

Location of a MixAlco Production Facility with Respect to Economic Viability

**Michael H. Lau, James W. Richardson, Joe L. Outlaw, Stephen W.
Fuller, Clair J. Nixon^a, and Brian K. Herbst**

Department of Agriculture Economics

a - Department of Accounting

Texas A&M University

College Station, TX 77843-2124

Phone: (979) 845-5913

Fax: (979) 845-3140

Email: michaellau@tamu.edu

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ABSTRACT

Monte-Carlo simulation modeling is used to perform a feasibility study of alternative locations for a MixAlco production facility. Net present value distributions will be ranked within feasible risk aversion boundaries. If MixAlco is a profitable investment, it would have a major impact on the fuel oxygenate and gasoline markets.

INTRODUCTION

Consumption of gasoline and diesel in the U.S. transportation sector has grown at an annual rate of 1.95% and 3.57% over the past decade (EIA, 2004). Increased gasoline prices, due to international events and the Clean Air Act, have led to an increased demand for oxygenates as fuel extenders and octane boosters (EIA, 2004). Methyl tertiary butyl ether (MTBE) and ethanol have been the primary fuel oxygenates in gasoline.

MTBE is currently an integral part of the U.S. gasoline supply in terms of volume and octane. However, gasoline and MTBE prices do not reflect the external costs of burning fuel such as health and environmental affects (Shapouri, 2003). MTBE has shown to more likely contaminate ground and surface water due to its persistence and mobility in water. Ethanol is extremely soluble in water but biodegrades much quicker than MTBE. The recent California ban of MTBE due to water pollution has put heavy pressure on increased ethanol production as distributors' transition away from MTBE to ethanol.

Production capacity for ethanol in the U.S. is expected to exceed 3 billion gallons during 2003 (Renewable Fuels Association, 2003). Conflicts over oil in the Middle East, the need for reduction in air pollution, a proposed ban on MTBE, and suppressed commodity prices for corn have driven a rapid increase in ethanol production (Herbst, 2003).

Growth of the ethanol industry has also been aided heavily by federal policies. The National Energy Act, passed in 1978, exempted ethanol blended gasoline from a portion of the U.S. federal excise tax. The current exemption is \$0.052 of the \$0.183

total excise tax in 2004 and decreases to \$0.051 for 2005-2007. Currently, ethanol is the only biofuel that receives this exemption. The Clean Air Act of 1990 aimed to reduce air pollution in targeted problem areas in the U.S. The Clean Air Act mandates the sale of oxygenated and reformulated gasoline during at least four winter months in metropolitan statistical areas (MSAs). Increase in demand for renewable fuels, the heavy subsidization of ethanol, and the high cost of corn used in the production of ethanol has led to new research in development of alternative renewable fuels using cellulose biomass as the primary feedstock source.

Biomass is used to describe any organic matter from plants that derives energy from photosynthetic conversion. Traditional sources of biomass include fuel wood, charcoal, and animal manure. Modern sources of biomass are energy crops, agriculture residue, and municipal solid waste (ACRE). Estimates show that 512 million dry tons of biomass residues is potentially available in the U.S. for use as energy production (Mazza).

Biomass has the potential to provide a sustainable supply of energy. Biomass has the advantages of being a renewable source of energy that does not contribute to global warming. It has a neutral effect on carbon dioxide emissions, has low sulfur content and does not contribute to sulfur dioxide emissions, is an effective use of residual and waste material for conversion to energy, and biomass is a domestic source that is not subject to world price fluctuations or uncertainties in imported fuels.

Figure 1 represents consumption of U.S. renewable energy sources. Biomass energy contributes approximately 14 percent to today's primary energy demand worldwide (Veringa). Renewable resources account for 7.7% of the total U.S. energy

consumption (OIT, 2001). Biomass currently has a 10.5% share of the U.S. renewable energy mix (Sterling Planet). It supplies approximately 30 times as much energy in the U.S. as wind and solar power combined. The Department of Energy believes that biomass could replace 10 percent of transportation fuels by 2010 and 50 percent by 2030 (Sterling Planet). Biogas, biodiesel, ethanol, methanol, diesel, and hydrogen are examples of energy carriers that can be produced from biomass are possible substitutes for fossil fuels (Bassam).

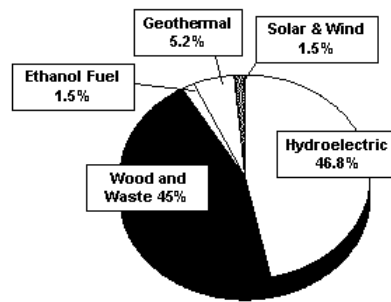


Figure 1. U.S. Consumption of Renewable Energy

Source: Office of Industrial Technologies 2001

Ethanol from cellulose biomass is still in the research and development phase (Mazza). Corn is the major feedstock used in ethanol production and no cellulose ethanol facilities are in operation (Herbst, 2003). The lack of real-world experience with cellulose biomass to ethanol production has limited investment in the first production facilities (California Energy Commission, 1999). Ethanol production using cellulose is costly due to the need for acid hydrolysis of the cellulose biomass pricing it above the current market price for ethanol (Badger, 2002). Because of this, advancements in chemical engineering have led to the development of the MixAlco process as an alternative to ethanol production using cellulose biomass.

MixAlco converts cellulose biomass such as energy crops, weed clippings, or rice straw, into a mixed alcohol fuel with the use of microorganisms, water, steam, and lime (Holtzaple, 2003). The anaerobic process converts the biomass to carboxylate salts. These salts are dried and thermally converted to ketones (e.g. acetone), which are then hydrogenated to produce alcohols. The alcohol fuel produced can be a direct replacement for ethanol and MTBE in gasoline and has two compositional advantages, (1) it has higher energy content, (2) it can be transported via pipeline when blended with gasoline unlike ethanol. The ability of MixAlco to convert any biomass source to alcohol fuel and its ability to be transported via pipeline creates an infinite number of location choices for production of alcohol fuel.

