CRITICAL ECONOMIC FACTORS FOR SUCCESS OF A BIOMASS CONVERSION PLANT FOR AGRICULTURAL RESIDUE, YARD RESIDUE AND WOOD WASTE IN FLORIDA

Ivan R. Granja, University of Florida, robgran@ufl.edu

John J. Vansickle, University of Florida, sickle@ufl.edu

Lonnie Ingram, University of Florida, ingram@ufl.edu

Rick Weldon, University of Florida, rweldon@ufl.edu

Selected Paper prepared for presentation at the Southern Agricultural Economics Association Annual Meeting, Orlando, FL, February 6-9, 2010

Critical economic factors for success of a biomass conversion plant for agricultural residue, yard residue and wood waste in Florida

Ivan R. Granja, John J. Vansickle, Lonnie Ingram, Rick Weldon

Abstract:

This model evaluates the potential success of a cellulosic ethanol plant in Florida. Critical Economic factors of the plant were simulated to assess the ability of this project. These critical factors include the feedstock to be used, the cost of the facility, transportation costs and the discount rate for the net present value (NPV). Results and observations are presented in this paper.

Introduction

The US Government has encouraged research and development of an advanced biofuels industry to help offset the inputs of ethanol production on food produced from feed grain. These advanced biofuels, also called second generation biofuels, include cellulosic ethanol, biohydrogen, Butanol, biomethanol and others. Cellulosic ethanol production is now in the advanced stage of development and is soon to be commercialized (Ingram, 2005). There has been considered research on cellulosic ethanol production because feedstock for the biofuel can be found throughout the US from a variety of fibrous organic materials. These materials include newly developed energy crops, agricultural residue, wood residue and municipal solid waste (MSW).

The state of Florida has energy crops designed particularly for the purpose of making biofuels. There is extensive research on these crops, particularly switch grass, sweet sorghum, elephant grasses and others. These feedstocks are being studied and modified to specifically be used in the production of biofuels. Florida has several industries that could contribute agricultural residue for the production of biofuels. Sugarcane baggase has already been tested in different research-scale plants in the state. Other residues in the state that have been considered are orange peels, trimming waste from orange trees, and other agricultural residues from other crops.

Municipal solid waste has great potential to supply large quantities of materials and is already collected and handled in a single place. MSW includes yard trash, construction debris from land clearing and carton and paper materials that could be recycled into cellulosic ethanol. Research suggests yard waste could yield the most ethanol from dry matter.

Florida has large quantities of agricultural, MSW and wood residues. The value of this feedstock available for potential cellulosic ethanol plants in Florida suggests a great potential for their development. North Florida has large quantities of wood residue as part of the milling industry that is mostly located in that region. MSW is abundant in the southeast region due to the large development of urban areas. The central and southeast areas are where the most agriculture is located.

The purpose of this study was to analyze the potential for developing a cellulosic ethanol industry in Florida. The feedstocks considered for this study are sugar cane baggase, wood residue, and yard waste from MSW. Economic feasibility will be evaluated by the net present values of cash flows a cellulosic ethanol plant generates from alternative feedstocks.

LITERATURE REVIEW

Relatively little research has been done on the economic feasibility of cellulosic ethanol plants that includes the stochastic risk associated with the biomass supply and the output values for the ethanol produced. Ethanol plant level risk models, using plant construction costs and budgets for converting biomass into ethanol, will provide a dollar measurement of the projected costs and returns to building a plant for this purpose. The model will also allow for analysis of policy related to ethanol production and the risks associated with output prices.

Most of the work associated with cellulosic ethanol production relates to the development of technologies (Ingram 2005). Only a small volume of work has been completed on the economic feasibility of such technology (Gill et al., 2007). Risks associated with implementation of this technology relate to the supply and cost of feedstock available for conversion into ethanol, and in the value of ethanol that is produced.

The U.S. National Renewable Energy Laboratory (NREL) and the U.S. Department of Energy (DOE) have developed models for the production of cellulosic ethanol from lignocellulosic biomass (Sandor et al., 2008). The models analyzed the economics of process design and future scenarios for the production of ethanol from lignocellulosic biomass using co-current dilute acid prehydrolysis and enzymatic. Arden et al. (2002) evaluated process design and cost of building a plant for this purpose. This report used a selling price of $1.07 per gallon of ethanol for a plant using approximately 770,000 tons of dry corn stover as the main feedstock.

