Economics of Lignocellulosic Ethanol Production From Energy Cane

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Introduction

In the Energy Independence and Security Act (EISA) of 2007, the U.S. Environmental Protection Agency (EPA) published new standards (RFS2) of the Renewable Fuel Standard (RFS) mandate, first established in the Energy Policy Act of 2005, as well as new biofuel categories based on a criterion that uses greenhouse gas (GHG) emissions lifecycle analysis. From the mandated total of 36 billion gallons, 21 billion gallons must come from advanced biofuels of which 16 billion have to be cellulosic biofuels by the year 2022. For cellulosic ethanol to be included in the "advanced cellulosic biofuel" category, its GHG emissions should be 60 percent, or no less than 50 percent, lower than the emissions produced by gasoline according to a 2005-baseline average and based on the EPA lifecycle analysis criteria. This fact compared to the required 20-percent-reduction for corn-based ethanol is evidence of the greater environmental benefits that could potentially be obtained from cellulosic ethanol if emissions requirements are met.

Cellulosic ethanol is a form of biofuel produced from lignocellulose, the structurally-rigid and inedible tissue that makes up much of the mass of plants. Even though lignocellulose is the most abundant plant tissue material and an attractive substrate for ethanol production, pretreatment is required to release the cellulose and hemicellulose and subject them to hydrolysis. Simple sugars resulting from this hydrolysis can then be subsequently converted to ethanol through fermentation. Other conversion technologies include pyrolysis or gasification. Although ethanolic biofuel can be obtained from a wide array of feedstocks, the ones that have received special attention recently are the perennial energy grasses (e.g. energy cane) due to their agronomic properties as well as their non-competitive nature with food, feed or fiber crops. In contrast to traditional sugarcane varieties, energy cane has much lower concentrations of soluble sugars but higher levels of fiber content. Energy cane exhibits desirable characteristics such as high yield potential, low input requirements, and wide geographic adaptability for large-scale commercial production. The U.S. Gulf Coast presents major competitive advantages over other regions for potential commercial production of energy cane. These advantages include long growing seasons with suitable climatic, edaphic, and logistic (i.e. transportation) conditions as evidenced by the current sugarcane industry.

Since energy cane has not been grown commercially, a unique opportunity exists to assess the economic feasibility of producing and processing it to obtain ethanol through the hydrolytic process. Available estimates indicate potential yields of 70 gallons per dry short ton of energy cane through hydrolysis (Aita, Salvi, & Walker, 2011). Hence, the present study uses an annual Monte Carlo financial statement model to assess the economic feasibility of ethanol production from energy cane.

Methodology

The probabilistic financial model is divided into two sections. The first section estimates feedstock and biofuel production, respectively, considering the feedstock yield and the prices of ethanol and of the by-products generated from the conversion process stochastic. The second section develops conventional pro-forma financial statements comprised of: 1) an income statement, 2) a cash flow statement, and 3) a balance sheet.

The probabilistic component of the model is based on the non-parametric empirical distribution and the parametric GRKS distribution available in the Simetar Excel add-in (Richardson, 2010). Energy cane yields are simulated with an independent empirical distribution whereas biofuel and by-product prices are simulated with a correlated multivariate empirical distribution (MVE) (Richardson, Klose, & Gray, 2000). The MVE is a non-normal alternative distribution that uses limited data on historical prices for different commodities and a correlation matrix to represent intra-temporal (across commodities) and inter-temporal (across time) relationships. With the historical data and the correlation matrix, the MVE distribution generates correlated error terms that are applied to a forecasted mean. Due to the limited information on sweet sorghum yields in the Rio Grande Valley region of Texas, the GRKS distribution was used to simulate yields. This parametric distribution is similar to the triangular distribution in that it is fully characterized by a minimum, expected and maximum value. However, the assumed minimum and maximum values in the GRKS represent the 2.5% and 97.5% quantiles. Hence, allowing the stochastic variable to take on values below and above the assumed minimum and maximum, respectively, with low probabilities of occurrence.

There is a construction period considered for the conversion plant. The model allocates fixed capital investment to every year of the construction period through a set of completion percentages. The model assumes that the initial capital needed to build and operate the plant is obtained from public sources or a loan. Interests are paid annually for the percentage of the fixed capital investment under a loan. The rest of the fixed capital investment is assumed to come from public sources and to generate dividends. The model also considers a start-up period once the plant is already built and operating. Since the conversion plant does not run at its full capacity during the start-up period; revenues, variable costs and fixed costs during this period are assumed to be percentages of full-capacity operations. The Modified Accelerated Cost Recovery System (MACRS) is the current tax depreciation system in the U.S. and the one considered in this study. The model considers two short-term loans destined to cover operating expenses and cash flow deficits. The operating loan is defined as a percentage of total annual operating expenses. The cash flow deficit loan is recursive and depends on the conversion plant's cash flow position in the previous year.

