# A Comparison of Pricing Strategies for Cellulosic Ethanol Processors: A Simulation Approach

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**Introduction**

The 2005 Energy Policy Act established a Renewable Fuel Standard (RFS), mandating 4 billion gallons of biofuels annually be produced by 2006 and rising to 7.5 billion gallons annually by 2012 (Tyner, 2007). The RFS has continued to drive the ethanol industry expansion, and both of these mandated levels were surpassed before their deadline, fueling the need for a new RFS. A new RFS was passed in 2007 with the ratification of the Energy Independence and Security Act, mandating that fuel producers use at least 36 billion gallons of biofuels by 2022 and placed an emphasis on the production of cellulosic ethanol (OPS, 2007). Of the 36 billion gallons 16 billion gallons are expected to be produced via "cellulosic ethanol." In order to reach these mandated levels of biofuel production, each region or state within the United States should produce the energy crop for which they have a competitive advantage.

Louisiana's subtropical climate makes it an advantageous location for the production of biomass. Louisiana lies between the 29 and 33 parallels north of the equator, has an average yearly temperature of 66 degrees, average precipitation of 64 inches per year, and growing days ranging from 230 to 290 growing days in the southern part of the state (Bucker). Under these conditions specifically energy cane can be produced. In 2000, sugarcane acres in Louisiana peaked at 465,000, but since have been decreasing at an average of two percent per year. Recognizing this decrease in acreage Louisiana producers have been search for alternative crops to grow in the area but until now no other crops have been adapted to be produced in the Louisiana sugarcane belt shown in figure 1. The emergence of crops to be used in the production of energy could be a possible solution for farmers in the sugarcane belt. Energy cane is lower in sucrose or brix content but higher in fiber content than traditional sugarcanes varieties (e.g. LCP85-384).

In 2007, the Louisiana Agricultural Experiment Station in conjunction with the American Sugar Cane League and the United States Department of Agriculture released three energy cane or high fiber cane varieties L79-1002, Ho 00-961, and HoCP 91-552 (ASCL, 2007). Currently there is no yield data for L 79-1002, but there have been reports of this variety yielding over 100 tons of wet cane (wt) per acre, which is significantly higher than the 30 wt/ac the current industry is producing (ASCL, 2007).

Altman et al. (2007) examine the linkages between asset fixity and contract length for the case of Iogen Company. Iogen Company is a cellulosic ethanol processor with facilities in Canada and is looking to expand into the pacific northwest region of the United States. Wheat, oat and barley are the raw materials they use in the production of cellulosic ethanol (Iogen, 2008). Iogen has given producers the opportunity to choose between two different production contracts with lengths of five to six years (Altman et al., 2007). The first contract type is a fixed pricing option that provides producers approximately $10 per ton of straw in the field. Alternatively, producers could choose a second, variable pricing strategy that provides approximately $7 to $15, dependent on the price of oil, for straw in the field (Pratt, 2005). The primary idea behind allowing producers to choose a variable pricing option is to allow them to manage input risks such as fuel and fertilizer costs that should move with crude oil prices. Harvest and delivery of the straw from the field to the processing plant is handled by a separate contract between Iogen and a custom harvester (Pratt, 2005). Altman et al. (2007), found that for Iogen asset specificity played a role in the desired contract length.

Zahn et al. (2005) examine two different procurement pricing strategies for switchgrass in Alabama. First, a fixed pricing strategy implies that one uniform price paid to biomass producers regardless of transportation costs. The advantages of this type of pricing strategy are the simplicity of implementation and avoidance of potential transportation-related disputes. However, the downside of this is the potential for high delivered raw material costs because the marginal price is fixed. Second, a discriminatory strategy is one where the price will be source-specific and based on farm-gate price and the cost of transportation to the processor. The advantage of a discriminatory type of pricing strategy is that once the demand level is high enough the procurement cost savings for this strategy will out weight the additional administration costs incurred. One downside to this strategy is it requires additional workers in order to do the site-specific pricing. Zahn et al. (2005) find that spatial variation does play a role in the procurement costs for both pricing strategies and that for the processor the fixed pricing strategy always costs more than the discriminatory strategy. Additionally, they were able to find a breakeven point of the two strategies and for processors with a demand over 300,000 tons the proper strategy to employ is a discriminatory strategy.

One of the key shortcomings to Altman et al. (2007) and Zahn et al. (2005) is that neither investigates how the potential biomass producers' net revenue is impacted. This study links six different pricing strategies with production cost information to determine from the producers perspective which pricing strategy would be preferred. For the purposes of this study potential profit margins for the biofuel processing firm are not investigated due to the lack of reliable information. However, examining this from the producers' perspective allows potential processors to discover a range of what they will have to pay per ton of biomass to bring the processors desired feedstock into production. In this area sugarcane is the predominate crop; therefore, it is set as the certainty equivalent and if the net returns per acre do not exceed that of sugarcane then there is no incentive for them to produce a biomass crop.

