Economic Value of Cellulosic Ethanol

Analysis of Advanced Biofuels from Energy Cane in South Florida

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ABSTRACT

This study presents a pro forma cash flow analysis of a cellulosic ethanol production facility in Florida, as well as insight about potential air quality impacts of cellulosic ethanol production and use. The economic analysis is based on a real company, Vercipia, which will produce cellulosic ethanol biochemically from a hybrid of sugarcane known as "energy cane".

The cash flow statements provide both a summary of input-output relationships as well as the relationship between revenue and costs. Some elements of the cash flow are generic in the sense that they are common to any firm, such as wages or the cost of land, but many others, such us the various credits and feedstock costs, are unique to this project. The net present value analysis indicates a net benefit to the economy, as well as Vercipia and the government. Sensitivity analysis was performed to determine the relative impact to the net present value of changes in feedstock, enzyme and plant (investment) costs and ethanol prices. The net present value is most sensitive to changes in the ethanol prices. Three Monte Carlo simulations were run--the enzyme costs, feedstock costs and ethanol prices were assigned log normal distributions for each year of the project. The Monte Carlo indicates the expected net present value is robust given the assumptions made in the analysis.

Given the mandated increases in ethanol production, there is a need to understand how cellulosic ethanol production and use will affect air quality (EPA, 2009). Because there are numerous routes for producing ethanol, different feedstocks, and different models for estimating inputs and emissions, life cycle analyses produces different estimates of total GHG and other emissions. The scientific conclusions seem to be that overall this technology would be beneficial compared to conventional gasoline. Three life-cycle analyses of cellulosic ethanol using best estimates of current and future technology point to an overall decrease in GHG emissions of 60 to 110% (including carbon sequestered in the soil by the feedstock). However, the three papers reviewed for toxics demonstrate a potential increase in air toxics relative to conventional gasoline usage.

Overall, the project as modeled is economically beneficial to the economy, governments and company given the assumptions made. Compared to conventional gasoline production and combustion, cellulosic ethanol will decrease greenhouse gas production; however, this benefit may be outweighed by production of air toxics. The impact of ethanol combustion on air toxic production must be determined before a more accurate conclusion of total benefits can be made.

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I. Impetus

The purpose of this paper is to present an analysis of the theoretical economic cash flows associated with a cellulosic ethanol production facility in Florida, as well as provide some insight about potential environmental impacts of cellulosic ethanol production and use. The following introduction will discuss the impetus for the project and provide more background about fuel use in the United States and security, emissions and supply issues associated with liquid fuel.

Both the Obama and Bush administrations have expressed a desire to increase national security by decreasing the reliance on imported fossil fuels. The Energy Independence and Security Act of 2007 required revisions to the Renewable Fuel Standards (RFS); by 2022, 36 billion gallons of biofuels are mandated to be incorporated by refiners in the U.S. Of these, 16 billion gallons are required to be from cellulosic biofuels. This would essentially take us from 0 to 16 billion gallons in a brief span of 12 years. To give perspective to this goal, the current domestic cellulosic ethanol production is less than 2 million gallons, equal to less than a hundredth of a percent of the goal.

Besides energy security issues, the effect of the greenhouse gasses (GHGs) emitted from producing and combusting fossil fuels is another reason biofuels are being given a closer look. Part of the RFS2 (the revised Renewable Fuel Standards) is a stipulation that lifecycle analyses of the candidate alternative fuels be considered and that the fuels have to meet a specified reduction of GHG emissions compared to conventional fossil fuels. The Environmental Protection Agency (EPA) estimates average annual reductions of 150 million tons of CO_2 equivalent, a measure of GHG emissions from implementation of RFS2, which would be equivalent to 24 million fewer cars on the roadway each year.

An additional factor moving the market towards additional ethanol use is the ban on Methyl Tert-Butyl Ether (MTBE) as an oxygenate in gasoline blends which led to an increase in ethanol usage as it is a substitute for MTBE. (Darby, Mark, & Salassi, 2010)

The amounts mandated by the RFS2 and impact of related programs leads to important questions, such as:

- Is cellulosic ethanol production economically feasible or desirable?
- Will emissions be better or worse using ethanol?

A. Fuel Usage

1. Patterns and Trends, Domestic and International

Liquid fuel use continues to grow in the U.S. and worldwide. In 2008, total domestic petroleum consumption was 19.5 million barrels per day, or 23% of the world total, making the U.S. the world's largest consumer of crude oil. According to the Energy Information Agency (EIA), the U.S. imported about 57% of the petroleum products we consumed in 2008. Despite the historic trends of increased consumption and imports and decreased production as shown in the line graph below, the EIA predicts that by 2030, only 40% of U.S. consumption will be imported and that the difference will be made up for by an increase in domestic production, as well as biofuels and coal-to-liquid technology. (EIA, 2009) In order for this prediction to be realized, biofuels production and use will have to continue to grow rapidly.