The study of location science has been developed out of the broad idea of where businesses and industries locate, why they locate, and what location is potentially most viable. Minimizing cost has been the most used aspect in location theory. Greenhut (1974) represents this as the least cost theory of plant location. Declining populations and limited economic growth have drastically changed rural areas (So, et. al. 1998). Public policies also affect industry development and can benefit from knowing recent location trends in business (Isik 2003).

Location science can be broken down into two different areas of study, static location models and dynamic location models. Static or deterministic models take constant known quantities of inputs and derive a solution to be implemented. Static models require that future information is given but in the real world sense of location science, future information, such as demand and supply, are uncertain. Dynamic location problems capture the characteristics of real world location analysis.

Dynamic models account for imperfect information and incorporate risk into the analysis and decision making process of locating a business.

The objective of this research is to analyze alternative locations and feasibility for MixAlco production under a probabilistic framework. If decisions are made without considering risk, the decision maker can easily determine which strategy is best, the strategy which returns the greatest average key output variable of the analysis (Richardson, 2004). When decisions are made considering risk, a distribution is returned for each alternative, not just a single value. The method used in this study for decision-making under risk is to simulate three alternative locations for a MixAlco production facility and estimate the distribution for the key output variable, net present value (NPV), at each alternative location. A simulation model is created using the SIMETAR© simulation package (Richardson, et. al., 2004). Each location is ranked based on the characteristics of the simulated NPV distribution using a risk ranking technique (Hardaker, et. al., 2004).

To accomplish this objective, this study compares the economics of locating a MixAlco production facility in the Panhandle, Central, and Coastal Bend Regions of Texas. When considering the economics of each location, various determinants or drivers affecting the probability of returning a positive NPV are addressed: the cost and quantity of feedstocks, variable costs of production, and the sale price of the alcohol fuel. These results allow for the identification and evaluation of target locations for building a MixAlco facility and will provide interested parties an unbiased analysis of whether MixAlco production is economically feasible in Texas.

MATERIALS AND METHODS

A Monte Carlo stochastic simulation and capital budgeting model was used to empirically estimate the probability distribution for NPV on a 45 ton/hour MixAlco production facility at alternative locations in Texas. Richardson and Mapp, Pouliquen, and Reutlinger all describe the benefits of Monte Carlo stochastic simulation for analyzing risk in business. If risk is incorporated into the model, probability distributions may be developed for key output variables, NPV in this study, showing the risk of success or failure.

A common set of financial statements, income statement, cash flow, balance sheet, was developed for each plant location. A 16-year planning horizon is used for this analysis. Information from the simulated financial sheets are used to calculate the NPV for each plant location. The NPV is defined as:

$$(1) NPV_j = -InitialEquityInvestment_j + \sum_{t=2}^{16} \left(\frac{Dividends_t}{(1+i)^t} \right) + \left(\frac{EndingNetWorth_{16}}{(1+i)^{16}} \right)$$

where j is location of the production facility, t is the year, *Dividends* are the annual withdrawal from the facility, i is the rate at which returns are discounted to present value dollars, and *Ending Net Worth* is the value of net worth in year 16, the last year of the analysis. A discount rate of 8 percent is assumed. In this NPV framework, a positive NPV would indicate returns greater than 8 percent or an economic success defined by Richardson and Mapp (1976).

Location Choices

Site-specific factors are key in choosing a location for a production facility. However, regional advantages and disadvantages affect the success of a business. Table

1 contains a matrix of advantages and disadvantages for three different regions in Texas the Panhandle Region, the Central Region, and the Coastal Bend Region. The Panhandle Region includes all the Texas Panhandle and extends south past Lubbock. It encompasses the primary cattle feeding area and the largest corn and cotton producing area of the state. The Central Region includes the area from Cameron north through the major dairy producing area of Stephenville. The Coastal Bend Region includes the area around Corpus Christi north to Matagorda County. This region is a major grain sorghum and rice production area and is home to a large number of petroleum refineries.

Table 1. Regional Advantages and Disadvantages for MixAlco Production.

Region	Feedstock	Livestock Feeding	Petroleum Infrastructure	Market & Transportation
Panhandle	Corn/Cotton/GS	+		
Central	Corn/GS			+
Coastal Bend	GS/Rice		+	+

The abundant livestock industry in the Panhandle Region can supply the necessary nutrient feedstock source for MixAlco production. However, this region is distant from petroleum refineries and will increase the cost of shipping the alcohol fuel. The vast petroleum infrastructure in the Coastal Blend is an advantage as alcohol fuel does not have to shipped a great distance to be blended with gasoline. The Central and Coastal Bend Regions are closer to large metropolitan areas and is viewed as a positive because of potential demand for air quality attainment.

Model Assumptions

A 45 ton/hour MixAlco production facility yields 33 million gallons year (MMGY) of alcohol fuel. The biomass to alcohol fuel conversion rate is assumed to be 93 gallons/ton. The process requires that 80 percent of the feedstock be cellulose

biomass (286,720 tons) and the remaining 20 percent a nutrient source (71,680 tons), such as manure or sewer sludge. The MixAlco process only requires feedstock input once a year to build the fuel pile for conversion to alcohol fuel.

The initial capital requirements are \$20.1 million for a 45 ton/hour facility according to Holtzapple (2003). For this analysis, the initial capital requirement includes construction, equipment, and engineering costs, and is based on reference numbers for standard chemical engineering costs (Holtzapple, 2003). Equipment and buildings are depreciated at 30 years using straight-line depreciation. It is assumed that 50 percent of the capital requirements are borrowed funds financed at 8 percent and the remaining 50 percent is contributed from prospective investors. The first year of the analysis is for construction of the facility. Production begins at half capacity in the second year of the analysis and reaches full capacity in the third year.

