The Feasibility of Ethanol Production in Texas

Brian K. Herbst, Texas A&M University, herbst@tamu.edu
Joe L. Outlaw, Texas A&M University
David P. Anderson, Texas A&M University
Steven L. Klose, Texas A&M University
James W. Richardson, Texas A&M University

The Feasibility of Ethanol Production in Texas

B. K. Herbst, J. L. Outlaw, D. P. Anderson, S. L. Klose and J. W. Richardson[1]

Abstract:

The resurgence of interest in ethanol production has also prompted interest in Texas. Projected net present values for ethanol plant investment are well below zero for corn based ethanol plants, but are positive for sorghum. Sensitivity analysis indicates relatively small increases in ethanol price are needed to make production viable.

Introduction

There has been increased interest in ethanol production recently in Texas for a number of different reasons, including:

- The continued conflict in the Middle East and the dependence on foreign oil has many in the United States looking for a more dependable and local fuel source;
- Recently, Houston was categorized as a non-attainment area in terms of air pollution. As a result, the speed limit was reduced from 70 mph to 55 mph in an attempt to reduce emissions;
- Methyl tertiary butyl ether (MTBE), the other widely used oxygenate has been linked to water contamination in California and is likely to be banned nationwide;
- Commodity prices, including corn, have been depressed and ethanol production would boost corn and grain sorghum use and possibly prices.

All four of these problems can be solved or improved by the use of ethanol as part of a blended fuel.

Ethanol, also known as ethyl alcohol, is a renewable fuel made from feedstocks such as corn, sorghum, wood pulp, and biomass (Wyman). Ethanol, which can be used as an oxygenate or an octane booster in gasoline, has been touted as one possible solution to the before mentioned problems.

---

[1] Authors are Extension Assistant, Associate Professor, Associate Professor, Assistant Professor and Professor in the Department of Agricultural Economics at Texas A&M University.

Background

Over the past 30 years there have been a large number of ethanol feasibility analyses undertaken. Research at Texas A&M University conducted in 1981 found that ethanol production was infeasible in Texas (Avant et al., 1981). Since that time, two major changes have occurred. First, EPA regulations on non-attainment cities have increased the demand for ethanol. And second, technological innovations in the production of ethanol have resulted in lower costs of production.

Many state governments, as well as, the Federal government have provided various financial incentives intended to assist in the development of production facilities leading to an increase in ethanol production.

Much like the push in the 1970s and 1980s to revitalize rural areas by attracting industry, locating an ethanol plant in a rural area is seen as a major boost to rural communities and their tax base. It is estimated that the ethanol industry is responsible for adding more than $6 billion to the U.S. economy each year and 40,000 direct and indirect jobs (Bernard).

The use of ethanol as a fuel additive has grown over the past 30 years. To date, almost all of the ethanol plants are located in states in or near the Corn Belt. While a wide array of commodities can be used as a feedstock, corn is the overwhelming favorite thus far. The proximity to large quantities of relatively cheap corn has led to a concentration of plants in the area. Two factors that are just as important as the supply and price of corn to the economic feasibility of ethanol production in an area are federal and state incentives. The federal incentive for ethanol is an excise tax exemption of $0.53 per gallon of ethanol. With most ethanol blended at 10 percent the tax exemption

is $0.053 per blended gallon of ethanol. Currently, almost every state that has an ethanol plant also provides a subsidy over and above the federal subsidy (California Energy Commission). Current state budget crises are causing states to reconsider their programs as evidenced by recent news stories from Minnesota.

The increasing demand for a renewable fuel source, coupled with the continued scrutiny of MTBE and the desire to find a value added use of Texas grown agriculture products has created amore interest in ethanol production. The increasing interest from around the state of Texas has also increased interest on the best location for a plant in the state. While interest in developing an ethanol industry in Texas has increased, there have not been many independent studies of the economic viability of building and operating an ethanol plant in Texas.

Several issues have been cited as possible inhibitors to the development of an ethanol industry in Texas are the high investment, ($1 to 2 per gallon to build a plant), and the fact that it was tried in the 1980s and failed (BBI International). Texas is a corn deficient state, so other sources of feedstock, such as sorghum, need to be considered.

An ethanol plant would increase the jobs in the local community and the economy of the local area and increase demand for the commodity used as a feedstock along with other commodities in the area. The main benefactors would be the producers of the commodity used in ethanol production and the consumers of the new ethanol blended fuels. Improved air quality where ethanol is used is also cited as a benefit of ethanol plants.