Economic feasibility is at the core of successful biomass conversion. Most ethanol used as fuel today comes from converting sugar-rich corn crops into ethanol. The value of corn as food makes this ethanol costly to produce as compared to ethanol that may be developed from agricultural residue, yard residue and wood waste. This project will evaluate the economic feasibility of alternative ethanol plants and the feedstock used to supply biomass to these plants. Florida has a large amount of biomass that can be converted into ethanol (Jackson 2007). The research will identify basic feasibility (net present value of cash flows for a modeled plant) and assess the risk associated with cellulosic ethanol plants based on product values and biomass supply.

Methods

Stochastic simulation was used to analyze the economic risks associated with the development of the cellulosic ethanol plants. An Excel Add-on program, Simetar, is used. Stochastic simulation is defined as a “tool for addressing ‘what if . . .’ questions about a real economic system in a non-destructive manner” (Richardson 2002).

Simetar functions allow the user to define and estimate distributions for random variables and to randomly sample those distributions so probabilistic outcomes for the system can be modeled. Simetar also provides useful tools to analyze the probabilistic outcomes generated from a stochastic simulation (Simetar, 2004).

The stochastic model is presented below to analyze the economic feasibility of locating cellulosic ethanol plants in the state of Florida. The model assumes a plant capacity of approximately 70 million gallons per year (MMGPY) (NREL, 2002). Three different feedstocks (MSW, agricultural residue, wood residue) are analyzed to evaluate the feasibility of ethanol production. The stochastic model is constructed based on assumed production levels, income statement, statement of cash flows and balance sheets for a modeled plant. Stochastic variables included in the model are ethanol price and the cost to acquire wood residue, agricultural residue, MSW yard trash and the prices of diesel, electricity and natural gas.

Cellulosic ethanol model. For the purpose of this study, the parameters used in the NREL reports (Aden et al., 2002) were used to estimate the cost of machinery for the plant, the size of the plant, the process for the production of cellulosic ethanol and other factors. The University of Florida and the Department of Agricultural and Biological Engineering with its Energy laboratory helped on upgrading some of these parameters from the NREL report.

Aden et al. (2002) used a market price for a gallon of ethanol of $1.07 for a plant that processed approximately 770,000 tons of dry corn stover as the main feedstock. For this study, the quantities and costs of Florida's feedstock were compiled from governmental agencies and from universities databases. The agricultural residue costs and quantities produced (sugar cane baggase) were provided by University of Florida extension service located in the Everglades region by Gilbert (2009) and from Ho (2006) analysis of the potential for bagasse-based cogeneration in the U.S. The National Forest Service (FIA, 2009) provided the data for wood residue produced in Florida as well as the costs of handling the material. The Florida

Department of Agriculture and Consumer Services (DACS) provided the data for MSW produced in Florida and the cost for handling alternative types of trash. The cost and quantity of yard waste was acquired from these reports as well.

The NPV discount rate had an important role in this study. The discount rate states how much the income and investment made in the present and future is worth in the present period. An important factor in the success of a conservation or renewable governmental project is the NPV discount rate used. Short et al. (1995) state that due the lack of information on investments in ethanol projects a high risk is associated with the economic plan, meaning high NPV discount rates should be used. Aden et al. (2002) used that as justification for assuming a discount rate of 10% in their evaluations of economic feasibility of a cellulosic ethanol plant.

Stochastic variables. Stochastic variables are the main inputs and outputs factors that affect the production feasibility of the plant model. Below is the explanation of the method to estimate the stochastic variables.

The annual price of ethanol was obtained from the Oxy-Fuel newsletter (Price, 2009) for the years 1999 to 2008. Wood residue prices were obtained from Energy Information Administration (EIA, 2007) statistics website. Agricultural residue prices were obtained from Gilbert (2009) at the UF-IFAS extension services. The fuel section of the transportation cost was derived from the total cost and diesel was considered for this purposes. Annual prices for diesel, electricity and natural gas were obtained from the EIA energy reports (EIA, 2009).