Table 2 presents land cost for the required 20 acres needed for a production facility. Land costs are determined from the Representative Farm Project of the Agriculture and Food Policy Center and are based on farm land value per acre for each region. Land value is held constant over the planning horizon.

The plant will require 4 percent of the initial investment amount for capital improvements and maintenance of the production facility. The annual capital improvement cost is \$804,000 in the first year and is inflated 2 percent annually.

Table 2. Land Cost for a MixAlco Facility

Region	County	Cost in Dollars
Panhandle	Deaf Smith	12,000
Central	Hill	20,000
Coastal Bend	Matagorda	20,000

Source: Agriculture and Food Policy Center, 2004.

This analysis assumes a generic business structure. Profits are taxed at corporate level consistent with 2003 federal income tax codes. Dividends withdrawn are paid as 30 percent of after-tax net income. An operating loan to cover feedstock costs and variable costs is available at 8 percent. If the facility experiences a loss, the analysis assumes unlimited financing of cash flow deficits to remain in operation. This assumption is important for evaluation purposes where the facility operates without shutdown.

Table 3 presents the average non-stochastic variable costs in dollars per ton for the analysis (Holtzaple, 2003). The deterministic variable costs (lime, inhibitor, hydrogen, water, labor, steam price, and administration) are inflated at 2 percent a year to adjust for inflation over the planning period.

Table 3. Variable Cost for MixAlco Production (\$/ton Feedstock).

	Dollars/Ton
Lime	\$4.93
Inhibitor	\$1.12
Hydrogen	\$5.44
Steam	\$4.94
Cooling Water	\$6.06
Labor	\$4.37
Administration Cost	\$1.48
Harvesting*	\$2.48

Source: Holtzaple, 2003.

* For sorghum only.

Stochastic Variables

The stochastic variables for the MixAlco production facility are annual cost per acre for sorghum silage and corn silage, annual yields for sorghum silage and corn silage, ethanol price, electricity price, and natural gas price. Corn silage is used as cellulose feedstock in the Panhandle Region and sorghum silage is used in the Central and Coastal Bend Regions.

Transportation cost for cellulose feedstock is dependent on plant capacity, density of the crop, and local hauling rates. Plant capacity determines the amount of feedstock required. Density of the crop is determined by the amount of acres harvested in a square mile and the yield per acre. As density decreases, transportation cost increases as greater distances are traveled to secure supply. Transportation cost (TC) is calculated as average cost per ton of cellulose feedstock using equation (2) (Gallagher¹):

$$(2) TC = \frac{2tr^*}{3}$$

where t is the transport cost in dollars/ton/mile and r^* is the maximum distance needed to supply the production facility. A full ring area is used in the Panhandle and Central Regions and a half ring is used for the Coastal Bend Region because of the coastline. Because of a half ring, r^* is larger for the Coastal Bend Region. A transportation rate of \$2.21/ton/mile is assumed (Texas Agriculture Statistic Service, 1999) and is inflated 2 percent annually.

1 – Gallagher et. al. calculated the cost of residual biomass for energy production. The physical relationship between distance from the plant, r , and available supplies, Q , can be approximated by $Q = (\pi r^2)dy$ where d is the density of planted crops per a square mile and y is the biomass yield per acre. Setting \tilde{Q} as the maximum plant capacity, the maximum distance required by the plant can be obtained by rearranging and solving $r^* = \sqrt{\tilde{Q}/(\pi dy)}$. The production from a ring of a given distance from a plant is given by the product of the circumference of the circle, the width of the ring, and the density of biomass. The total cost function can be calculated by

$$C(r) = \int_0^{r^*} P(r)(2\pi r)(dy)dr \text{ where } P(r) \text{ is a linear price gradient. The average biomass cost per}$$

ton is $AC = P_0 + \frac{2tr^*}{3}$ where P_0 is the farm cost of biomass per ton and $\frac{2tr^*}{3}$ is the transportation cost per ton.

Because of the compositional advantages of the alcohol fuel produced from MixAlco, Holtzaple (2003) hypothesized that the alcohol fuel produced will have a higher price than ethanol. However, until petroleum blenders derive a real price for the alcohol fuel, ethanol price is used for analysis. The average annual ethanol price for 33 cities is recorded by *Hart's Oxy Fuel News*. A mean value of \$1.21 per gallon (average ethanol price from 1994 to 2002) is used as the deterministic forecast value for simulation.

Industrial electricity and natural gas prices for 1994 to 2002 are available from the Energy Information Administration of United States Department of Energy. The mean price for this period (electricity price of \$0.043/kWh and natural gas price of \$4.9/GJ) is used as the deterministic forecast for simulation and is inflated at 2 percent a year to adjust for inflation over the planning period.

The source of historical yields for grain sorghum and corn silage for the period of 1994 to 2002 is the National Agriculture Statistics Service (NASS) of the United States Department of Agriculture (USDA). Corn silage yields are reported for the Panhandle Region. Sorghum silage yields are not reported for the Central or Coastal Bend Regions by USDA. Sorghum silage yields in the Central and Coastal Bend Regions are interpolated using a regression where historical sorghum silage yields are a function of historical grain sorghum yields².