## Objectives

Unlike the conventional corn-to-ethanol supply chain that is well developed, the biomass supply chain still has significant hurdles that it must cross. Identify pricing strategies for biomass is pivotal for the development of the cellulosic ethanol industries supply chain. Altman, Sanders and Boessen (2007), point out that the current *ad hoc* supply chain of informal contracts and even bartering need to become more formal for large-scale processors. The infancy of the industry in conjunction with the nontraditional nature of energy crops has left many agribusinesses and producers wondering how the different feedstocks might be priced. The objective is to determine the most favorable pricing strategy that covers the producers cost of production the largest percentage of the time.

## Model Framework and Data

Traditional literature in agriculture economics suggests that simulation of a Multivariate Empirical (MVE) distribution should use the procedure set forth by Richardson et al. (2000). According to Richardson et al. (2000) there are several unique aspects of developing an agricultural farm-level simulation model: 1) non-normally distributed random yields and prices; 2) intra-temporal correlation of production across enterprises and fields; 3) intra- and inter-temporal correlation of output prices; 4) heteroskedasticity of random variables over time due to policy changes; 5) numerous enterprises that are affected by weather and carried out over the growing season; 6) government policies that effect price distributions; and 7) strategic risks with technology adoption and contract negations. However, for the purposes of this paper we are examining a nontraditional production situation where a farmer is considering the switch from tradition sugarcane production to either energy cane or switchgrass production. Assuming that current technology for cellulosic ethanol production has not advanced to the level where they can handle any type of biomass that come into the plant the farmer will have to make a choice as to which crop to plant. Additionally, due to the relative sparse availability of historical price and yield data for new biomass crops, there is no observed correlation between crops, as in the case of corn and soybeans, so the Richardson et al. (2000) procedure is not employed.

Instead, kernel density estimation procedures are used to determine the bivariate empirical distribution for both energy cane (yield and prices) and switchgrass (yield and prices). The kernel density estimator is a generalization of the histogram done by an alternative weighting function,

(1) $$\hat{f}(x_0) = \frac{1}{Nh}\sum_{i=1}^{N} K\left(\frac{x_i - x_0}{h}\right),$$

where *h* is the bandwidth or the smoothing parameter (Cameron and Travedi, 2005). Selection of the proper *h* is an important decision when using the kernel density estimator because it determines the smoothness of the curve and for the purposes of this paper we allow SAS to use its automatic bandwidth selector to determine the *h* to be used (SAS, 2009 and Barnes et al., 2001). Additionally, it is important to examine how different kernels (e.g. uniform, gaussian, parzen, etc.) impact the results of the estimator. According to Richardson et al. (2006), the kernel that should be used is the one that has the smallest root mean squared error.[1]

One of the key issues with analyzing potential energy crops is the sparse data available on yield and prices for these crops. According to Schlaifer (1959) and Anderson et al. (1977), sparse data can contain abnormalities due to sampling error that can be smoothed out by implementing kernel density estimation. Furthermore this procedure has been used estimate a

[1] For the purposes of this study the Gaussian kernel implement since it what the SAS command PROC KDE uses (SAS, 2009). This will be the focus of future study as to how changing the kernel impacts the results.

univariate empirical with sparse historical information on sweet sorghum yields (Outlaw et al., 2007). Following this procedure the bivariate distributions for both energy cane and switchgrass. Since neither of these crops are in actual production in the state sugarcane yields and prices were used to estimate the distribution for energy cane since the current varieties of energy cane available for commercial production are similar in yields to that of sugarcane. Switchgrass yield data for Louisiana is also not available so the hay yields for the state were used instead. These yields are similar to those found by Epplin (1996) but are a ton and a half lower than those reported by Cassida et al. (2005) for Clinton, LA. All yield and price information is taken from the National Agricultural Statistics Service (NASS) and the yields were detrended for energy cane and switchgrass to 35 and 3 tons per acre, respectively.

Representative budgets for each of the crops have been constructed for each of the crops (Tables 1-4). One caveat is that for energy cane there are three different budgets to account for the typical stubbling lengths. Tables 1-3 are based on sugarcane production budgets developed by Salassi and Deliberto (2008). The only modification made to them are that growers will now be paid base on tons of biomass delivered and not sugar content per acre. Other than that the production practices remain the same. For the switchgrass budgets the Mississippi State Budget Generator was used in conjunction with production practice and pricing information gleaned from Popp (2007), Khanna et al. (2008), Duffy and Nanhou (2001), and Hallam et al. (2001) (Laughlin and Spurlock, 2008). The only additional price which was added to the budget generator is a price for switchgrass seed which was set at $20 per pound for Alamo switchgrass pure live seed (Sharp Bros., 2009).

As discussed earlier, Altman et al. (2007) suggested two possible pricing strategies that were being offered by Iogen to potential producers. However, there are numerous pricing additional strategies that could be examined and we have narrowed it down to six different pricing strategies that to examine.