All the technical and financial random variables estimated in the first section are used in the second one to develop the pro-forma statements for a 10-year horizon using forecasted interest and inflation rates. The stochastic outputs generated by these pro-forma statements are summarized as probability distributions of key output variables (KOV). The probability distributions are obtained by simulating the stochastic KOVs over 500 iterations. These functions help the analyst by graphically representing the probabilities of being in a financially sound position or the contrary.

The net cash income (*NCI*) is one of these KOVs and is obtained from the income statement:

$$\widetilde{NCI}_t = \widetilde{RECEIPTS}_t - \widetilde{EXPENSES}_t$$

$$\widetilde{RECEIPTS}_t = \left(ETHQ_t * \widetilde{ETHP}_t\right) + \left(ELYQ_t * \widetilde{ELYP}_t\right) + TAXCREDIT$$

$$\widetilde{EXPENSES}_t = \left[\sum\nolimits_i \left(\widetilde{FEEDQ}_{it} * \widetilde{FEEDP}_{it}\right) * (1 + INF_t)\right] + OPEXP_t + INTEXP_t$$

where the ~ subscript represents a stochastic variable, the *t* subscript represents the period of time, the *i* subscript represents both feedstock types, *ETHQ* ethanol production, *ETHP* ethanol price, *ELYQ* excess electricity generated, *ELYP* electricity price, *TAXCREDIT* the second generation biofuel producer tax credit, *FEEDQ* feedstock production, *FEEDP* feedstock price, *INF* inflation rate, *OPEXP* total operating expenses and *INTEXP* interest expenses for conversion plant loan.

The ending cash (*EC*) is the KOV obtained from the cash flow statement in the following manner:

$$\widetilde{EC}_t = \widetilde{INFLOW}_t - \widetilde{OUTFLOW}_t$$

$$\widetilde{INFLOW}_t = \widetilde{NCI}_t + \widetilde{BEGCASH}_t + \widetilde{INTRESV}_t$$

$$\widetilde{OUTFLOW}_t = LOANPMT_t + \widetilde{DEFPMT}_t + \widetilde{DIVIDEND}_t + \widetilde{INCTAX}_t$$

where *BEGCASH* represents beginning cash or the ending cash of the previous period, *INTRESV* is the interest earned on positive beginning cash at a determined savings rate, *LOANPMT* is the principal payment for the plant loan, *DEFPMT* is the payment for the cash deficit loan, *DIVIDEND* represents the dividends paid for the publicly financed portion of the fixed capital investment, and *INCTAX* is the income tax charged on the net income tax after considering depreciation.

The net worth (*NW*) is the KOV obtained from the balance sheet:

$$\widetilde{NW}_t = \widetilde{ASSET}_t - \widetilde{LIAB}_t$$

$$A\widetilde{SSET}_t = \widetilde{EC}_t + LANDVAL_t + PLANTVAL_t$$

$$L\widetilde{IAB}_t = DE\widetilde{FLOA}N_t + PLAN\widetilde{TLOA}N_t$$

where *LANDVAL* is the value of land, *PLANTVAL* is the value of the conversion plant, *DEFLOAN* is the deficit loan, and *PLANTLOAN* is the loan for the conversion plant.

The present value of the annual projection of net cash income (*PVNCI*) represents a rough measurement of profitability:

$$P\widetilde{VNC}I = \sum_t^{10} \widetilde{NCI}_t \,/(1+r)^t.$$

The present value of the ending net worth (*PVENW*) shows the capital position of the firm at the end of the forecasted horizon:

$$P\widetilde{VEN}W = N\widetilde{W_{t=10}}/(1+r)^{t=10}.$$

The net present value (*NPV*) is the financial metric that encapsulates the entire performance of the firm in present dollars:

$$\widetilde{NPV} = -BEGNW + P\widetilde{VEN}W + PVD\widetilde{IVID}END$$

where *BEGNW* represents the beginning net worth and *PVDIVIDEND* the present value of the dividends paid annually and estimated as following:

$$PVD\widetilde{IVID}END = \sum_t^{10} DIV\widetilde{IDE}ND_t \,/(1+r)^t.$$

By creating a probability distribution of the stochastic NPV, the criteria of economic success considered in this study is when the NPV is positive 95% of the time or: $P\left(\widetilde{NPV} > 0\right) > 0.95$.