Table 4 presents the average historical corn silage and grain sorghum gross

2 - The regression equation is $SilageYield = 0.206 GrainYield + \varepsilon$ where the t-statistic is in parenthesis and $R^2 = 0.98$, $\bar{R}^2 = 0.98$. The calculated within sample Mean Absolute Percent Error is 12.2%. Historical silage and grain sorghum yields are available from the USDA.

income, average total cost, and yields for each region. Historical feedstock costs are determined from annual farm budgets for 1998 to 2003 from the Texas Crop Enterprise Budgets prepared by the Texas Extension Agriculture Economics. To entice farmers to grow sorghum silage and corn silage for alcohol production, it is assumed that farmers are offered a guaranteed income per acre between the maximum of gross income (farming receipts for grain plus loan deficiency payment) or total cost of production plus a 10 percent risk premium. Based on the historical averages, gross income is offered to farmers in the Panhandle Region and Coastal Bend Region and total cost is offered in the Central Region. Corn silage budgets are used for the Panhandle Region while grain sorghum budgets are used in the Central and Coastal Bend Regions. The mean cost per acre of feedstock is inflated 2 percent annually. Nutrient source feedstock for the analysis is priced at \$10 per ton and is inflated 2 percent annually.

Table 5 presents the required contracted acres for cellulose feedstock production calculated using average historical silage yields in each region. Total cellulose feedstock for fuel conversion is stochastic and calculated by multiplying contracted acres by stochastic yield. A conservation and crop density percentage of 30 percent is incorporated into the required acreage.

Table 4. Historical Gross Income, Average Total Cost, and Yields for Corn Silage and Grain Sorghum.

Region	Commodity	Dollars/Acre		Tons/Acre**
		Gross Income*	Average Total Cost*	
Panhandle	Corn Silage	686	638	23.7
Central	Grain Sorghum	151	184	13.5
Coastal Bend	Grain Sorghum	186	175	14.5

Source: Texas Extension Agriculture Economics, 2004.

NASS, United States Department of Agriculture, 2003.

* Average annual values for 1998-2003.

** Average annual values for 1994-2002.

Table 5. Required Acres for Cellulose Feedstock Production.

Region	Commodity	Acres
Panhandle	Corn Silage	17,250
Central	Sorghum Silage	30,297
Coastal Bend	Sorghum Silage	28,238

A multivariate empirical (MVE)³ distribution for prices, cost per acre, and yields was estimated to simulate annual prices, costs, and yields. The MVE distribution has been shown to appropriately correlate random variables based on historical correlations (Richardson, et. al., 2000). The actual historical values for sorghum cost and yield, corn cost and yield, ethanol price, electricity price, and natural gas price were used to develop fractional deviates from the mean. The deviates are used to quantify the variation of each variable to develop stochastic deviates. The stochastic deviates from the MVE distribution are combined with the annual forecasted deterministic mean values to simulate stochastic costs, prices, and yields in each year. The stochastic variables are then incorporated into the financial statements.

Risk Analysis and Ranking

Ranking risky alternatives such as locations is more difficult than simply comparing the simulated average NPV. In previous literature, risky alternatives have been ranked using mean variance and stochastic dominance techniques (Richardson, 2004). However, both mean variance and stochastic dominance analysis often result in

3 – A MVE distribution is defined using actual historical values rather than assuming a parametric distribution. It is analogous to simulating random values from a frequency distribution made up of the actual historical data and is a closed form distribution which eliminates the possibility of values exceeding reasonable values observed in history. The parameters for a MVE distribution are the means, deviates from the mean expressed as a fraction, and the correlation matrix.

inconclusive rankings for some types of decision makers (McCarl, 1988).

Stochastic efficiency with respect to a function (SERF) is a procedure for ranking risky alternative scenarios when mean variance and stochastic dominance give inconsistent results (Hardaker, et. al., 2004). SERF varies risk aversion over a defined range and ranks risky alternatives in terms of certainty equivalence⁴. SERF can be used with any utility function and can identify a smaller efficient set than stochastic dominance analysis with respect to a function (SDRF). Using SERF will provide an ordinal ranking of the three alternative location choices for the MixAlco facility within feasible risk aversion boundaries. It will provide a cardinal measure for decision makers based on risk preferences defined by the risk aversion coefficient (RAC⁵). Comparisons between strongly risk adverse agents, risk neutral agents, and strongly risk-preferring agents are possible with SERF.

RESULTS AND DISCUSSION

The simulated stochastic variables are compared to the historical values to validate the simulation procedure. Statistical Student t-tests show all stochastic variables were equal in mean, variance and correlation to the respective historical values at the 0.05 significance level. This validates that the simulated stochastic variables return the

4 – Certainty equivalence (CE) is the amount of money a decision maker would be willing to pay to gain a fair bet for a risky alternative versus a risk-free alternative with the same average return. The concept of CE, introduced by Freund (1956) and refined by Hardaker (1997), can be used for evaluating risky decisions.

5 – RAC or $r(x)$ is defined as a function of wealth (x) as the negative ratio of the second and first derivatives of a utility function $u(x)$, where $r(x) = -u''(x)/u'(x)$ (Pratt, 1964; Arrow, 1965). The RAC is positive for risk aversion and diminishes for x if there is diminishing risk aversion (Hardaker et al., 1997). The RACs represent the decisions maker's degree of risk aversion (RAC>0), neutrality (RAC=0), and preference (RAC<0) and are used to classify decisions makers. SERF ranks risky strategies over a feasible range of RACs and avoids having to estimate RACS for individual decision makers. Meyer (1997) suggests using a range of RACs so that ranking of risky alternatives could be made for policy applications.

given mean, variability, and maintain the appropriate correlation among variables.

Simulated corn silage yields in the Panhandle Region are higher than sorghum silage yields in the Central and Coastal Bend Regions. However, average sorghum silage yield is higher in the Coastal Bend Region than the Central Region but are not statistically different at the 0.05 significance level using a Student t test. The similar yields can be explained by the use of dry-land farming in both regions. The mean and variance for the simulated yields in each region are statistically equal to their respective historical values. The mean and variance of simulated values for prices and costs are statistically equal in mean and variance to their respective historical values. The relative risk, measured by the coefficient of variation (CV), is also equal. The average cost of cellulose feedstock is highest in the Panhandle Region and lowest in the Coastal Bend Region. Transportation cost for feedstock is highest in the Coastal Bend Region and lowest in the Panhandle Region. All other variable costs were the same for each region.