1) a variable rate that is tied to the price of corn
2) a variable rate that is tied to the price of ethanol
3) a variable rate that is tied to the price of crude oil
4) a fixed rate of production costs plus some variable rate dependent upon realized yield
5) variable rate that is tied to the price of crude oil but is bounded from above and below
6) a price equal to the price that sugarcane producers would receive

Pricing strategies 1-3 are premised on the idea that in recent years there has been a strong positive correlation between corn, ethanol, and crude oil prices (Wagner, 2009)[2]. Therefore, one might expect as the prices rise then cellulosic ethanol will become increasing competitive with traditional ethanol. More detail on how these variable rates are calculated is shown in the appendix. Pricing strategy 4 is adapted from a study by Morris et al. (2009) that examined the usage of sweet sorghum juice for fermentation of ethanol. Morris et al. (2009) create a pricing strategy that has two components. First, is the fixed portion that says producers are assured to receive 90 percent of their production costs. Second, assume that producers will receive an extra $2.50 per ton of actual realized yield. The rational for strategy five is that firms are only going to be will to pay so much for biomass and by setting a range for which the price can vary in allows both producers and processor to know maximum profits or losses. This range was set by taking the average of crude oil price over the last 10 years and it was an average of $44 per barrel, with a standard deviation of 25. From there we took one standard deviation below and two above and set these as our upper ($94) and lower bounds ($19). These were then matched up with production costs for these crops so that for energy cane $44 corresponded to a per acre payment

[2] Projected prices for corn, ethanol, and crude oil are taken from FAPRI 2009.

of \$22 and \$47for energy cane and switchgrass, respectively. From there we allow the grower payment to move up or down by no more than \$5 in either direction and grower payment can be calculated based on its relative distance above or below its initial starting value of \$44 per barrel. Pricing strategy six is a certainty equivalent measure that it uses data from the ASCL on sugar recovery rates in conjunction with sugar prices and the yields per acre (ASCL, 2009; and USDA, 2009). Since sugarcane is the primary crop produced in the sugarcane belt potential ethanol producers will have to provide growers with at least the same return per acre that they can receive from growing sugarcane in order to buy acres away from the sugarcane industry.

Now using all of the above information calculations of total revenue and net revenue per acre are done for each of the different strategies. Equations 2 and 3 show how total revenue is calculated for each of the different pricing strategies and how net revenue is calculated for each of the 10,000 observations ($i$) in the sample. In equation 2, ($j$) represent each of the six pricing strategies and in all of the pricing strategies except for number four variable rate is set to zero. Additionally, for equation 2 under pricing strategy 6 total revenue is multiplied by 61 percent to account for the sugar mills share for processing of the sugar. In equation 3, ($s$) represents the cost of production for stubble four, five, six, and switchgrass.

(2) $$total\ revenue_i = yield_i * price_{ij} + yield_i * variable\ rate_{ij}$$

where j =(1,…,6)

(3) $$net\ revenue_i = total\ revenue_i - cost\ of\ production_{is}$$

where s = (1,2,3,4)

**Results**

Table 5 shows the results of from year ones run of the six different pricing strategies. As expected the preferred pricing strategy from a growers perspective is a pricing strategy 4. Pricing strategy 4 is a two tiered pricing strategy where the grower is guaranteed 90 percent of their cost of production and then is paid a variable rate of $2.50 on the realized yield. Under this scenario the average return for the 10,000 samples is $127.29, $125.17, and $125.39, respectively for stubbles four through six. These returns per acre are significantly higher than what sugarcane producers would have received under the given assumptions of the model. Plausible reasons as to why this may not only be the preferred strategy in this simulation but in reality as well is that energy cane like sugarcane has a high upfront cost with planting expenses. Additionally, it takes two years before what is planted can be harvest because of the way in which energy cane acres are expanded. Furthermore, energy cane has no real alternative uses other than cellulosic ethanol production because the brix content is so low that it would be unprofitable to use it in the production of sugar.

Additional pricing strategies examined all showed negative net returns per acre and in all cases sugarcane farmers would not consider switching into the production of energy can. However, under pricing strategies 1 to 3 producers could potential gain a larger percentage of the corn price as cellulosic ethanol facilities are able to decrease enzyme and processing costs to levels that are more comparable to those within the traditional ethanol processing industry. This could potentially mean producers could move from capture 46 percent of the corn price to upwards of 70 percent if the trend in feedstock costs for cellulosic biomass mirror those of the traditional ethanol industry.

## Conclusions and Discussion

Overall, the results give the expected conclusion that energy cane producers would prefer to grow energy cane a two tiered pricing strategy such as this one or one similar was offered by cellulosic ethanol processors. However, in reality producers should not expect drastically higher net returns for energy cane over sugarcane. Over time it is expected that this pricing strategy will change as processor become more efficient at the production process and lower their overall production costs. Additionally, producers have the opportunity to become more efficient with the adoption of technology and new varieties of energy can that are currently being developed. In conclusion there are several extensions left to be made to this work by incorporating more years worth of net returns for energy cane and adding switchgrass and sweet sorghum to the potential crops as well.

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## Appendix: Calculations for Pricing Strategies 1-3

Determination of pricing strategies 1 through 3 is accomplished in the follow manner. According to Collins (2007), currently feedstock purchase for the cellulosic ethanol process is estimated to be 46 percent compared to that in the traditional ethanol industry where feedstock costs account for about 70 percent of the cost to produce ethanol. Given this information strategies 1 to 3 can be calculated.