A correlation matrix was estimated for the annual observations for the stochastic variables. There is significant correlation between ethanol prices and agricultural and municipal residue as well as transportation, electricity and natural gas. Every correlation coefficient was 0.57 or higher with t-statistics ranging from 1.98 to 14.50.

The next step in the simulation was to estimate OLS regression models for each of the stochastic variables in order to collect the residuals that are used to define an empirical probability distribution function for each of the variables (table 1).

Forecasts for the stochastic variables are calculated for ten years using the empirical distribution for each of the variables. These inputs represent the risk factor associated with the net present value of the ethanol plant.

Capital & Operating Loans and Interest Rate Assumptions. The capital loan interest rate is set to a fixed 0.5 % for the 15 year loan period (Weldon, 2009). The operating loan interest rate is set to 0.6 for the ten year period from 2009 to 2018 (Weldon 2009). The capital value for the project is taken from Aden et al. (2002) report and updated to 2009 values. IMPLAN economic impact modeling system was used for acquiring the inflators and deflators of each industry sector that manufactures the different parts of the plant.

For the purpose of this study, 100% of capital and operating loans are financed, assuming no investor contribution.

Production Assumptions. Ethanol yields are calculated from the total production by the price of the stochastic variable for each forecasted years. Added to this production is the denaturant which is 0.05 percent of every year. The function of the denaturant is to convert the ethanol so it must be used for industrial purposes and not for human consumption. Ethanol production plus the denaturant will give the total production numbers. The study assumes the plant production at 100% for all years.

The variable costs are derived from Aden et al. (2002) reports. These variables costs include the denaturant, electricity, natural gas, maintenance materials, labor and administration, and miscellaneous costs. These costs were updated for 2009 and inflated by 10% for each of the forecasted years (Aden et al, 2002).

Income Statement. Total receipts from the proposed ethanol plant were calculated by multiplying the total production of ethanol with the denaturant added by the stochastic ethanol average priced for the 10 years.

The variable costs include the transportation, feedstock, denaturant, enzymes, chemicals, natural gas, electricity, maintenance materials, labor, administration and miscellaneous costs. Transportation is calculated from the Aden et al (2002). It uses an average cost of transporting a dry ton of feedstock is $13.65 and then this is multiply by the total yearly plant capacity. Feedstock cost is calculated by the total plant capacity in dry tons per year by the price of the feedstock being used (MSW, agriculture or wood residue). The denaturant, enzymes, chemicals, natural gas, electricity, maintenance materials, labor, administration and miscellaneous costs are calculated multiplying its respective price by the gallons of ethanol produced every year.

Loan costs include the capital and operational loan interest. The capital loan interest costs are calculated from the capital loan schedule for 15 years. The operational loan interest costs are calculated from the total variable costs multiplied by the operating loan interest rate.

Total expenses are the sum of the total variable costs, the total loan interest costs and the depreciation expenses which are taken from the balance sheet calculations.

Statement of cash flows. The beginning cash balance in 2009 is zero. The following years, the beginning cash balance equals to the ending cash balance from the previous year. The net cash income is taken from the income statement. The beginning cash, the net cash income and a depreciation adjustment adds up to calculate the total inflows.

Total outflows are calculated from the property part and equipment (PP&E) which accounts for the principal portion of the capital loan annual payment. This is summed to the Federal income taxes and the capital replacements which are calculated from estimates provided by Aden et al. (2002) for each year.

Total inflows and outflow are then computed to get the ending cash balances for each year of the projected plan.

Balance sheet. The assets of the firm are calculated from the cash, capitalized start up costs, land and capital improvement values. The capitalized start-up costs are derived from the PP&E depreciation schedule which calculates depreciation from the depreciation tables from the US Internal Revenue Service 2009 for the number of years of the project. Land values are calculated from Clouser et al (2007). The average value in dollars per acre from transitional land, which is agricultural land converted to nonagricultural uses, is $18,356.00.

The total liabilities were calculated adding total current liabilities with the total long term debt. Since cash flow deficit borrowing is zero, it is zero as well in the flow deficits liabilities section, total liabilities accounting only the loan payments.

Total equity was calculated at the sum of the beginning equity (beginning loan value) and retained earnings.