The correlation matrix of simulated annual values for all stochastic variables was tested against the historical correlation matrix. Tests show the difference between the simulated correlation matrix and historical correlation matrix is not statistically significant at the 0.01 significance level. Therefore, we can say the simulation model reproduced the historical correlation among all stochastic variables.

Non-stochastic Results

Based on a mean (risk free) NPV ranking of the three alternative locations, the location with the highest NPV is preferred. The deterministic NPVs are \$3.7 million, \$25.1 million, and \$25.8 million for the Panhandle, Central, and Coastal Bend Regions, respectively. The Panhandle Region is the clearly the lowest while the Central and

Coastal Bend Regions are nearly identical. A decision maker cannot say the Central Region is strongly preferred to the Coastal Bend Region and vice-versa.

Stochastic Results

The simulated NPVs for each region are presented as cumulative distribution functions (CDFs) in Figure 2. The CDF graphs show the probability of NPV being less than a particular value. Probability is measured on the vertical axis and values for NPV are measured on the horizontal axis. The Central and Coastal Bend Regions showed a zero probability of NPV being below zero. The Panhandle Region showed a slight probability, 3 percent, that NPV will be below zero.

In this analysis, the Central Region returns the highest NPV at each probability level (CDF line farthest to the right in Figure 2). Because the CDF graphs do not cross, one can say risk-adverse, risk-neutral, and risk-preferring decision makers' all prefer the Central Region to the Panhandle and Coastal Bend Regions.

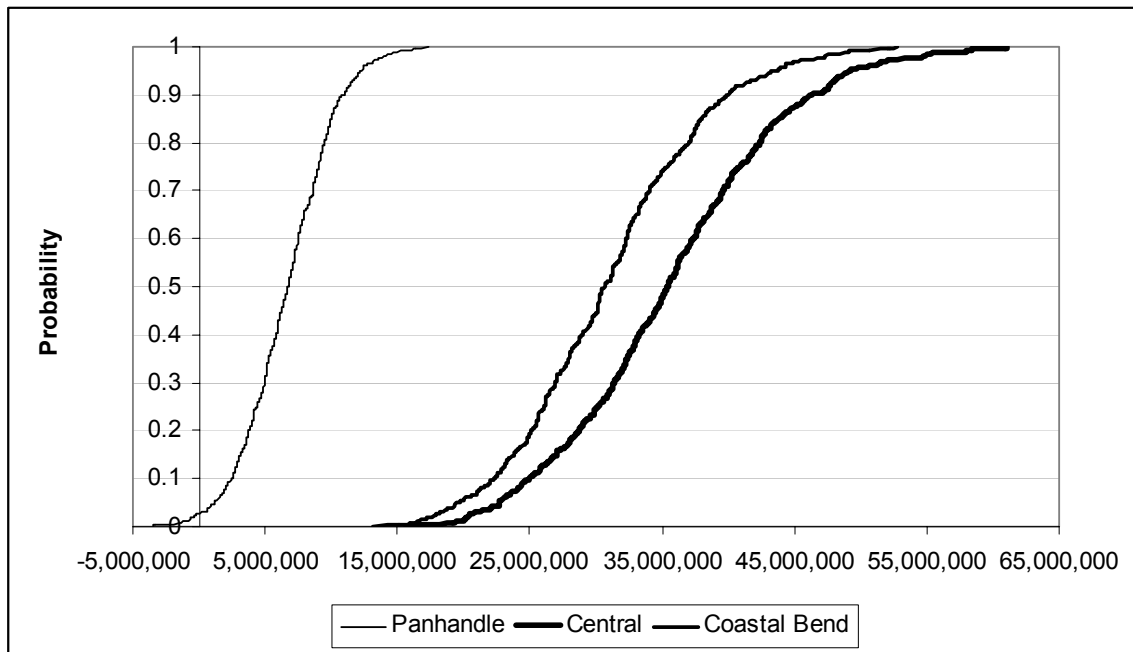


Figure 2. Cumulative Distribution Functions of NPV for a MixAlco Plant in Panhandle, Central, and Coastal Bend Regions of Texas.

Table 6 presents the minimum, mean, maximum, CV, and range for NPV in each region. Table 8 shows values from the financial statements for each region. The Panhandle Region has minimum, mean, and maximum NPVs of \$-3.49 million, \$6.7 million, and \$17.36 million, respectively. These NPVs are all lower than the minimum, mean, and maximum for the Central and Coastal Bend Regions. The Central Region returned simulated NPVs of \$15.73 million, \$35.69 million, and \$61.11 million for the minimum, mean, and maximum. The Coastal Bend Region has minimum, mean, and maximum NPVs of \$13.2 million, \$30.98 million, and \$52.81 million. The Panhandle Region had the lowest range while the Central Region had the highest range of all three regions. The simulated relative risk is comparable in Central and Coastal Bend Regions. The relative risk is higher in the Panhandle Region because there is greater variability in the cost and yield per acre of corn silage.

Table 6. Minimum, Mean, Maximum, CV, and Range Values of Net Present Value for Panhandle, Central, and Coastal Bend Regions.

Region	In Millions of Dollars				CV
	Minimum	Mean	Maximum	Range	
Panhandle	-3.49	6.70	17.36	20.85	51.01
Central	15.73	35.69	61.11	45.38	22.97
Coastal Bend	13.20	30.98	52.81	39.61	22.78

The CDF graphs and simulation results in Table 6 clearly show the Central Region is preferred over the Panhandle and Coastal Bend Regions. The difference in NPV between the Panhandle Region versus the Central and Coastal Bend Regions can be explained by the cost of cellulose feedstock. Even though corn silage yields cellulose material more than sorghum silage per acre, the additional yield is not enough to overcome the additional cost of corn silage. Cellulose feedstock cost is approximately 30 percent of all variable costs for the MixAlco Plant.