**Strategy 1**
Assume:
cellulosic ethanol plant efficiency is 80 gal/dt
yield per acre of cane is 35 tons

Cane is 35 percent dry matter therefore there are:
35*0.35 = 12.25 dry tons of cane per acre

If the processor can produce 80 gal/dt then
80*12.25 = 980 potential gallons per acre

Under current technologies ethanol plant are producing 2.75 gal/bu of corn
980/2.75 = 356.36 bu of corn are needed to produce the same amount of ethanol

According to FAPRI corn price for 2009 is going to be $3.98 which give you a total corn cost of $3.98 * 356.36 = 1418.32

Now dividing by wet tons of cane per acre we get to an equivalent value per acre between corn and energy can of $40.52 and given that feedstock costs account for 46 percent of the cost of production we arrive at a price relative to corn of **$18.46**

**Strategy 2**
According to FAPRI ethanol price is going to be $1.83 per gallon in 2009 so

980*1.83 = 1793.4
1793.4 / 35 = 51.25
51.25 * 0.46 = **23.57**

**Strategy 3**
FAPRI crude oil 63.460.
980 / 42 = 23.33
23.33 * 63.460 = 1480.73
1480.73 / 35 = 42.31
42.31 * 0.46 = **19.46**

## Figure 1: Louisiana Sugarcane Belt

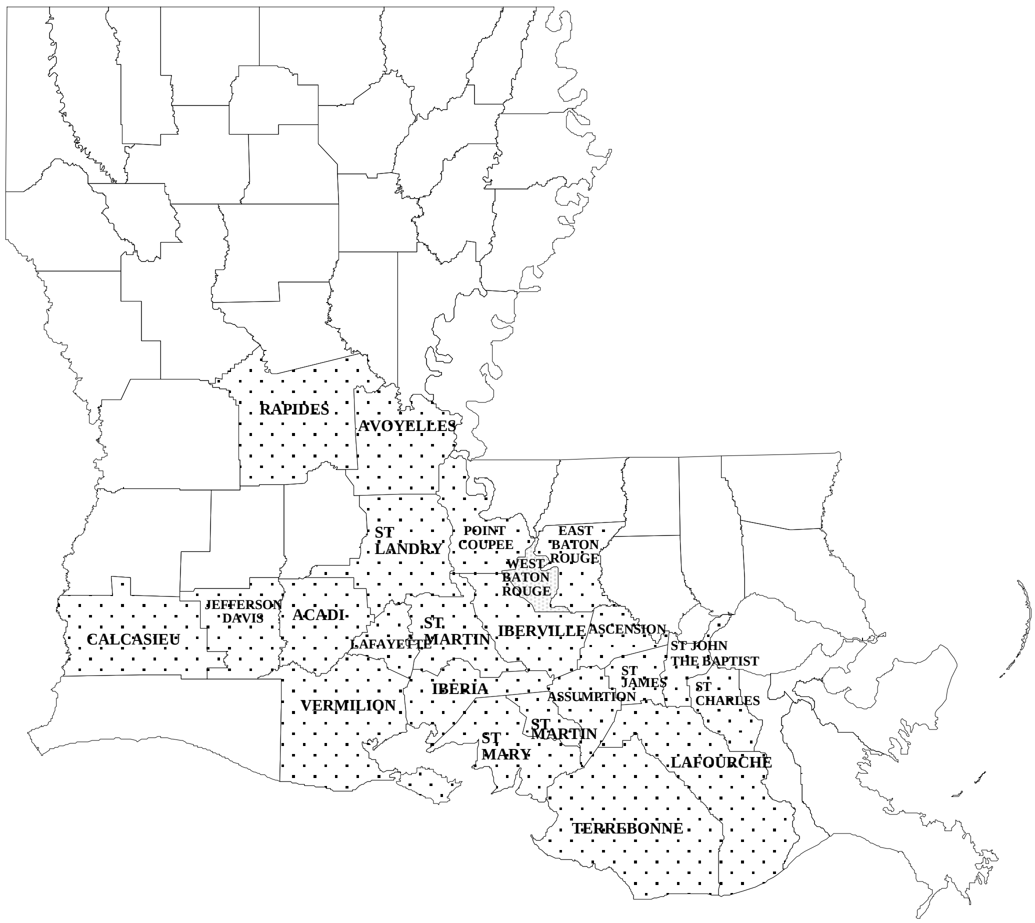

**Table 1. Projected Costs and Returns on 1000 Acres of Energy Cane, Harvest through 4th stubble, Louisiana, 2008**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Enter-> | **1,000** Total farm acres | | | | | |
| | | | | **30.0** Tons of cane per harvested acre | | | | | |
| | | | | **23.9** Tons of cane per total acre | | | | | |
| | | | | **4.3** Mechanical planting ratio ( tons harv / 7 tons plt) | | | | | |
| | COST CALCULATION | | | **5** Years of harvest | | | | | |
| | | | | **6** Years of rotation | | | | | |
| Crop | Total Specified Cost per Acre | | | Acres | | Total Farm Cost over 1000 acres | | | |
| | Direct Costs | Fixed Costs | Total Costs | Percent of Rot. Acre | Total Acres | Direct Costs over Farm | Total Costs over Farm | Direct Costs | Total Costs |
| | ($/acre) | ($/acre) | ($/acre) | (%) | (acres) | ($) | ($) | ($/acre) | ($/acre) |
| Fallow Field & Seedbed Preparation Operations | **169.24** | **92.61** | **261.85** | 16.67 | 166.67 | 28,206.67 | 43,641.67 | 28.21 | 43.64 |
| Cultured Seed Cane | **538.97** | **10.97** | **549.94** | 0.70 | 7.05 | 3,797.75 | 3,875.04 | 3.80 | 3.88 |
| Hand Planting Wholestalk Seed Cane | **259.92** | **77.74** | **337.66** | 0.70 | 7.05 | 1,831.48 | 2,379.26 | 1.83 | 2.38 |
| Wholestalk Seed Cane Harvest | **74.95** | **50.28** | **125.23** | 3.72 | 37.24 | 2,791.49 | 4,664.16 | 2.79 | 4.66 |
| Mechanical Planting Wholestalk Seed Cane | **232.91** | **58.36** | **291.27** | 15.96 | 159.62 | 37,177.18 | 46,492.62 | 37.18 | 46.49 |
| Plant Cane Field Operations | **225.48** | **46.83** | **272.31** | 16.67 | 166.67 | 37,580.00 | 45,385.00 | 37.58 | 45.39 |
| 1st Stubble Field Operations | **334.36** | **53.04** | **387.40** | 16.67 | 166.67 | 55,726.67 | 64,566.67 | 55.73 | 64.57 |
| 2nd Stubble Field Operations | **343.37** | **53.04** | **396.41** | 16.67 | 166.67 | 57,228.33 | 66,068.33 | 57.23 | 66.07 |
| 3rd Stubble Field Operations | **343.37** | **53.04** | **396.41** | 16.67 | 166.67 | 57,228.33 | 66,068.33 | 57.23 | 66.07 |