Objective

The primary objective of this research is to evaluate the feasibility of ethanol production in Texas. Secondary objectives are to identify: 1) where is the best location for a plant in Texas, 2) what is the best feedstock, 3) what is the demand for ethanol in Texas and 4) how much, if any, subsidy is needed to make ethanol production economically feasible in Texas. The results from this study will provide interested parties an unbiased analysis of whether it is economically feasible to start an ethanol industry in Texas.

Methodology and Assumptions

This report will utilize a Monte Carlo stochastic simulation model to build a ethanol production facility using capital budgeting. Stochastic simulation allows for the "What if..." questions to be answered in a way that is economically feasible.

Simulation can be done both deterministically and stochastically. Deterministic results are the status quo with no risk on any variables and gives "on average" results. Most ethanol studies to this point have been done with this kind of research. In a deterministic model it is also possible to look at best and worst case scenarios and manipulate the numbers to the desired results. Deterministic modeling is also called perfect knowledge because the results come from only the single variable that are entered and has no risk.

Stochastic simulation is done with risk around the parameters and variable that can change, in the case of an ethanol plant – corn price, grain sorghum price, ethanol price, DDGS price, natural gas price and electricity priceThe model will run 500 times

and use different prices for the stochastic variables in each run within the range of possible prices for that variable.

For this analysis the SIMETAR© simulation package, developed by Richardson, Schumann, and Feldman at Texas A&M University in the Department of Agricultural Economics, was used. SIMETAR© is an Add-In to Microsoft Excel© and was developed in Visual Basic for Applications. It consists of both User Defined Functions in Microsoft Excel© and Menu Driven functions. This software can be used to manipulate capital budgets for each size plant, feedstock and location in one Excel file. Risk can be incorporated for selected stochastic variables within the capital budget framework.

Framework for Ethanol Plant Model

This section describes the framework of a stochastic simulation model for the evaluation of ethanol plants under alternative feedstocks and locations. The model simulates the economic activity of a 20 MMGY plant located in the Panhandle with corn as its feedstock. The assumptions can be changed to evaluate at sorghum, the central and southeast regions of Texas and three other plant sizes, 40, 60, and 80 MMGY.

The feasibility of ethanol production in Texas is evaluated using capital budgeting and simulation analysis. Capital budgets were developed for construction and operating costs for each of the four alternative size (20, 40, 60 and 80 MMGY) dry milling plants. Alternative feedstock and dry distillers grain with solubles (DDGS) price assumptions were used to analyze four different regions of Texas. These plant sizes provide a good range of the size plants that are currently in production across the country. Dry milling was chosen over wet milling because the standard in new plant construction over the past few years has been dry milling (Shapouri, et al., January 2002).

The following sections of the chapter describe the development of stochastic variables used in the model, capital requirements and interest rate assumptions, production assumptions, financial statements and key output variables.

Stochastic Variables

The stochastic variables used in the ethanol model are annual prices for corn, sorghum, ethanol, DDGS, electricity, and natural gas. Differentials between national and local prices for corn and sorghum, referred to as price wedges, are also stochastic. These stochastic variables capture the risk in both production cost and plant revenue. Ethanol and DDGS prices affect the receipts while the other variables affect cost of production. A description of the method used to develop parameters for simulating the stochastic variables is provided in this section.

Ethanol prices are neither collected nor reported by government agencies. Therefore, only a limited amount of monthly historical ethanol prices were found for use in this study. The average prices used in this analysis are based on the calendar year, January through December, instead of commodity marketing years. Monthly ethanol prices were collected from Independent Commodities Information Service – London Oil Report (ICIS-LOR), from February 1994 to May 2002. The data collected for ICSI-LOR is a simple average of high and low ethanol prices for each month.

The source for historical monthly corn, sorghum, DDGS, and soybean meal prices for the period of January 1994 to December 2000 is the Feed Grains Data Delivery Service within the Economic Resource Service of the United States Department of Agriculture (USDA). Historical monthly commercial electricity and natural gas prices were taken from the United States Department of Energy and the Texas Comptroller web

page, respectively, for the period January 1994 to December 2000. Dr. Mark Waller, who maintains a database of local cash grain markets in Texas, provided local market grain prices. Annual historical prices wedges were calculated as the difference between the national average commodity price and the local cash price. Localized wedges were calculated for corn in the panhandle and central Texas regions and for sorghum in the Panhandle, Central and Southeast regions.