Feedstock costs per acre and yields are similar for the Central and Coastal Bend Regions. The difference in NPV between the two regions is due to the increased cost of transporting cellulose feedstock in the Coastal Bend Region. The Coastal Bend Region requires a half ring area to supply the necessary feedstock because of the adjacent coastline, thus increasing the travel distance and the average shipping cost per ton.

Figure 3 presents the SERF ranking for the three alternative locations. The SERF results for comparing the Panhandle, Central, and Coastal Bend Regions reaffirms the Central Region is preferred by all classes of decision makers because the certainty equivalence (CE) line for the Central Region is above the CE lines for the Central and Coastal Bend Regions for RAC levels⁶ of -0.000001 to +0.000001, indicating a preference for the Central Region for all classes of decision makers.

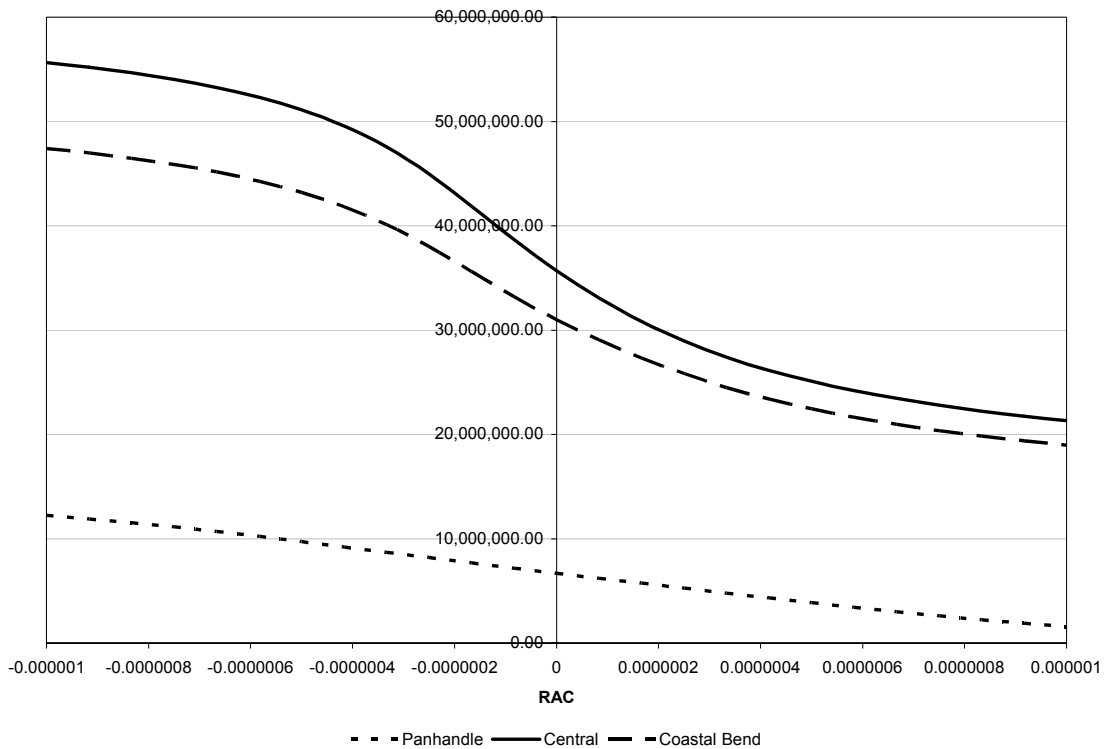


Figure 3. Stochastic Efficiency with Respect to a Function Ranking of NPV for a MixAlco Plant in the Panhandle, Central, and Coastal Bend Regions of Texas.

Table 7 presents the calculated risk premiums between the locations. The absolute differences between the CE lines in Figure 3 represent the risk premium decision makers place on the preferred alternative over another alternative. Risk premiums represent the amount of money decision makers would have to be paid to be indifferent between two risky alternatives

Table 7. Risk Premiums between Panhandle, Central, and Coastal Bend Regions Assuming Alternative Classes of Risk Preferences.*

Region	In Millions of Dollars		
	Risk-Loving	Risk-Neutral	Risk-Averse
Panhandle	-43.42	-29.00	-19.74
Coastal Bend	-8.25	-4.71	-2.35

* The Central Region is used as the base location for comparison.

The Central Region is used as the base region for comparison to calculate the risk premiums. Risk-loving decision makers have risk premiums of \$43.42 million and \$8.25 million when comparing the Central Region to the Panhandle Region and Coastal Bend Region. The risk premiums for risk-neutral decision makers are \$29 million and \$4.71 million for the Central Region compared to the Panhandle and Coastal Bend Regions. Risk-averse decision makers have the smallest risk premiums, \$19.74 million and \$2.35 million for the same comparisons, respectively. A decision maker would have to be paid these amounts to be indifferent from locating in the Central Region to the Panhandle Region or from the Central Region to the Coastal Bend Region. These results are consistent for entire range of risk aversion levels. Because the risk premiums are so large, we are more confident that the ranking is robust (Mjelde and Cochran, 1988).

6 – Ranges of -0.000001 to 0.000001 were used for RAC values to demonstrate the ranking of alternative locations across a wide range of decision makers. If the rankings change over the given RAC range, then alternative locations can be preferred at different risk aversion levels.

SUMMARY AND CONCLUSIONS

The fuel oxygenate market has grown at a rapid pace due to increasing gasoline prices and federal legislation mandating a reduction in air pollution. Because MTBE is being banned for water pollution and ethanol production is costly, MixAlco was developed as an alternative process of for making alcohol fuel for oxygenation. Because any biomass source can be used as feedstock for conversion to alcohol fuel, a number of location choices for MixAlco production is possible.