NPV is calculated subtracting the 10th year present value of the ending equity from the first year of the beginning equity. The potential success of the project is determined by whether the NPV is positive (successful) or 0 if negative (not successful).

Critical Economic Factors

The NPV economic model shows that the discount rate is the most important factor influencing the success of the project. The NPV formula from Short et al. (1995) is:

$$NPV = \sum_{n=0}^{N} \frac{F_n}{(1+d)^n} = F_0 + \frac{F_1}{(1+d)^1} + \frac{F_2}{(1+d)^2} + \cdots + \frac{F_N}{(1+d)^N}$$

Where:

NPV = net present value

F_n = net cash flow in a year n

N = analysis period

d = annual discount rate

According to the Short et al. (2002) the NPV discount rate is 10%. Using a 10% discount rate, the chances of success are very small. The scenario analysis done is the study shows the different results using different discounts rates. At 10% discount rate the probability of stay below zero is 89%. On the other extreme, at 6% discount rate the probability to be below zero is 23%. The optimal discount rate for a project that includes conservation or renewables is 8% (Short et al., 1995). This is shown in graphs 2 and 3.

Building a plant is another critical factor. Changes in technology from that assume by Aden et al. in 2002 until the present day have significantly impacted the ways to process the biomass into ethanol. Disclosure of information that pertain the present costs of mounting a cellulosic ethanol plant is very limited. The NREL will issue their new report on biomass to ethanol at the end of this year. There are different ways to produce ethanol from biomass including different technologies like enzymatic or steam pressure processes among others. The NREL bases their report on enzymatic Prehydrolysis.

Transportation costs are an important factor that is also critical for the economic success of a cellulosic ethanol plant. Feedstock farther away from the plant is more costly. This is evaluated using an average $13.65 in transportation's cost from Aden et al (2002).

Results and Conclusions

This model used in the analysis evaluates the critical economic factors for the success of a cellulosic ethanol plant in Florida. The introduction of stochastic variables in this study helped to input the risk factors associated with the investment in ethanol production. Additional variable costs like enzymes and chemicals will be added as stochastic data is collected to measure the stochastic risk. Data on residue in the orange industry is also being collected and will be quantified for purposes of assessing its potential as an agricultural residue that can be converted to ethanol in Florida.

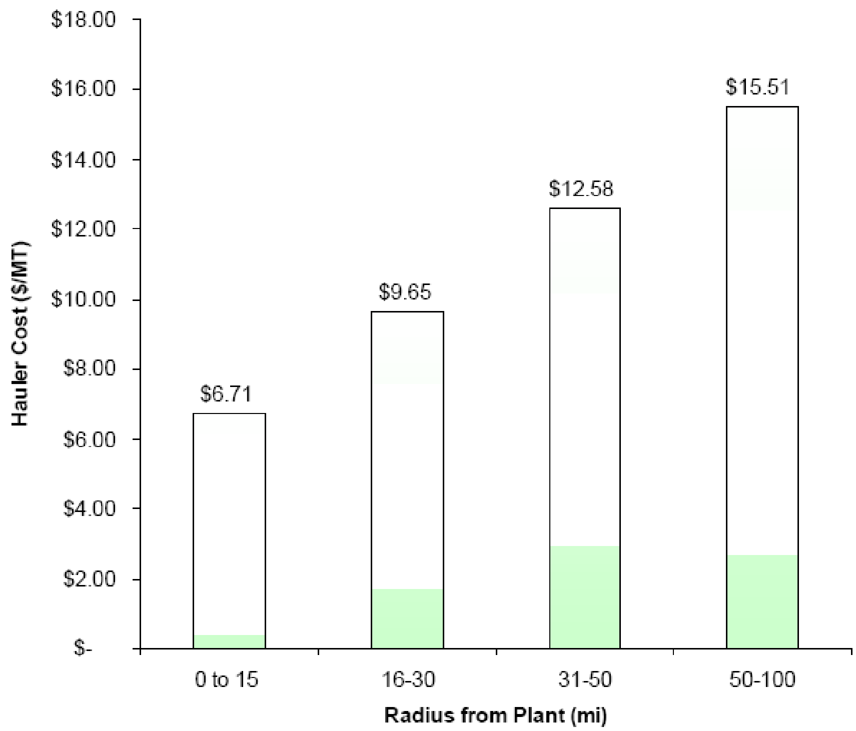
There a new technologies at the present time that will make the process simpler and cheaper, which will affect the costs of the plant in the study. At the same time, the private industry is encountering higher costs at the moment for building the plant. The costs range from $200 million to $400 million according to Aden et al. (2002) and the costs estimated by British Petroleum with its joint venture with Verenium (BP, 2009).