Data Sources

Due to seasonal and agronomic limitations in the production energy cane, it is assumed that the hydrolysis conversion plant also demands sweet sorghum as a complementary feedstock. Energy cane could be potentially supplied to the plant from October to April leaving the rest for sweet sorghum.[1] Hence, approximately 70% of the biomass supplied to the plant on an annual basis is energy cane and the rest is sweet sorghum.

Large experimental field plots (i.e. over an acre) of energy cane have been under production since 2004 in Weslaco, Texas (26° 09’ 45” N, 97° 57’ 24” W; elevation 65 ft.), and are managed by Texas A&M AgriLife Research and Extension Center. Production records include yield data for plant cane and ratoon crops for 2010, 2011 and 2012 as listed in Table 6. These yields were used to develop a univariate empirical distribution used to simulate stochastic energy cane yields. The average yield for energy cane from the experimental plots was 20.4 dry short tons/acre compared to an average sugar cane yield of 10.5 dry short tons/acre (both at 20% moisture level) demonstrates one advantage of growing energy cane from an agronomic standpoint. The minimum, expected and maximum sweet sorghum yields for the GRKS distribution are 9, 12 and 15 dry tons per acre (20% moisture level), respectively.

The production and harvest costs on a per-dry-short-ton or per-acre basis have been obtained from the feedstock production literature, different universities’ extension budgets and the private sector. Table 1 lists the expected yields and costs of each feedstock. Energy cane production costs were obtained from the regional budgets for plant and ratoon sugarcane for District 12 in Texas (Texas A&M AgriLife Extension, 2012). Production and harvest costs for sweet

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[1] There exist the opportunity to extend the harvesting period of energy cane by two months from September to May.

sorghum were obtained from a Mississippi State University's study (Linton, Miller, Little, Petrolia, & Coble, 2011). Moisture content follows the Department of Energy's (DOE) designs for 2012 conventional logistics systems listed in the Biomass Multi-year Program Plan (US DOE, 2011). It is assumed that the producer receives returns equivalent to 20% of the production costs. This return percentage is meant to represent the margin by which producers would switch from growing current crops to energy cane. Fixed and variable harvest and hauling costs for energy cane are assumed to be the same as for sugar cane and were obtained from the Rio Grande Valley Sugar Growers, Inc. for 2011. All costs have been inflated from their original values to 2012 dollars using the Producer's Price Index (PPI).

Table 1. Feedstock Production Costs

	Units	Energy cane	Sweet sorghum
Expected feedstock yield	dry short tons/acre	20.39	12.00
Share of feedstock wasted in handling	percent	8%	8%
Feedstock delivered yield	dry short tons/acre	18.76	11.04
Moisture content for processing	percent	20%	20%
Harvested acreage	acres	29,911.19	21,785.71
Feedstock production cost per acre	$/acre	613.00	181.97
Feedstock production cost per short ton	$/dry short ton	30.06	15.16
Return to producer	percent	20%	20%
Production cost plus return to producer	$/dry short ton	36.07	18.20
Fixed harvest cost	$/acre	92.13	0.00
Variable harvest cost	$/dry short ton	8.53	20.51
Complementary feedstock storage cost	$/dry short ton	9.04	9.04
Total feedstock production	dry short tons/year	610,000.00	261,428.57
Total feedstock cost	$/year	35,478,716.07	12,483,518.80
Expected feedstock cost	$/dry short ton	58.16	47.75

The technical assumptions considered for the conversion plant were obtained from the most updated hydrolysis study from the National Renewable

Energy Laboratory (NREL) and listed in Table 2 (Humbird, et al., 2011). Although corn stover is the plant's feedstock in the NREL study, we assumed that energy cane can also be converted with the same technological specifications. The ethanol yield assumed in the NREL study was 79 gallons/dry short ton of corn stover. However, the yield used in this study is 70 gallons/dry short ton of energy cane according to a study from the Audubon Sugar Institute in Louisiana State University (Aita, Salvi, & Walker, 2011).

