biomass-to-Ethanol Facility
Appendix VII-A	Evaluation of Feedstock Costs
Appendix VII-B	Evaluation of Ethanol Production Costs
Appendix VII-C	Update on the Ethanol Market: Current Production Capacity, Future Supply Prospects, and Cost Estimates for California
Appendix VII-D	Summary of Biomass Benefits Studies