Table 1. OLSs summary

	R2	F-test	95% Intercept Beta
Ethanol $/gal	0.789	29.923	-302.275
Wood Residue $/ton	0.959	188.315	-1735.635
Ag. Residue $/ton	0.894	67.328	-1759.207
MSW residue $/ton (yard trash)	0.956	173.444	-1061.748
Transportation (diesel) $/gal	0.861	45.503	-531.809
Electricity $/Kwh	0.929	104.115	-5.253
Natural Gas m3/ton	0.879	58.323	-1307.031

Graph 1.

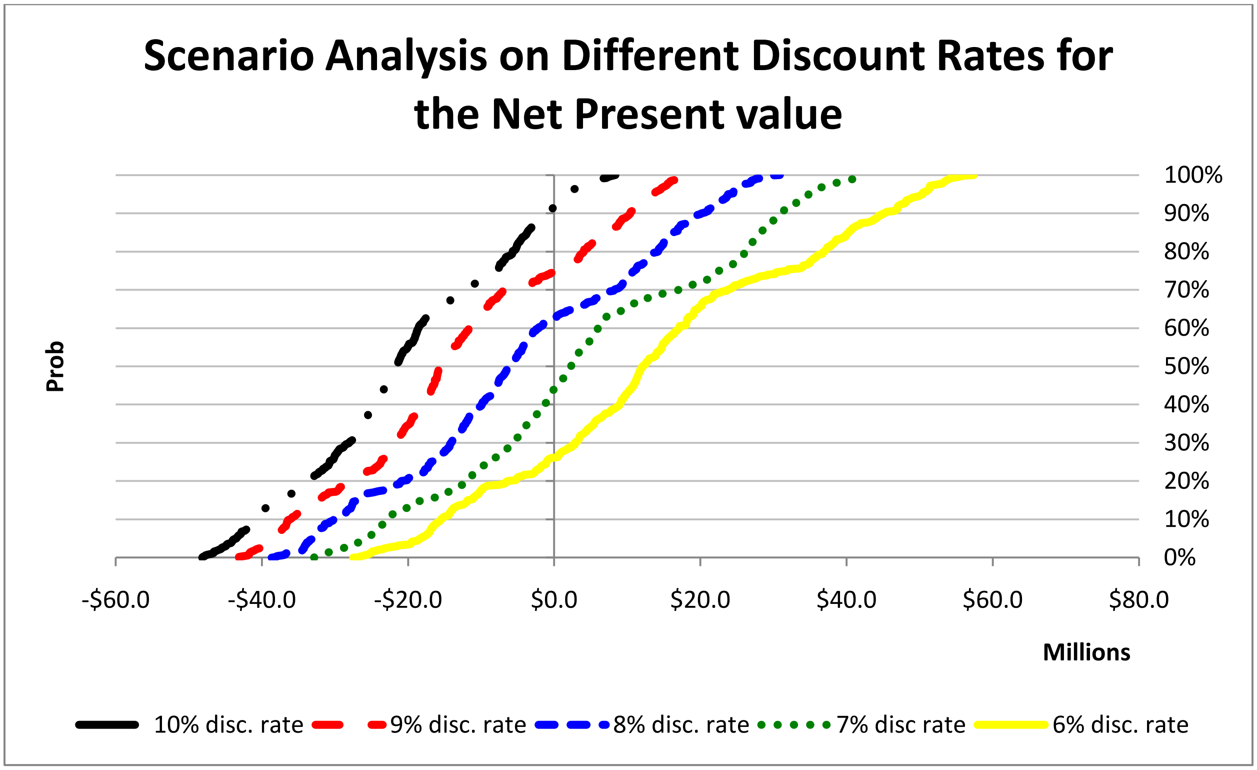
Costs of transportation as a function of distance to the plant



Source: NREL cellulosic ethanol report, 2002.