Location choices greatly affect the economic success of a business. Regional differences in the cost of land, input costs, available inputs, and transportation costs, all add risk when evaluating alternative locations. The objective of this study is to compare three alternative locations in Texas for a MixAlco production facility under a probabilistic framework. The method used in this study for decision-making under risk is to estimate the distribution for each alternative locations' NPV using simulation. Each location is then ranked based on the characteristics of the simulated NPV distribution using the SERF risk ranking procedure.

Based on the non-stochastic NPV ranking, the Panhandle Region is the least preferred location while the Central and Coastal Bend Regions returned almost identical NPVs. A decision maker cannot say Central Region is preferred to the Coastal Bend Region and vice-versa. Results of simulating the alternative locations under risk were presented as CDFs of NPV. Since the NPVs do not cross, one can say that the Central Region is preferred over the other two regions for all classes of decision makers. SERF rankings show the Central Region is preferred to the Panhandle and Coastal Bend Regions for risk-loving, risk-neutral, and risk-adverse decision makers.

Risk premiums range from \$43.42 million for risk-loving decision makers to \$19.74 million for risk-adverse decisions makers when comparing the Central Region to the Panhandle Region. Risk premiums when comparing the Central Region to the Coastal Bend Region for risk-loving decision makers are \$8.25 million and \$2.35 million for risk-adverse decision makers.

The results of this study provide useful information to compare the risk and benefits of MixAlco production. If the alcohol fuel is priced similar to ethanol, MixAlco production can be profitable and could substantially impact the fuel oxygenate market. The ability of MixAlco to convert any biomass material to alcohol fuel makes it an attractive alternative to ethanol production. Large amounts of available residual biomass represent a low cost feedstock source that can be used on MixAlco production. However, even in the Panhandle Region where feedstock cost was highest, MixAlco production returned a 97 percent probability that NPV will be positive.

LIMITATIONS OF THE STUDY

- Historical budgets for the three regions are limited from 1998 to 2003.
- Alcohol yield is constant for this analysis but may vary in real life production. Lab experiments have shown yield may vary from the mean 93 gallons/ton feedstock.
- No MixAlco facility is in production. The initial capital investment of \$20.1 million is only an estimate and may increase with the uncertainties of new technology.
- This study is limited to three locations and production of feedstock for fuel conversion. Alternative locations and residual biomass may be available.
- No location incentives were considered in this study.

REFERENCES

- Agriculture and Food Policy Center. "Represented Farm Project." Texas A&M University, College Station, TX, 2004.
- Arrow, K.J. *Aspects of the Theory of Risk-Bearing*. Academic Bookstore, Helsinki, Finland, 1965.
- Australian CRC for Renewable Energy Ltd. "What is Biomass?." <<http://acre.murdoch.edu.au/refiles/biomass/text.html>>
- Badger, P.C. "Ethanol from Cellulose: A General Review." *Trends in New Crops and Uses*, 2002.
- Bassam, N. "Global Potential of Biomass for Transport Fuel." Federal Agriculture Research Center, Institute of Crop and Grassland Science.
- California Energy Commission. "Evaluation of Biomass-to-Ethanol Fuel Potential in California." Publication P550-99-011. <http://energy.ca.gov/mtbe/ethanol/1999-08-16_500-99-011.html> 1999.
- Energy Information Administration, U.S. Department of Energy, <<http://www.eia.doe.gov/>> 2004.
- Gallagher, P. W., M. Dikeman, J. Fritz, E. Wailese, W. Gauthier, and H. Shapouri. "Biomass from Crop Residues, Cost and Supply Estimates." Office of Energy Policy and New Uses. AER-819.
- Greenhut, M.L. *A Theory of the Firm in Economic Space*. Austin Press, Educational Division, Lone Star Publishers, Inc., 1974.
- Hardaker, J.B., Huirne, R.B.M., and J.R. Anderson. *Coping with Risk in Agriculture*. Chapter 7, 1997.
- Hardaker, J.B., J. W. Richardson, G. Lien, and K. D. Schumann. "Stochastic Efficiency Analysis with Risk Aversion Bounds: A Simplified Approach." *Australian Journal of Agriculture and Resource Economics*, Forthcoming, 2004.
- Hart's Oxy-Fuel News*, 2003.
- Herbst, B. K. "The Feasibility of Ethanol Production in Texas." M.S. Thesis, Department of Agriculture Economics, Texas A&M University, 2003.
- Holtzaple, M. "MixAlco Process." Texas A&M University, College Station, TX, 2003.

- Isik, M., K. H. Coble, D. Hudson, and L. O. House. *A Model of Entry-Exit Decisions and Capacity Choice under Demand Uncertainty*. Unpublished manuscript presented at the 2002 American Agriculture Economics Association Annual Meeting, July, 2002.
- Mazza, P. "Ethanol: Fueling Rural Economic Revival." *Climate Solutions Report*.
- McCarl, B. "Preference Among Risky Prospects Under Constant Risk Aversion." *Journal of Agriculture and Applied Economics* 20:25-33, Dec. 1988.
- Meyer, J. "Choice Among Distributions." *Econometric Theory* 14:326-336, 1997.
- Mjelde, J.W. and M.J. Cochran. "Obtaining Lower and Upper Bounds on the Value of Seasonal Climate Forecasts as a Function of Risk Preferences." *Western Journal of Agriculture Economics* 13:285-293, Dec. 1988.
- National Agriculture Statistics Service, U.S. Department of Agriculture, <<http://www.usda.gov/nass/>> 2004.
- Office of Industrial Technology. *Biobased Products: Chemicals and Materials*. Unpublished manuscript presented at the 2001 Bioenergy Feedstock Meeting, November 2001.
- Pouliquen, L.Y. *Risk Analysis in project Appraisal*. Baltimore, MD: The Johns Hopkins University Press, 1970.
- Pratt, J.W. "Risk Aversion in the Small and in the Large." *Econometrica* 32: 122-136, 1964.
- Renewable Fuels Association. "Ethanol Industry Outlook 2003." 2003.
- Reutlinger, S. *Techniques for Project Appraisal Under Risk*. Baltimore: The John Hopkins Press, 1970.
- Richardson, J.W., K. Schumann, and P. Feldman. *Simulation for Applied Risk Management*. Department of Agriculture Economics, Texas A&M University. 2004.
- Richardson, J.W. and H.P. Mapp, Jr. "Use of Probabilistic Cash Flows in Analyzing Investment Under Conditions of Risk and Uncertainty." *Journal of Agriculture and Applied Economics* 8:19-24, Dec. 1976.
- Richardson, J.W., S.L. Klose, and A.W. Gray. "An Applied Procedure for Estimating and Simulating Multivariate Empirical (MVE) Probability Distributions in Farm Level Risk Assessment and Policy Analysis." *Journal of Agriculture and Applied Economics* 32,2:299-315, Aug. 2000.