Table 2. Technical Parameters for Conversion Plant

	Values	Units
Ethanol yield	70	gallons/dry short tons
Ethanol annual production	61,000,000	gallons/year
Annual biomass feedstock demand	871,429	dry short tons/year
Daily biomass feedstock demand	2,487	dry short tons/day
On-stream percentage	96%	percent
Plant life	30	years
Construction period	3	years
Completion in first year	8%	percent
Completion in second year	60%	percent
Completion in third year	32%	percent
Start-up time	3	months
Revenues	50%	percent
Variable costs	75%	percent
Fixed costs	100%	percent
Excess electricity yield as a by-product	1.80	kWh/gallon

The operating and capital expenses used to develop the pro-forma financial statements were also obtained from the same NREL study and listed in Table 3 and Table 4, respectively. Since this study uses the same plant capacity as in the NREL study, capital expenses are the same. However, capital expenses for different plant sizes would be estimated as a function of the plant's capacity and a scaling factor. Since the operating and capital expenses were reported in 2007 dollars in the NREL study, the Chemical Engineering Plant Cost Index (CEPCI) was used to convert them to 2012 dollars (Chemical Week Associates, 2012).

Table 3. Operational Expenses of Conversion Plant

	Values	Units
Enzyme	0.22	$/gallon
Chemicals	0.10	$/gallon
Other raw material	0.15	$/gallon
Waste disposal	0.03	$/gallon
Fixed costs	12,047,788	$/year

Table 4. Capital Expenses of Conversion Plant

	Values	Units
Fixed capital investment	452,757,921	$
Value of land at the beginning of construction	2,034,336	$
Total project investment	454,792,256	$
Discount rate	7%	percent
Dividend as a percent of net income	15%	percent
Depreciation		
MACRS recovery period for biofuel plant	7	years
Biofuel plant installed equipment costs	386,757,921	$
MACRS recovery period for steam plant	20	years
Steam plant installed equipment costs	66,000,000	$
Plant loan		
Fraction of plant financed with loan	60%	percent
Fraction of plant financed with equity	40%	percent
Fixed capital investment (FCI) under loan	271,654,752	$
Fixed capital investment (FCI) under equity	181,103,168	$
Length of plant loan	10	years
Interest rate of plant loan	8%	percent
Operating loan		
Year fraction to repay interest of operating loan	0.01	fraction

Ethanol and electricity (by-product) prices were simulated as an MVE distribution and correlated with other fuel and by-product prices such as gasoline, diesel, liquefied petroleum gas, natural gas, naphtha, wood and waste (i.e. char), and other petroleum products. The historical prices for all these fuels (except ethanol) and by-products were obtained from the U.S. Energy

Information Administration (EIA). Historical ethanol prices were obtained from Hart's Oxy Fuel News for different regions in the U.S. The mean national ethanol price for the last 18 years was used in this study. Inflation rate figures were obtained from the Food and Agricultural Policy Research Institute (FAPRI) U.S. Baseline Briefing Book. The interest rates were obtained from the Agricultural and Food Policy Center (AFPC) 2012 mid-year update (Raulston, 2013).

Results

The probability distribution functions (PDF) shown in Figure 1 were obtained by simulating yields 500 times using the empirical and GRKS distributions for energy cane and sweet sorghum, respectively. The mean and standard deviation of energy cane were 20.2 and 3.5 dry short tons per acre, respectively. The mean and standard deviation for sweet sorghum were 12 and 1.5 dry short tons per acre, respectively.

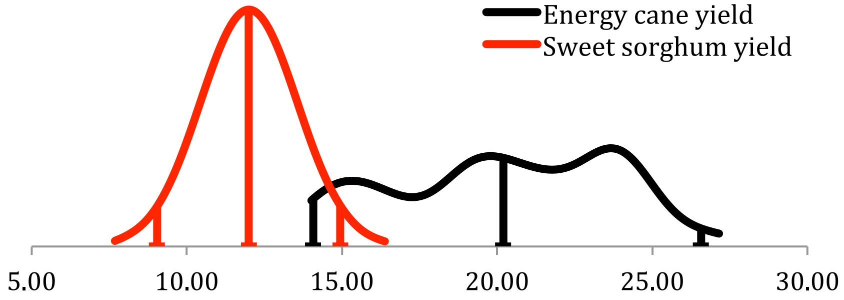


Figure 1. Probability Distribution Functions of Both Feedstock Yields in Dry Short Tons per Acre

Ethanol prices were also considered stochastic and simulated with a correlated MVE distribution. Figure 2 depicts a fan graph of the stochastic prices over a 10-year horizon with their respective variation represented by percentiles.

The average ethanol price was forecasted as a linear projection using the last 18 years. The MVE distribution was estimated using the last 18 years as well.