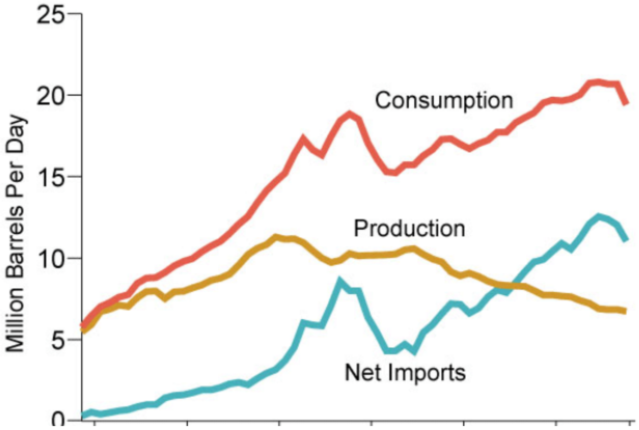

Figure 1 Consumption, Production and Import Trends (1949-2008), Image Source: U.S. EIA, 2009

2. Related Issues

Although private investment in any project hinges ultimately on the prices and revenue potential, because cellulosic ethanol production is not currently cost competitive with gasoline, external factors that affect the market for cellulosic ethanol are important considerations. Prices for fossil fuels like gasoline and coal may not include all the costs ultimately "paid" for them, such as costs associated with poor air quality and related health effects. Programs like the RFS2 attempt to correct for the lack of these pricing signals by providing incentives to invest in technologies with fewer of these external costs.

Two frequently cited arguments in favor of ethanol use and production are increased security and decreased emissions. By encouraging the use of ethanol, the U.S. will have decreased costs for security and decreased costs for the negative impacts of emissions associated with conventional gasoline. Regardless of the veracity of this logic, because of their prevalence in this area, these arguments are important considerations when determining the continued or increased support of biofuel production.

a. Security

Those who favor ethanol production in the U.S. point to the increased national security provided through a decrease in imported petroleum products. The U.S. is said to have only 3% of the world's known oil reserves and about 60% of known oil reserves are found in sensitive and volatile regions of the globe (DOE, 2009). By producing and purchasing domestic fuel, the dollars are available for domestic investments as opposed to being sent overseas. Increased supplies of liquid fuel will also provide insulation from volatile price swings in oil prices that were as high as $140 in 2008 after having spent most of the previous decade closer to $10 to $20 per barrel. Interestingly, the Renewable Fuels Association (RFA), an ethanol industry group, reports on their web page "Ethanol Facts: Energy Security" that the EIA reports an increase in imports of up to 70% by 2030, clearly at odds with the most recent EIA prediction of a decrease to 40% by the same year. (RFA, 2005-2010)

President Obama stated in the 2009,

> "America's dependence on oil is one of the most serious threats that our nation has faced. It bankrolls dictators, pays for nuclear proliferation, and funds both sides of our struggle against terrorism. It puts the American people at the mercy of shifting gas prices, stifles innovation and sets back our ability to compete." (RFA, 2005-2010)

With the emphasis on renewable fuels in the Energy Independence and Security Act of 2007 and the continued emphasis from successive Presidential administrations, biofuels are clearly seen as at least a political answer to security issues.

Despite the arguments in favor of ethanol to increase national security, there is controversy about the expected amount of benefits. In a 2008 paper, the authors argue that costs of ethanol outweigh the benefits by billions of dollar (Hahn & Cecot, 2009). Other papers come to similar conclusions about the benefits of ethanol and it is difficult to argue that the costs would offset the security benefits, which are difficult to monetize. However, these estimates are typically based only on corn ethanol and do not consider cellulosic ethanol from diverse feedstocks. As this industry develops, it will be easier to analyze whether cellulosic ethanol produced and consumed domestically really does hold the promise to increase security as is assumed.

b. Emissions

Currently, transportation accounts for 29% of GHG emissions in the U.S. and it accounts for 47% of the net increase in total domestic emissions since 1990 (EPA, 2009). Because of the volume of these emissions and the growth, reducing these emissions will be necessary if the U.S. is to vigorously reduce GHG emissions regardless of how the reduction strategy is implemented.