Once historical monthly corn, sorghum, ethanol, DDGS, electricity and natural gas prices were collected, the data was sorted and matched by date, February 1994 to December 2000. An annual model is used in this study so the monthly prices were averaged to generate annual average prices for corn, sorghum, localized wedges, ethanol, DDGS, electricity and natural gas. A correlation matrix of annual prices for corn, ethanol, electricity, natural gas and soybean meal was estimated in preparation for simulating these variables. Due to the strong historic correlation sorghum was assumed to be perfectly correlated to corn. The wedges were also correlated to the prices for corn and sorghum based on their respective observed correlation to history.

The residuals from the regression models contributed the risk component for the stochastic variables in the model. More precisely, the residuals were used to develop the parameters for simulating the stochastic variables in a multivariate empirical (MVE) distribution. The key parameters for a MVE distribution are the correlation matrix for the residuals and the sorted residuals. The MVE probability distribution was simulated with SIMETAR© generating stochastic deviates that were then applied to the projected means for 2003 to 2018.

Forecasted means for 2003-2011 corn and soybean meal prices (SBM) were taken from the Food and Agriculture Policy Research Institute (FAPRI) July 2002 Baseline Projections. After 2011, the FAPRI forecast was flat lined and used as the forecasted corn and SBM prices for 2011 to 2018 (Table 3.2). DDGS forecasted mean prices were calculated from the multivariate regression of DDGS as a function of FAPRI's projected corn and soybean meal prices. Mean prices for ethanol, electricity and natural gas were held constant for 2003 to 2018 at a historical average price for the last 3 years. Forecasted mean prices of corn, sorghum, ethanol, DDGS, electricity, localized wedges for the three regions and natural gas prices for 2003 to 2018 were combined with annual stochastic deviates from the MVE distribution to simulate stochastic prices for each year of the planning horizon.

The MVE simulation procedure insured that the future prices are correlated the same way they were correlated in the past and the relative risk of simulated prices equal their historical relative risks. The stochastic annual prices were linked into the financial statements to calculate costs and receipts.

Capital Requirements and Interest Rate Assumptions

Interest rates for the 10-year loan on the proposed ethanol facilities are 8 percent. Revolving or operating loans would not be needed because the plant would carry the needed working capital to cover short-term cash requirements. Yearly cash flow short falls would be refinanced at 8 percent interest for 1 year.

The capital loan values for the four size facilities were taken from current industry standards (Bryan and Bryan International, August 2001). Total capital loan amounts are: $30 million, $55 million, $78 million and $100 million, respectively, for the 20, 40, 60

and 80 MMGPY facilities. This study assumes that the value of the property (land only) does not appreciate as normal property would, as upon the termination of the facility's use, the property should have significant clean-up costs that should offset the appreciated value of the property. Lastly, capital requirements include startup costs of working capital, start-up inventory, spare parts, organizational costs and independent engineering costs.

It was assumed that 50 percent of the capital requirements are borrowed funds. The remaining half of the total capital requirements is contributed capital, or equity capital, from prospective investors. This ratio of borrowed to owned equity is an industry standard. According to Jeff Kistner of CoBank, most lenders require 50 percent of the total required capital to be made up by equity and the loan is broken up between 3 or 4 different banks to spread out the risk.

Instead of assuming a certain type of business structure (e.g., corporation, cooperative, limited liability company, partnership, etc) this analysis assumes a generic entity. This means that profits are taxed at 30 percent, which is consistent with shareholders and/or partners paying taxes on their earnings. Dividends equal to 30 percent of after-tax net income are paid any time net income is greater than zero. If the plant experiences losses, the analysis assumes that there is unlimited financing available. While this is not realistic, it is important for evaluation purposes that the plant is allowed to operate without having to shut down because of a cash shortage.

Production Assumptions

Ethanol yields, DDGS yields, variable costs including denaturant, enzymes, chemicals, natural gas, maintenance materials, labor, administrative and miscellaneous

costs were taken from the feasibility study developed for the city of Dumas, Texas

(Bryan and Bryan International, August 2001a). They were then modified to a 20

MMGY basis from a 15 MMGY. These assumptions are summarized in Table 1 on a

cost per gallon basis.

Table 1. Assumed Plant Costs by Size.