| 4th Stubble Field Operations | **343.37** | **53.04** | **396.41** | 16.67 | 166.67 | 57,228.33 | 66,068.33 | 57.23 | 66.07 |
| Harvest for Biomass | **135.34** | **85.99** | **221.33** | 79.61 | 796.09 | 107,745.20 | 176,200.86 | 107.75 | 176.20 |
| Overhead | **0.00** | **0.00** | **0.00** | 100.00 | 1000.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Total | | | | | | 446,541.43 | 585,410.28 | 446.54 | 585.41 |

**Table 2. Projected Costs and Returns on 1000 Acres of Energy Cane, Harvest through 5th stubble, Louisiana, 2008**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Enter-> | **1,000** Total farm acres | | | | | |
| | | | | **30.0** Tons of cane per harvested acre | | | | | |
| | | | | **24.8** Tons of cane per total acre | | | | | |
| | | | | **4.3** Mechanical planting ratio ( tons harv / 7 tons plt) | | | | | |
| | COST CALCULATION | | | **6** Years of harvest | | | | | |
| | | | | **7** Years of rotation | | | | | |
| Crop | | Total Specified Cost per Acre | | Acres | | Total Farm Cost over 1000 acres | | | |
| | Direct Costs | Fixed Costs | Total Costs | Percent of Rot. Acre | Total Acres | Direct Costs over Farm | Total Costs over Farm | Direct Costs | Total Costs |
| | ($/acre) | ($/acre) | ($/acre) | (%) | (acres) | ($) | ($) | ($/acre) | ($/acre) |
| Fallow Field & Seedbed Preparation Operations | **169.24** | **92.61** | **261.85** | 14.29 | 142.86 | 24,177.14 | 37,407.14 | 24.18 | 37.41 |
| Cultured Seed Cane | **538.97** | **10.97** | **549.94** | 0.60 | 6.04 | 3,255.21 | 3,321.47 | 3.26 | 3.32 |
| Hand Planting Wholestalk Seed Cane | **259.92** | **77.74** | **337.66** | 0.60 | 6.04 | 1,569.84 | 2,039.36 | 1.57 | 2.04 |
| Wholestalk Seed Cane Harvest | **74.95** | **50.28** | **125.23** | 3.19 | 31.92 | 2,392.71 | 3,997.85 | 2.39 | 4.00 |
| Mechanical Planting Wholestalk Seed Cane | **232.91** | **58.36** | **291.27** | 13.68 | 136.82 | 31,866.15 | 39,850.82 | 31.87 | 39.85 |
| Plant Cane Field Operations | **225.48** | **46.83** | **272.31** | 14.29 | 142.86 | 32,211.43 | 38,901.43 | 32.21 | 38.90 |
| 1st Stubble Field Operations | **334.36** | **53.04** | **387.40** | 14.29 | 142.86 | 47,765.71 | 55,342.86 | 47.77 | 55.34 |
| 2nd Stubble Field Operations | **343.37** | **53.04** | **396.41** | 14.29 | 142.86 | 49,052.86 | 56,630.00 | 49.05 | 56.63 |
| 3rd Stubble Field Operations | **343.37** | **53.04** | **396.41** | 14.29 | 142.86 | 49,052.86 | 56,630.00 | 49.05 | 56.63 |
| 4th Stubble Field Operations | **343.37** | **53.04** | **396.41** | 14.29 | 142.86 | 49,052.86 | 56,630.00 | 49.05 | 56.63 |
| 5th Stubble Field Operations | **343.37** | **53.04** | **396.41** | 14.29 | 142.86 | 49,052.86 | 56,630.00 | 49.05 | 56.63 |
| Harvest for Biomass | **135.34** | **85.99** | **221.33** | 82.52 | 825.22 | 111,687.78 | 182,648.34 | 111.69 | 182.65 |
| Overhead | **0.00** | **0.00** | **0.00** | 100.00 | 1000.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Total | | | | | | 451,137.40 | 590,029.27 | 451.14 | 590.03 |
| | Wet ton yield per total acre | | | **24.8** | | Cost per wet ton of cane | | $18.22 | $23.83 |
| | Dry ton yield per total acre | | | **8.7** | | Cost per dry ton of cane | | $52.07 | $68.09 |
| | Dry matter content | | | **35%** | | (using tons per total acre) | | | |