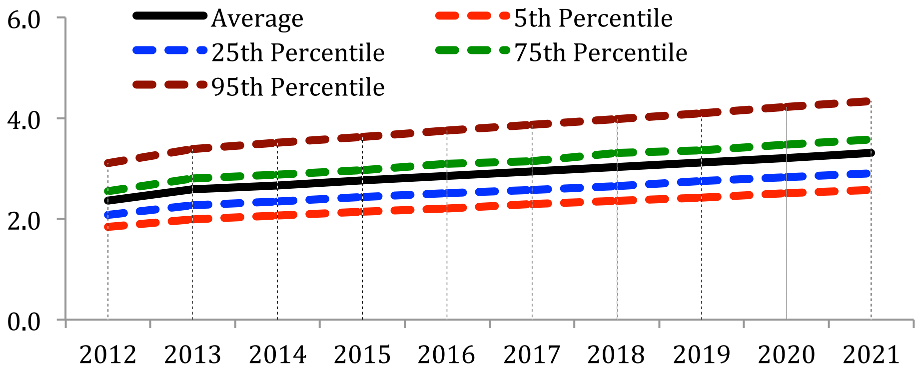


Figure 2. Forecasted and Correlated Stochastic Ethanol Prices in $ per Gallon with their respective percentiles

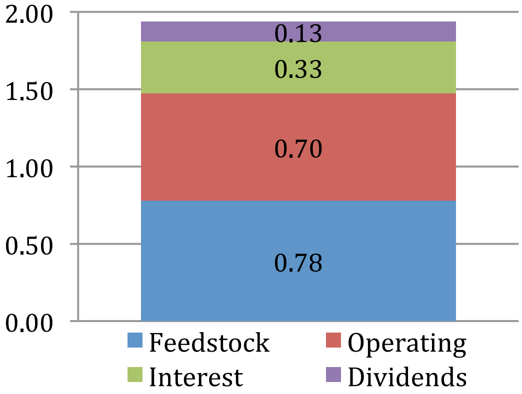


Figure 3. Ethanol Cost Distribution in $ per Gallon

By considering expected feedstock and ethanol yield, feedstock costs and operating expenses account for approximately 40% and 36% for every gallon of ethanol produced, respectively, as depicted in Figure 3. The expected total cost of a gallon of ethanol is approximately $1.97. Capital expenses account for approximately 24% of every gallon of ethanol assuming that 60% of the capital invested in the plant comes from a loan for 10 years at an interest rate of 8%. However, by considering the probabilistic nature of yields, feedstock costs can reach a minimum of $0.66 and a maximum of $1 per gallon as depicted in Figure

4. These figures demonstrate that feedstock takes the biggest share of the total cost of a gallon of ethanol.

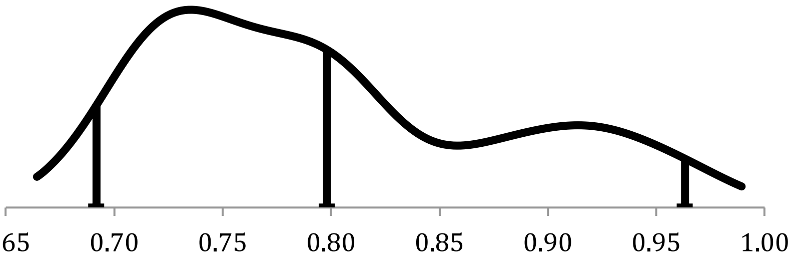


Figure 4. Probability Distribution Function of Feedstock Cost in $ per Gallon of Ethanol

When considering the total cost of every gallon of ethanol, it can reach a minimum of $1.78 and a maximum of $2.24/gallon as depicted in Figure 5. The forecasted mean price of ethanol in 2013 is approximately $2.58/gallon reaching a minimum of $1.86 and a maximum of 3.40/gallon. In a broad manner and without the tax credit, it is profitable to produce a gallon of ethanol when considering the expected cost and price of ethanol. However, it becomes unprofitable by considering the minimum price of ethanol.

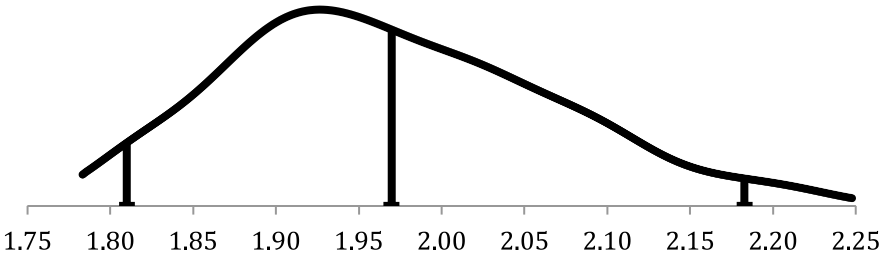


Figure 5. Probability Distribution Function of Total Biofuel Cost in $ per Gallon of Ethanol