Plant Size	20 MMGY	40 MMGY	60 MMGY	80 MMGY
Capacity (gal)	20,000,000	40,000,000	60,000,000	80,000,000
Capital Requirements $/gallon	1.5	1.38	1.30	1.25
Total Construction and Start-up	$30,000,000	$55,000,000	$78,000,000	$100,000,000
Variable Cost	$/gallon			
Denaturant	.04	.04	.04	.04
Enzymes	.06	.06	.06	.06
Chemicals	.03	.03	.03	.03
Main. Materials	.04	.03	.02	.02
Labor	.10	.07	.05	.04
Admin. Costs	.05	.03	.0233	.02
Misc. Costs	.03	.03	.03	.03
Natural Gas	.16	.16	.16	.16
Electricity	.04	.04	.04	.04

The corn and grain sorghum to ethanol conversion was assumed at 2.7

gallons/bushel. The DDGS yield is assumed to be 6.41 lbs/gallon of ethanol produced or

17.3 lbs/bushel of feedstock. These conversions tend to be on the upper end of the range

contained in the literature. However, these levels are justified based on the efficiency

gains the industry has obtained over the past 15 years.

Variable costs for 2003 are inflated at 1 percent per year to adjust for inflation

over the 15-year analysis period. Variable electrical and natural gas costs per gallon were

stochastically simulated and incorporated into the variable costs in the income statement.

The mean electricity and natural gas prices from 2003 to 2018 were held constant. The

respective costs and assumptions for each of the four size facilities being analyzed are incorporated into the individual models for the analysis.

There are economies of size as evidenced by cost saving for large plants (Table 1). The primary differences in costs across plant size are due to labor, administration and maintenance costs.

Plant construction would begin in 2003 and finish in 2004. This report assumes that each of the four size facilities would be operated at 50 percent capacity in 2004, 100 percent for the rest of the period of analysis.

State Subsidy

This study assumed the passage of a state subsidy of $0.20 per gallon. The subsidy was provided to the plant regardless of size on production up to 15 million gallons of ethanol production or $3 million per facility.

Indicator Variables

The analysis of this report is based on five indicator variables, which are reported for each of the four size facilities. The five variables are as follows:

1. Net Income - Net income is defined as revenues minus operating expenses minus depreciation expense.
2. Ending Cash Before Borrowing - Ending cash before borrowing is the ending cash flow result before borrowing carryover debt to bring the ending cash value to zero.
3. Dividends Paid - Dividends are paid at the rate of 30 percent of positive net income.
4. Real Net Worth - Real net worth is the nominal net worth discounted to present day dollars. This eliminates the effects of inflation over time.
5. Net Present Value - Net present value was calculated through 15 years of operation. The discount rate used in the net present value calculation was 8 percent.

Net present value is:

$$NPV = -InitialEquityInvestment + \sum_{t=1}^{16} \left(\frac{Dividends}{(1+i)^{\wedge}t} \right) + \left(\frac{EndingNetWorth}{(1+i)^{\wedge}16} \right)$$

and is the average return at the end of the period above what was invested.

The discount rate, i, is the rate at which returns are discounted to present value dollars. The discounting of future returns allows for the comparison of the initial capital investment to returns that occur in different time periods. Included in the discount rate of 8 percent are the combined assumptions of future inflation and the investors required real rate of return. In this simple NPV framework, an NPV of zero would suggest that the investment exactly meets the required 8 percent rate of return. A positive NPV would indicate returns over and above eight percent.

Results

The projected financial feasibility results show little economic incentive to entice equity investment in Texas ethanol production using corn. The projected Net Present Value (NPV) of any size plant is well below zero, and shows only slight probabilities of being positive under the best of conditions. In addition, the strain on the operation's cash flow is beyond manageable. For both the Panhandle and Central Texas regions, investment in a plant using corn does not appear to be profitable. However, as expected, in the volume-driven production of ethanol, only slight changes in average assumptions are needed to project a profitable situation. For example, the 80 MMGY corn plant in the panhandle region would need to average only $0.06 per gallon higher ethanol price relative to the base assumption of $1.12 per gallon. The higher ethanol price would generate on average an NPV of zero--an acceptable investment. With uncertain changes in future demand and the potential for substantial increases in ethanol supply, the market

price of ethanol could generate a profit for an 80 MMGY plant. Unfortunately, prices may also be lower than $1.12 per gallon.