## Table 3. Projected Costs and Returns on 1000 Acres of Energy Cane, Harvest through 6th stubble, Louisiana, 2008

| | | | Enter-> | **1,000** Total farm acres | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **30.0** Tons of cane per harvested acre | | | | | | |
| | | | | **25.4** Tons of cane per total acre | | | | | | |
| | | | | **4.3** Mechanical planting ratio ( tons harv / 7 tons plt) | | | | | | |
| | COST CALCULATION | | | **7** Years of harvest | | | | | | |
| | | | | **8** Years of rotation | | | | | | |
| Crop | | Total Specified Cost per Acre | | Acres | | Total Farm Cost over 1000 acres | | | | |
| | Direct Costs | Fixed Costs | Total Costs | Percent of Rot. Acre | Total Acres | Direct Costs over Farm | Total Costs over Farm | Direct Costs | Total Costs |
| | ($/acre) | ($/acre) | ($/acre) | (%) | (acres) | ($) | ($) | ($/acre) | ($/acre) |
| Fallow Field & Seedbed Preparation Operations | **169.24** | **92.61** | **261.85** | 12.50 | 125.00 | 21,155.00 | 32,731.25 | 21.16 | 32.73 |
| Cultured Seed Cane | **538.97** | **10.97** | **549.94** | 0.53 | 5.28 | 2,848.31 | 2,906.28 | 2.85 | 2.91 |
| Hand Planting Wholestalk Seed Cane | **259.92** | **77.74** | **337.66** | 0.53 | 5.28 | 1,373.61 | 1,784.44 | 1.37 | 1.78 |
| Wholestalk Seed Cane Harvest | **74.95** | **50.28** | **125.23** | 2.79 | 27.93 | 2,093.62 | 3,498.12 | 2.09 | 3.50 |
| Mechanical Planting Wholestalk Seed Cane | **232.91** | **58.36** | **291.27** | 11.97 | 119.72 | 27,882.88 | 34,869.47 | 27.88 | 34.87 |
| Plant Cane Field Operations | **225.48** | **46.83** | **272.31** | 12.50 | 125.00 | 28,185.00 | 34,038.75 | 28.19 | 34.04 |
| 1st Stubble Field Operations | **334.36** | **53.04** | **387.40** | 12.50 | 125.00 | 41,795.00 | 48,425.00 | 41.80 | 48.43 |
| 2nd Stubble Field Operations | **343.37** | **53.04** | **396.41** | 12.50 | 125.00 | 42,921.25 | 49,551.25 | 42.92 | 49.55 |
| 3rd Stubble Field Operations | **343.37** | **53.04** | **396.41** | 12.50 | 125.00 | 42,921.25 | 49,551.25 | 42.92 | 49.55 |
| 4th Stubble Field Operations | **343.37** | **53.04** | **396.41** | 12.50 | 125.00 | 42,921.25 | 49,551.25 | 42.92 | 49.55 |
| 5th Stubble Field Operations | **343.37** | **53.04** | **396.41** | 12.50 | 125.00 | 42,921.25 | 49,551.25 | 42.92 | 49.55 |
| 6th Stubble Field Operations | **343.37** | **53.04** | **396.41** | 12.50 | 125.00 | 42,921.25 | 49,551.25 | 42.92 | 49.55 |
| Harvest for Biomass | **135.34** | **85.99** | **221.33** | 84.71 | 847.07 | 114,644.71 | 187,483.95 | 114.64 | 187.48 |
| Overhead | **0.00** | **0.00** | **0.00** | 100.00 | 1000.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Total | | | | | | 454,584.38 | 593,493.52 | 454.58 | 593.49 |

| | |
|---|---|
| Wet ton yield per total acre | **25.4** |
| Dry ton yield per total acre | **8.9** |
| Dry matter content | **35%** |

| | Direct | Total |
|---|---|---|
| Cost per wet ton of cane | $17.89 | $23.35 |
| Cost per dry ton of cane | $51.11 | $66.73 |
| (using tons per total acre) | | |