The probabilistic results of the key output variables estimated from the pro-forma statements are listed in Table 7. Although all the expected values look promising, the minimum values are negative in some years. For example, the forecasted net worth shows negative minimum values until the 7th forecasted year. When considering financial metrics that do not take into account the initial investment, the enterprise looks promising. For example, by adding the present value of the net cash income (PVNCI), both the minimum and maximum values are positive as shown in Table 5. The minimum and maximum values of the present value of the last year's net worth (PVENW) are positive as well. However, when considering a financial metric that takes into account the initial investment, such as the net present value (NPV), the minimum value is negative as shown in the second column of Table 5. The cumulative probabilities of a negative NPV would be helpful to appreciate the risk involved in the enterprise.

Table 5. Probabilistic Results of Net Present Value (NPV), Present Value of Net Cash Income (PVNCI) and Net Worth (PVNW)

KOV	NPV	PVNCI	PVENW
Mean	23,149,617	524,372,593	177,104,512
Std. Dev.	44,469,421	65,137,625	34,826,262
Coeff. Var.	192	12	20
Min.	-113,889,246	323,305,443	68,386,423
Max.	144,923,973	706,890,456	271,563,737

Figure 6 presents the cumulative distribution function (CDF) of the NPV without the tax credit, as has been considered so far, and with the tax credit. The second generation biofuel producer tax credit is a federal provision of \$1.01/gallon for biofuels that comply with the 60% reduction requirement (considering the life-cycle analysis and compared to petroleum-based fuels) specified in the new Renewable Fuel Standards (RFS2). This tax credit is renewed every year and was recently renewed for 2013. Without the tax credit, the probabilities of a positive NPV are 70% demonstrating that the project is not economically successful according to the economic success criteria of a positive NPV 95% of the time. By considering the recently renewed tax credit of \$1.01/gallon, the project becomes economically successful.

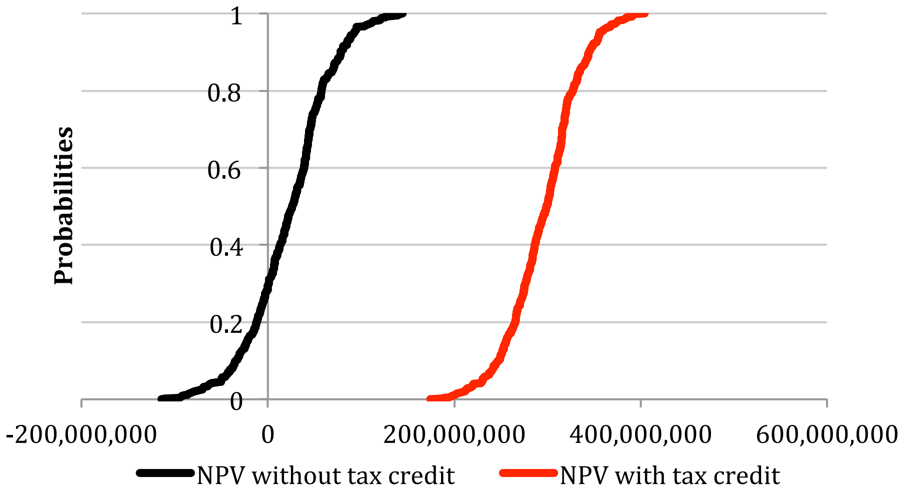
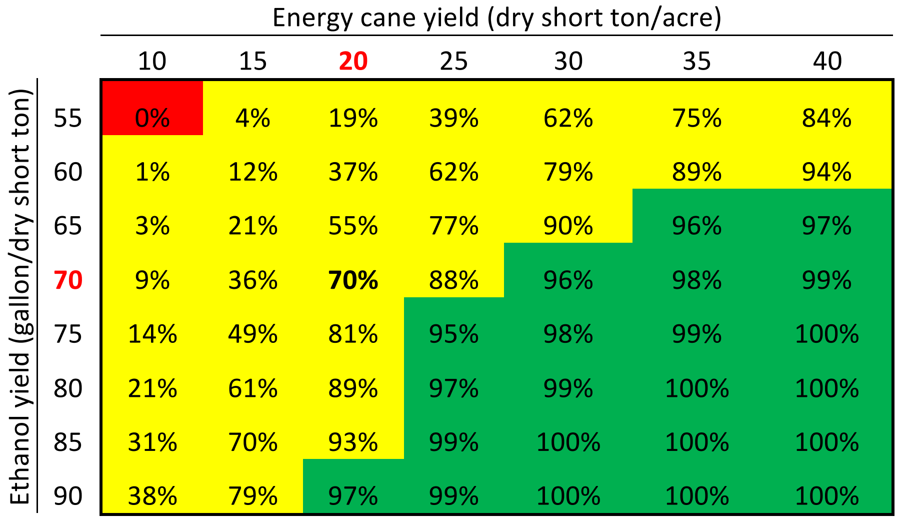