Graph 2.

Discount Rate of Return at 10,9,8,7,6 percent



References:

1. Aden, A., Ruth, M., Ibsen, K., Jechura, J., Neeves, K., Sheehan, J. and Wallace, B., National Renewable Energy Laboratory. (2002) Lignocellulosic Biomass to Ethanol Process Design and Economics Utilizing Co-Current Dilute Acid Prehydrolysis and Enzymatic Hydrolysis for Corn Stover. Available at: http://www.nrel.gov/docs/fy02osti/32438.pdf (Accessed: 5 December 2008)
2. British Petroleum Press Office. (2009) BP and Verenium form leading cellulosic ethanol venture to deliver advance biofuels. Available at: http://www.bp.com/genericarticle.do?categoryId=2012968&contentId=7051362 (Accessed: 04 August, 2009)
3. Department of Agricultural Economics, Agricultural and Food Policy Center, Duoba John, CCH Incorporated. (2009) 150% Declining Balance Method Half-Year Convention. Available at: http://taxguide.completetax.com/tools/download/deptablesa14.rtf (Accessed: 07 September, 2009)

4. Energy Information Administration. (2007) Industrial sector energy price estimates by source in 2007. Available at: http://www.eia.doe.gov/emeu/states/sep_sum/html/pdf/sum_pr_ind.pdf (Accessed: 10 October, 2009)

5. Florida Department of Agriculture and Consumer Services. (2009) Recycling -1999-2008 Solid Waste Annual Report Data. Available at: http://www.dep.state.fl.us/waste/categories/recycling.html (Accessed: 11 February, 2009)

6. Forest Inventory and Analysis National Program. (2009) Tree preservation orders (TPO) reporting tool. Available at: http://srsfia1.fia.srs.fs.fed.us/php/tpo2/tpo.php (Accessed: 20 May, 2009)

7. Gilbert, Robert. (2009) What is the Sugarcane bagasse production in Florida? 7th October [Telephone]. Available e-mail: ragilbert@ifas.ufl.edu

8. Hodges, Alan. 2009. Minnesota IMPLAN group Inc. IMPLAN professional software. 2009. Stillwater, Minnesota, 2008.

9. Ingram, LO. 2005. The potential role of alternative (renewable) fuels in the US. Journal of Biotechnology 118: S91-S91 Suppl.

10. Jackson, Samuel W. Florida Biomass and Bioenergy Overview. 2007. Southeast Sun Grant Initiative. Southeastern Regional Center. Tennessee Agricultural Experiment Station.

11. Kevin Ho, Columbia University. (2006) The potential of bagasse-based cogeneration in the US. Available at: http://www.columbia.edu/~kjh2103/US-Bagasse-Cogen-Potential.pdf (Accessed: 25 July, 2009)

12. R. Chope Gill II, James W. Richardson, Joe L. Outlaw and David P. Anderson, Texas A&M University. (2003) An Analysis of Ethanol Production in Texas Using Three Ethanol Facility Sizes and Their Relative Optimal Subsidy Levels. Available at: http://ageconsearch.umn.edu/bitstream/35003/1/sp03gi04.pdf (Accessed: 25 March, 2009)

13. Rodney L. Clouser, Ronald Muraro, Laila Racevskis, and Charles Moss, University of Florida. (2007) 2007 Florida Land Value Survey. Available at: http://edis.ifas.ufl.edu/pdffiles/FE/FE71000.pdf (Accessed: 10 October, 2009)

14. Sandor, D., R. Wallace and S. Peterson. 2008. Understanding the Growth of the Cellulosic Ethanol Industry. National Renewable Energy Laboratory. NREL/TP-150-42120. (http://www.nrel.gov/biomass/pdfs/42120.pdf).

15. Software Package SIMETAR©: Simulation for Excel to Analyze Risk. Texas A&M University. January 2002.

16. Walter Short, Daniel J. Packey, and Thomas Holt, National Renewable Energy Laboratory. (1995) A Manual for the Economic Evaluation of Energy Efficiency and Renewable Energy Technologies. Available at: http://www.nrel.gov/csp/troughnet/pdfs/5173.pdf (Accessed: 10 September, 2009)