# Table 4. Projected Costs and Returns on 1000 Acres of Switchgrass, Louisiana, 2008

Enter-> **1,000** Total farm acres
**3.0** Tons of cane per harvested acre
**3.0** Tons of cane per total acre
Mechanical planting ratio ( tons harv / 7 tons plt)
COST CALCULATION **10** Years of harvest
**11** Years of rotation

| Crop | Total Specified Cost per Acre | | | Acres | | Total Farm Cost over 1000 acres | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Direct Costs | Fixed Costs | Total Costs | Percent of Rot. Acre | Total Acres | Direct Costs over Farm | Total Costs over Farm | Direct Costs | Total Costs |
| | ($/acre) | ($/acre) | ($/acre) | (%) | (acres) | ($) | ($) | ($/acre) | ($/acre) |
| Fall Field Prep | **64.32** | **3.92** | **68.24** | 100.00 | 1000.00 | 64,320.00 | 68,240.00 | 64.32 | 68.24 |
| Preplant Weed Control | **14.69** | **1.60** | **16.29** | 100.00 | 1000.00 | 14,690.00 | 16,290.00 | 14.69 | 16.29 |
| Seedbed Prep | **2.82** | **1.97** | **4.79** | 100.00 | 1000.00 | 2,820.00 | 4,790.00 | 2.82 | 4.79 |
| Planting | **192.82** | **4.60** | **197.42** | 100.00 | 1000.00 | 192,820.00 | 197,420.00 | 192.82 | 197.42 |
| Postplant Weed Control | **4.37** | **58.36** | **62.73** | 100.00 | 1000.00 | 4,370.00 | 62,730.00 | 4.37 | 62.73 |
| Replant | **87.33** | **4.93** | **92.26** | 100.00 | 1000.00 | 87,330.00 | 92,260.00 | 87.33 | 92.26 |
| Early Season Weed Control | **6.71** | **1.60** | **8.31** | 100.00 | 1000.00 | 6,710.00 | 8,310.00 | 6.71 | 8.31 |
| Fertilizer | **51.85** | **0.00** | **51.85** | 100.00 | 1000.00 | 51,850.00 | 51,850.00 | 51.85 | 51.85 |
| First Harvest | **9.77** | **7.48** | **17.25** | 100.00 | 1000.00 | 9,770.00 | 17,250.00 | 9.77 | 17.25 |
| First Storage | **8.40** | **4.26** | **12.66** | 100.00 | 1000.00 | 8,400.00 | 12,660.00 | 8.40 | 12.66 |
| 2nd early season weed control | **4.84** | **1.60** | **6.44** | 100.00 | 1000.00 | 4,840.00 | 6,440.00 | 4.84 | 6.44 |
| 2nd Fertilizer | **52.30** | **0.00** | **52.30** | 100.00 | 1000.00 | 52,300.00 | 52,300.00 | 52.30 | 52.30 |
| 2nd Harvest | **9.77** | **7.48** | **17.25** | 100.00 | 1000.00 | 9,770.00 | 17,250.00 | 9.77 | 17.25 |
| 2nd Storage | **8.40** | **4.26** | **12.66** | 100.00 | 1000.00 | 8,400.00 | 12,660.00 | 8.40 | 12.66 |
| 3rd early season weed control | **4.84** | **1.60** | **6.44** | 100.00 | 1000.00 | 4,840.00 | 6,440.00 | 4.84 | 6.44 |
| 3rd Fertilizer | **52.30** | **0.00** | **52.30** | 100.00 | 1000.00 | 52,300.00 | 52,300.00 | 52.30 | 52.30 |
| 3rd Harvest | **9.77** | **7.48** | **17.25** | 100.00 | 1000.00 | 9,770.00 | 17,250.00 | 9.77 | 17.25 |
| 3rd Storage | **8.40** | **4.26** | **12.66** | 100.00 | 1000.00 | 8,400.00 | 12,660.00 | 8.40 | 12.66 |
| 4th early season weed control | **4.84** | **1.60** | **6.44** | 100.00 | 1000.00 | 4,840.00 | 6,440.00 | 4.84 | 6.44 |
| 4th Fertilizer | **52.30** | **0.00** | **52.30** | 100.00 | 1000.00 | 52,300.00 | 52,300.00 | 52.30 | 52.30 |
| 4th Harvest | **9.77** | **7.48** | **17.25** | 100.00 | 1000.00 | 9,770.00 | 17,250.00 | 9.77 | 17.25 |
| 4th Storage | **8.40** | **4.26** | **12.66** | 100.00 | 1000.00 | 8,400.00 | 12,660.00 | 8.40 | 12.66 |
| 5th early season weed control | **4.84** | **1.60** | **6.44** | 100.00 | 1000.00 | 4,840.00 | 6,440.00 | 4.84 | 6.44 |
| 5th Fertilizer | **52.30** | **0.00** | **52.30** | 100.00 | 1000.00 | 52,300.00 | 52,300.00 | 52.30 | 52.30 |
| 5th Harvest | **9.77** | **7.48** | **17.25** | 100.00 | 1000.00 | 9,770.00 | 17,250.00 | 9.77 | 17.25 |
| 5th Storage | **8.40** | **4.26** | **12.66** | 100.00 | 1000.00 | 8,400.00 | 12,660.00 | 8.40 | 12.66 |
| 6th early season weed control | **4.84** | **1.60** | **6.44** | 100.00 | 1000.00 | 4,840.00 | 6,440.00 | 4.84 | 6.44 |
| 6th Fertilizer | **52.30** | **0.00** | **52.30** | 100.00 | 1000.00 | 52,300.00 | 52,300.00 | 52.30 | 52.30 |
| 6th Harvest | **9.77** | **7.48** | **17.25** | 100.00 | 1000.00 | 9,770.00 | 17,250.00 | 9.77 | 17.25 |
| 6th Storage | **8.40** | **4.26** | **12.66** | 100.00 | 1000.00 | 8,400.00 | 12,660.00 | 8.40 | 12.66 |
| 7th early season weed control | **4.84** | **1.60** | **6.44** | 100.00 | 1000.00 | 4,840.00 | 6,440.00 | 4.84 | 6.44 |
| 7th Fertilizer | **52.30** | **0.00** | **52.30** | 100.00 | 1000.00 | 52,300.00 | 52,300.00 | 52.30 | 52.30 |
| 7th Harvest | **9.77** | **7.48** | **17.25** | 100.00 | 1000.00 | 9,770.00 | 17,250.00 | 9.77 | 17.25 |
| 7th Storage | **8.40** | **4.26** | **12.66** | 100.00 | 1000.00 | 8,400.00 | 12,660.00 | 8.40 | 12.66 |
| 8th early season weed control | **4.84** | **1.60** | **6.44** | 100.00 | 1000.00 | 4,840.00 | 6,440.00 | 4.84 | 6.44 |
| 8th Fertilizer | **52.30** | **0.00** | **52.30** | 100.00 | 1000.00 | 52,300.00 | 52,300.00 | 52.30 | 52.30 |
| 8th Harvest | **9.77** | **7.48** | **17.25** | 100.00 | 1000.00 | 9,770.00 | 17,250.00 | 9.77 | 17.25 |
| 8th Storage | **8.40** | **4.26** | **12.66** | 100.00 | 1000.00 | 8,400.00 | 12,660.00 | 8.40 | 12.66 |
| 9th early season weed control | **4.84** | **1.60** | **6.44** | 100.00 | 1000.00 | 4,840.00 | 6,440.00 | 4.84 | 6.44 |
| 9th Fertilizer | **52.30** | **0.00** | **52.30** | 100.00 | 1000.00 | 52,300.00 | 52,300.00 | 52.30 | 52.30 |
| 9th Harvest | **9.77** | **7.48** | **17.25** | 100.00 | 1000.00 | 9,770.00 | 17,250.00 | 9.77 | 17.25 |
| 9th Storage | **8.40** | **4.26** | **12.66** | 100.00 | 1000.00 | 8,400.00 | 12,660.00 | 8.40 | 12.66 |
| 10th early season weed control | **4.84** | **1.60** | **6.44** | 100.00 | 1000.00 | 4,840.00 | 6,440.00 | 4.84 | 6.44 |
| 10th Fertilizer | **52.30** | **0.00** | **52.30** | 100.00 | 1000.00 | 52,300.00 | 52,300.00 | 52.30 | 52.30 |
| 10th Harvest | **9.77** | **7.48** | **17.25** | 100.00 | 1000.00 | 9,770.00 | 17,250.00 | 9.77 | 17.25 |
| 10th Storage | **8.40** | **4.26** | **12.66** | 100.00 | 1000.00 | 8,400.00 | 12,660.00 | 8.40 | 12.66 |
| Overhead | **0.00** | **30.00** | **30.00** | 100.00 | 1000.00 | 0.00 | 30,000.00 | 0.00 | 30.00 |
| Total | | | | | | 1,120,870.00 | 1,359,650.00 | 1,120.87 | 1,359.65 |