Figure 6. Comparison of Net Present Value With and Without the Second Generation Biofuels Tax Credit

However, considering the ephemeral nature of the tax credit (renewed every year), it would be prudent to analyze to what extent feedstock and ethanol yields affect the probability of economic success without the tax credit. Hence, Figure 7 shows the sensitivity of decreasing and increasing both yields on the probability of economic success without the tax credit. The expected yields are shown in red figures and are 20 dry short tons per acre and 70 gallons per dry short ton for energy cane and ethanol, respectively. When considering a sugar cane yield of 10 dry short tons/acre and an ethanol yield of 70 gallons/dry short ton, the chances of obtaining a positive NPV become extremely slim (9%) as shown in Figure 7. This is a reason why cellulosic ethanol from sugar cane is not currently produced. By considering only feedstock production, yields would have to increase by 10 dry tons per acre. By considering only ethanol conversion, yields would have to increase by 20 gallons per dry ton. However, by considering an increment of both, feedstock and ethanol yields would have to increase by only 5 dry tons per acre and 5 gallons per dry ton, respectively, to make the project economically successful.



	Energy cane yield (dry short ton/acre)						
Ethanol yield (gallon/dry short ton)	10	15	20	25	30	35	40
55	0%	4%	19%	39%	62%	75%	84%
60	1%	12%	37%	62%	79%	89%	94%
65	3%	21%	55%	77%	90%	96%	97%
70	9%	36%	**70%**	88%	96%	98%	99%
75	14%	49%	81%	95%	98%	99%	100%
80	21%	61%	89%	97%	99%	100%	100%
85	31%	70%	93%	99%	100%	100%	100%
90	38%	79%	97%	99%	100%	100%	100%

Figure 7. Sensitivity Analysis of Probability of Economic Success with Different Energy Cane and Ethanol Yields

Conclusions

By developing a probabilistic financial model considering feedstock yields and fuel prices stochastic, the economic feasibility of ethanol production from energy cane through a hydrolytic process was assessed. Historical energy cane yields from the Texas A&M AgriLife Research and Extension Center in Weslaco, Texas and hypothetical yields for sweet sorghum were used to develop probabilistic distributions. Historical fuel prices from private and public sources were used to develop a correlated multivariate empirical distribution. Ethanol conversion plant parameters were obtained from the most updated NREL study on hydrolysis.

By considering expected feedstock yields, the cost per gallon of ethanol was $1.97. Feedstock and conversion plant operating expenses accounted for approximately 40% and 36% of the cost per gallon of ethanol, respectively. However, with the stochastic nature of yields, the cost per gallon of ethanol could reach a minimum and a maximum of $1.78 and $2.24. When considering expected ethanol and electricity (by-product) prices, the expected key output variables obtained from the pro-forma statements were all promising. However, with stochastic prices, all key output variables resulted in negative minimums demonstrating the probability of economic losses. By considering a probability of (or greater than) 95% of a positive net present value as the criteria for economic success, it was determined that without the tax credit the project was not economically successful (70% probability of success). However, when considering the tax credit, the project was economically successful.

By analyzing the sensitivity of the probability of economic success with different energy cane and ethanol yields and without the tax credit, it was identified that by increasing both yields by 5 units the project would become economically successful. This conclusion shows that with the parameters assumed in this study, the joint efforts of agronomists, plant breeders and chemical engineers would most likely make the project economically successful in the short term.