The financial projections for plants using sorghum show greater potential for generating interest in equity investment. The different sized sorghum plants in the panhandle show a 50 to 75 percent probability of realizing a positive NPV. The two larger plants show a positive NPV on average. The panhandle region appears to be the most likely area to attract sorghum-based ethanol production. The results for the Central Texas region show 25 to 50 percent chance of positive NPV, but the average NPV for each size plant is still negative. The southeast location projects average NPVs well below zero and limited probabilities for positive NPV. The promising results for the sorghum plant in the panhandle region should be viewed with some caution. The analysis assumes the presence of a plant would not significantly change the local market price for sorghum. The assumption is reasonable, given the likelihood of a particular region increasing the acreage of sorghum to match the added demand. However, it is possible that a plant may have to pay higher prices for sorghum to encourage continuous supply. These higher prices would certainly dampen the financial outlook for the sorghum ethanol plant.

The extended economic benefits from the business of an ethanol production facility can be significant. However, it is important to note these benefits assume continued profitable ethanol production. As a direct reflection of the risky financial outlook for the equity investor, the overall benefits to the local economy are also quite risky. The financial failure an ethanol plant would obviously preclude the realization of any benefits to the local economy.

Sensitivity Analysis

Sensitivity analyses were performed on the 20 and 80 MMGY size plants in the Panhandle using corn and sorghum as the feedstock to determine what levels of key variables are required to achieve at least a Net Present Value of zero. For example, the base ethanol price is $1.12 per gallon in the analysis. A sensitivity analysis allow "what if" questions about what the ethanol price needs to be to ensure a reasonable chance of success. Each variable was tested holding the other variables at their base levels. The value that generated a NPV 0 over the 15 year planning horizon is reported in Tables 2 and 3.

Table 2. Sensitivity Analysis of Ethanol Input and Output Prices to Generate a NPV=0 holding all other factor constant for Corn Production in the Texas Panhandle.

Variable	Base	20 MMGY	80 MMGY
Corn Price ($/bu.)	2.67	2.21	2.34
Natural Gas ($/Mcf)	2.55	0.90	1.39
Ethanol Price ($/gal)	1.117	1.19	1.15
DDGS ($/ton)	106.38	130.31	117.20
Discount Rate (%)	8.00	-3.40	1.20

Corn

The base annual average corn price that is used in the panhandle region is $2.67 per bushel. When all other input costs and output prices are held constant, the corn price needed for the 20 MMGY plant to have a net present value equal zero is $2.21 per bushel. The corn price for the 80 MMGY to have a net present value equal to zero is $2.34. The higher corn price needed for the larger plant illustrates the returns to scale associated with the larger plant. This plant can withstand higher prices and still generate the desired return.

The base natural gas cost is $2.55/Mcf. Holding all other costs and prices constant a natural gas price of $1.90 in a 20 MMGY plant is required for the net present value to equal zero. The figure for the 80 MMGY plant is $1.39 / Mcf.

The base ethanol price is $1.12/gallon. A price of $ 1.19/gallon is required for the 20 MMGY plan to have a NPV equal to 0 if all other prices are held constant. When all prices are held constant on the 80 MMGY plant the ethanol price required to have a NPV = 0 is $1.15. Neither of these prices are far from the base assumed in the model. Ethanol prices have been up over $1.30 per gallon as recently as two years ago.

Grain Sorghum

The base annual average sorghum price that is used in the panhandle region is $2.39 per bushel. When all other input costs and output prices are held constant, the sorghum price needed for the 20 MMGY plant to have a net present value equal zero is $2.32 per bushel. That means that the plant achieves its eight percent returns. The sorghum price for the 80 MMGY to have a net present value equal to zero is $2.41.

Table 3. Sensitivity Analysis of Ethanol Input and Output Prices to Generate a NPV=0 holding all other factor constant for Sorghum Production in the Texas Panhandle.

Variable	Base	20 MMGY	80 MMGY
Sorghum Price ($/bu.)	2.39	2.32	2.41
Natural Gas ($/Mcf)	2.55	2.11	2.60
Ethanol Price ($/gal)	1.117	1.10	1.07
DDGS ($/ton)	106.38	100.08	90.98
Discount Rate (%)	8.00	7.01	8.83

The base natural gas cost is $2.55/Mcf. Holding all other costs and prices constant a natural gas price of $2.11 in a 20 MMGY plant is required for the net present value to equal zero. The figure for the 80 MMGY plant is $2.60/Mcf.