**Table 5: Results for Energy Cane (Net Returns per acre)**

| Variable | Mean | Std Dev | Minimum | Maximum |
|---|---|---|---|---|
| nrenergy411 | $ (233.08) | $ 66.86 | $ (347.72) | $ (118.44) |
| nrenergy412 | $ (61.28) | $ 84.54 | $ (206.24) | $ 83.67 |
| nrenergy413 | $ (50.67) | $ 85.63 | $ (197.50) | $ 96.16 |
| nrenergy414 | $ 127.29 | $ 103.94 | $ (50.95) | $ 305.52 |
| nrenergy415 | $ (204.49) | $ 69.80 | $ (324.18) | $ (84.81) |
| nrenergy416 | $ (4.11) | $ 119.82 | $ (292.57) | $ 369.71 |
| nrenergy511 | $ (208.59) | $ 66.86 | $ (323.23) | $ (93.95) |
| nrenergy512 | $ (36.79) | $ 84.54 | $ (181.75) | $ 108.16 |
| nrenergy513 | $ (26.18) | $ 85.63 | $ (173.01) | $ 120.65 |
| nrenergy514 | $ 126.17 | $ 101.31 | $ (47.54) | $ 299.89 |
| nrenergy515 | $ (180.01) | $ 69.80 | $ (299.69) | $ (60.32) |
| nrenergy516 | $ 20.38 | $ 119.82 | $ (268.08) | $ 394.20 |
| nrenergy611 | $ (191.30) | $ 66.86 | $ (305.94) | $ (76.66) |
| nrenergy612 | $ (19.51) | $ 84.54 | $ (164.47) | $ 125.45 |
| nrenergy613 | $ (8.89) | $ 85.63 | $ (155.72) | $ 137.94 |
| nrenergy614 | $ 125.39 | $ 99.45 | $ (45.14) | $ 295.92 |
| nrenergy615 | $ (162.72) | $ 69.80 | $ (282.40) | $ (43.03) |
| nrenergy616 | $ 37.67 | $ 119.82 | $ (250.80) | $ 411.49 |