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Table 6. Yield Data from the Large Experimental Plots in Weslaco, Texas

Year	Life stage	Variety I.D.	Rep.	Wet Yield (short tons/acre)	Moisture content (%)	Dry Yield (dry tons/acre @ 20% moisture)
2010	Plant Cane	EC1	1	55.93	68%	21.26
2010	Plant Cane	EC1	2	63.26	68%	24.09
2010	Plant Cane	EC1	3	72.59	72%	24.11
2010	Plant Cane	EC1	4	54.28	71%	19.22
2010	Plant Cane	EC2	1	65.42	71%	22.58
2010	Plant Cane	EC2	2	63.21	68%	24.06
2010	Plant Cane	EC2	3	71.22	73%	23.32
2010	Plant Cane	EC2	4	62.68	73%	20.53
2010	Plant Cane	EC3	1	71.30	68%	27.15
2010	Plant Cane	EC3	2	52.82	68%	20.26
2010	Plant Cane	EC3	3	70.24	71%	24.58
2010	Plant Cane	EC3	4	55.65	71%	19.47
2011	Ratoon 1	EC4	1	55.95	72%	18.58
2011	Ratoon 1	EC4	2	48.62	72%	16.15
2011	Ratoon 1	EC4	3	58.16	72%	19.31
2011	Ratoon 1	EC4	4	42.83	72%	14.22
2011	Ratoon 1	EC5	1	48.03	71%	16.58
2011	Ratoon 1	EC5	2	48.16	71%	16.62
2011	Ratoon 1	EC5	3	45.85	73%	15.01
2011	Ratoon 1	EC5	4	45.91	73%	15.04
2011	Ratoon 1	EC6	1	63.82	71%	22.33
2011	Ratoon 1	EC6	2	40.06	71%	14.02
2011	Ratoon 1	EC6	3	39.87	68%	15.28
2011	Ratoon 1	EC6	4	62.79	68%	24.06
2012	Plant Cane	EC7	1	68.21	71%	23.77
2012	Plant Cane	EC7	2	65.76	70%	23.71
2012	Plant Cane	EC7	3	55.16	71%	19.00
2012	Plant Cane	EC8	1	53.80	70%	19.19
2012	Plant Cane	EC8	2	61.14	71%	21.42
2012	Plant Cane	EC8	3	57.61	70%	21.04

Table 7. Probabilistic Results for Net Cash Income (NCI), Ending Cash (EC) and Net Worth (NW) for a 10-Year Horizon

KOV	NCI 1	NCI 2	NCI 3	NCI 4	NCI 5	NCI 6	NCI 7	NCI 8	NCI 9	NCI 10
Mean	26,336,421	55,722,630	61,813,535	69,402,649	77,073,197	85,118,837	92,672,390	101,440,700	109,488,463	117,453,924
Std. Dev.	19,885,988	24,804,632	26,270,561	26,226,535	27,082,771	28,621,246	28,869,061	29,412,514	30,049,189	31,637,082
Coeff. Var.	76	45	42	38	35	34	31	29	27	27
Min.	-13,566,509	2,491,613	5,952,247	18,775,114	23,471,803	27,551,423	31,341,411	42,183,369	49,106,580	52,277,936
Max.	72,807,753	114,318,134	121,467,953	132,166,929	140,938,182	149,924,580	159,788,008	169,151,523	178,634,436	189,715,151

KOV	EC 1	EC 2	EC 3	EC 4	EC 5	EC 6	EC 7	EC 8	EC 9	EC 10
Mean	3,274,622	30,375,893	60,568,419	92,997,550	126,982,177	164,354,376	204,803,749	243,049,275	277,896,296	315,143,910
Std. Dev.	16,422,363	27,472,519	36,612,854	42,069,646	46,760,852	50,943,575	55,537,739	59,236,737	63,499,109	68,508,530
Coeff. Var.	502	90	60	45	37	31	27	24	23	22
Min.	-32,318,698	-48,170,211	-57,342,377	-39,883,032	-12,255,821	4,136,287	33,840,536	50,860,945	73,416,189	101,278,973
Max.	37,959,684	107,003,416	172,070,557	223,015,189	263,377,232	308,352,481	370,766,335	425,736,693	466,849,231	500,959,503

KOV	NW 1	NW 2	NW 3	NW 4	NW 5	NW 6	NW 7	NW 8	NW 9	NW 10
Mean	147,716,388	95,588,473	75,602,778	79,271,387	100,460,102	127,398,516	159,841,696	209,991,259	276,602,356	348,391,426
Std. Dev.	16,422,353	27,472,514	36,612,824	42,069,592	46,760,778	50,943,501	55,537,647	59,236,624	63,498,983	68,508,357
Coeff. Var.	11	29	48	53	47	40	35	28	23	20
Min.	112,123,063	17,042,430	-42,308,035	-53,609,216	-38,777,922	-32,819,604	-11,121,550	17,802,891	72,122,208	134,526,444
Max.	182,401,445	172,215,986	187,104,900	209,289,005	236,855,131	271,396,591	325,804,249	392,678,640	465,555,250	534,206,974