The base ethanol price is $1.117/gallon. A price of $ 1.10/gallon is required for the 20 MMGY plan to have a NPV equal to 0 if all other prices are held constant. When all prices are held constant on the 80 MMGY plant the ethanol price required to have a NPV = 0 is $1.07.

It's important to note that the firm would not have to have a single costs or price change the whole amount indicated in the Tables. A combination of some or all of the variables would suffice. A combination of a higher sorghum price and a lower DDGS price could have the same affect as a higher natural gas cost and a lower ethanol price. The combined effect of multiple price changes would have to be equal to or greater than the single price change for the NPV to be equal to or less than zero.

Summary and Conclusions

The recent resurgence of interest in ethanol production has prompted various stakeholders in the State to call for an unbiased analysis of the potential in Texas. Unlike the experience with ethanol during the 1980s which found it to be a relatively expensive fuel alternative, there appears to be a number of plants operating in the U.S. that are significantly more cost effective.

The ethanol industry in the United States tends to be located in the Midwest. This is primarily due to the abundant supply of relatively low priced corn used as the primary feedstock. This means that in order to compete with plants located near cheap feedstocks, a plant located in another area will need to have some other advantage.

This paper was designed to assess the overall statewide feasibility of ethanol production and its economic impact in Texas.

The projected financial feasibility results show little economic incentive to entice equity investment in Texas ethanol production using corn. The projected Net Present Value (NPV) of any size plant is well below zero, and shows only slight probabilities of being positive under the best of conditions.

The financial projections for plants using sorghum show greater potential for generating interest in equity investment. The different sized sorghum plants in the panhandle show a 50 to 75 percent probability of realizing a positive NPV. The two larger plants show a positive NPV on average. The panhandle region appears to be the most likely area to attract sorghum-based ethanol production.

The extended economic benefits from the business of an ethanol production facility can be significant. However, it is important to note these benefits assume continued profitable ethanol production. As a direct reflection of the risky financial outlook for the equity investor, the overall benefits to the local economy are also quite risky. The financial failure an ethanol plant would obviously preclude the realization of any benefits to the local economy.

References

Avant, B., S. Fuller, B. Gardner, R. Griffin, R. Kay, R. D. Lacewell, L. Makus, S. Masud, J. Richardson, C. R. Taylor and T. J. Taylor. "The Production and Sale of Gasahol in Texas." Texas Agricultural Experiment Station, College Station, TX, May 1981.

Bernard, R. "MTBE's Fall From Grace: Ethanol's Savior?" *Landowner*. August 23, 1999.

Bryan and Bryan International. "Ethanol Info: Ethanol Plant Production Lists." Cotopaxi CO: Bryan and Bryan International, Available at http://www.bbiethanol.com/ethanol_info/,November 25, 2002.

Bryan and Bryan International. *Dumas Texas Area Ethanol Feasibility Study.* Cotopaxi CO: Bryan and Bryan International, August 2001a.

Bryan and Bryan International. *Ethanol Plant Development Handbook: Points to Consider*. Cotopaxi, CO: Bryan and Bryan International, 2001.

FAPRI. "Baseline Projections, July 2002." Food and Agriculture Policy Research Institute University of Missouri-Columbia, July 2002.

Kistner, J. Personal Communication, November 8, 2002.

Richardson, J.W. *Simulation for Applied Risk Management with An Introduction to the Software Package SIMETAR©: Simulation for Excel to Analyze Risk.* Department of Agricultural Economics, Agricultural and Food Policy Center, Texas A&M University. January 2002.

Shapouri, H., J. A. Duffield and M. Wang. "The Energy Balance of Corn Ethanol: An Update." U.S. Department of Agriculture, Economic Research Service, Agricultural Economic Report No. 813, July 2002.

U.S. Department of Agriculture. *Feed Grains Data Delivery Service.* Available at http://www.ers.usda.gov/db/feedgrains. Washington DC, June 2002.

U.S. Department of Energy (DOE). *Alternative Fuel Vehicle Fleet Buyer's Guide: Incentives, Regulations, Contacts.* Washington DC, June 2002.

Wyman, C. E. and N. D. Hinman. "Ethanol: Fundamentals of Production from Renewable Feedstocks and Use as a Transportation Fuel." *Applied Biochemistry and Biotechnology*. Volume 24/25, pp. 735-53, 1990.