Shapouri, H. *The U.S. Biofuel Industry: Present and Future*. Unpublished manuscript presented at the 2003 Conference Agro-Demain, December 2003.

So, K. S., P. F. Orazem, and D. M. Otto, *The Effects of Housing Prices, Wages, and Commuting Time on Joint Residential and Job Location Choices*. Unpublished Manuscript presented at the 1998 American Agriculture Economics Association Annual Meeting, July 1998.

Sterling Planet. "Energy for Biomass." <<http://sterlingplanet.com/sp/biomass.jsp>>

Texas Extension Agriculture Economics. "Texas Crop and Livestock Budgets." <<http://agecoext.tamu.edu/>> 2004.

Texas Agriculture Statistics Service. *1999 Texas Custom Rates Statistics*. Texas Agriculture Extension Service, 1999.

Veringa, H.J. "Advanced Techniques for Generation of Energy from Biomass and Waste." ECN Biomass.

Table 8. Simulated Mean Values from the Financial Statements for a MixAlco Plant in the Panhandle, Central, and Coastal Bend Regions of Texas.

	In Millions of Dollars														
Panhandle Region	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Gross Income	17.91	35.83	35.86	35.89	36.00	36.10	36.27	36.26	36.37	36.44	36.50	36.50	36.50	36.41	36.47
Total Cost*	15.27	28.87	29.38	29.95	30.43	30.97	31.52	32.06	32.66	33.22	33.82	34.43	35.02	35.60	36.24
Net Income (Loss)	2.64	6.96	6.48	5.94	5.57	5.13	4.76	4.20	3.71	3.22	2.68	2.07	1.47	0.81	0.23
Ending Cash Balance	1.52	5.00	8.23	11.18	13.91	16.41	18.68	20.63	22.30	23.64	24.61	25.13	25.18	24.73	23.73
Total Assets	20.96	23.77	26.33	28.61	30.68	32.50	34.10	35.38	36.39	37.05	37.35	37.21	36.59	35.46	33.79
Ending Net Worth	11.27	14.49	17.48	20.22	22.79	25.16	27.35	29.27	30.95	32.36	33.46	34.18	34.49	34.37	33.79
Dividends Paid	0.52	1.38	1.28	1.18	1.10	1.02	0.94	0.84	0.74	0.67	0.58	0.50	0.43	0.34	0.30
Central Region	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Gross Income	18.10	36.09	36.34	36.29	36.61	36.87	37.07	37.28	37.36	37.59	37.86	38.07	38.17	38.11	38.37
Total Cost*	12.59	23.37	23.75	24.10	24.58	25.05	25.41	25.89	26.29	26.76	27.22	27.75	28.17	28.60	29.10
Net Income (Loss)	5.51	12.72	12.59	12.19	12.02	11.82	11.66	11.39	11.07	10.83	10.63	10.32	10.00	9.51	9.27
Ending Cash Balance	2.85	9.72	16.55	23.03	29.43	35.60	41.68	47.62	53.24	58.68	63.96	69.07	73.85	78.18	82.37
Total Assets	22.30	28.50	34.66	40.47	46.20	51.70	57.11	62.38	67.33	72.10	76.71	81.15	85.26	88.92	92.44
Ending Net Worth	12.61	19.21	25.80	32.08	38.31	44.36	50.36	56.26	61.90	67.41	72.82	78.12	83.16	87.83	92.44
Dividends Paid	1.09	2.83	2.83	2.69	2.67	2.59	2.57	2.53	2.42	2.36	2.32	2.27	2.16	2.00	1.97
Coastal Bend Region	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Gross Income	17.96	35.95	36.12	36.18	36.41	36.61	36.91	37.05	37.15	37.32	37.50	37.62	37.73	37.77	37.97
Total Cost*	12.79	23.99	24.39	24.80	25.25	25.68	26.15	26.58	27.02	27.52	27.99	28.41	28.96	29.39	29.91
Net Income (Loss)	5.17	11.96	11.73	11.38	11.16	10.92	10.76	10.48	10.13	9.80	9.51	9.21	8.77	8.38	8.06
Ending Cash Balance	2.69	9.03	15.27	21.19	26.98	32.60	38.09	43.33	48.37	53.19	57.64	61.91	65.94	69.56	72.97
Total Assets	22.14	27.81	33.38	38.63	43.75	48.70	53.52	58.09	62.46	66.61	70.39	73.99	77.35	80.30	83.04
Ending Net Worth	12.45	18.52	24.52	30.24	35.86	41.36	46.77	51.97	57.02	61.91	66.50	70.96	75.25	79.22	83.04
Dividends Paid	1.02	2.60	2.57	2.45	2.41	2.36	2.32	2.23	2.17	2.10	1.97	1.92	1.84	1.71	1.65

* Includes depreciation cost.