Of the myriad ways to reduce emissions, biofuels is an appealing and logical option because it would likely require the fewest changes to existing infrastructure. No alterations to the electricity grid would be necessary, as with electric cars; no radical changes to vehicle production, maintenance and disposal, as with hybrids; and no radical changes to lifestyle, as with adoption of public transportation on a mass scale. Ethanol seems to be the path of least resistance. To produce ethanol in quantities that would significantly displace imported oil, however, alternative feedstocks to corn and new production technologies must be explored so that ethanol can be produced closer to consumers, with less energy and cost, and with greater assurance of low feedstock cost.

But at what cost to air quality? As of 2004, only 2% by volume of U.S. gasoline fuel supply came from ethanol and that represents only 1.3% of the of the energy content of gasoline sold (Davis & Diegel, 2004). The RFS volume mandate expands the use of a combustion fuel source that, for the most part, has elusive overall air quality impacts. Along with the volume mandates, the RFS also mandates an overall reduction of 60% in life cycle GHG emissions (EPA, 2009). One would think this stipulation would serve to improve overall air quality; however, ethanol use is associated with air toxics that are not produced when burning regular, fossil-fuel based, gasoline. Because of the potential production of toxics and the impending changes in the gasoline to ethanol ratio, there is an imperative need to understand how cellulosic ethanol production and use will affect air quality

B. Introduction to Ethanol

1. Alternative Fuels

Numerous automobile fuel alternatives exist, including natural gas, ethanol and biodiesel. As most vehicles in the United States are currently powered by gasoline, ethanol is the most substitutable as it can be blended with gasoline and used to power vehicles currently on the road with only minor loss of efficiency. Because of the near-term viability of ethanol, it presents the most valid case for economic analysis.

a. Ethanol in General

There has been considerable press coverage and academic analysis of ethanol produced from corn in recent years. Many of these have found corn ethanol to have a negative energy balance, that is, it requires more energy to make than what is available in the final product. An alternative to conventional ethanol is cellulosic ethanol, which is the focus of this analysis. It is produced from the tough, starchy fibers of plants as opposed to the readily available sugars like those found in corn kernels.

Ethanol is also known by many other names, including grain alcohol or ethyl alcohol. It is a clear and colorless liquid that has the same chemical structure whether the feedstock used to produce it is grain, grass, or newspapers. Therefore, cellulosic ethanol and ethanol produced from corn grain are essentially chemically identical, despite the difference in production processes. (U.S. Department of Energy, 2009)

An important characteristic of ethanol is the ability to mix it with conventional gasoline to reformulate the fuel mixture to have a higher octane rating and burn more efficiently, thus producing fewer emissions. This is particularly important in the reduction of carbon monoxide concentrations. (EPA, 2008) Because of the hygroscopic nature of ethanol (meaning it attracts water molecules), it can be potentially corrosive and therefore gasoline/ethanol blends with more than 10% ethanol (E10) are typically used in engines specially designed for higher ethanol content. Fuel with approximately 85% ethanol (E85) is used in many flex-fuel vehicles in the U.S. and there are over 2,200 E85 stations in the country (E85 Stations, 2009). Since ethanol can be used in conjunction with regular gasoline or can be burned as 100% pure ethanol (E100) in appropriate engines, the emissions can vary with the blends. Although ethanol blends can be burned in vehicle engines, there are fewer units of energy in each gallon of ethanol than gasoline. A gallon of E85 blend typically has about about 70% of the British thermal units (btu's) as does a gallon of unblended gasoline (AFDC), therefore, when compared to gasoline, more ethanol is needed to provide the same amount of energy.

b. Cellulosic Ethanol, Specifically

What is the appeal of cellulosic ethanol? Part of it is the lower feedstock costs and another part is the decrease in GHG emissions over the life cycle when compared to fossil-fuel based gasoline or conventional ethanol. Despite the extra efforts needed to break down cellulose into sugars before conversion, the relative plethora of viable feedstocks in many different locations around the U.S. and the reduction in GHGs make cellulosic ethanol production appealing. Not only are cellulosic feedstocks like corn stover or switchgrass typically less expensive relative to conventional ethanol feedstocks like corn grain, they are also less likely to compete with food crops for land (NREL, 2007). At this time, the extra steps needed to produce cellulosic ethanol make it more expensive to produce than conventional ethanol; it is expected, however, that the needed breakthroughs will be achieved within the next five years and cellulosic ethanol produced on a commercial scale will be a reality. A brief outline of the different pathways of ethanol production are outlined below.

The main differences in cellulosic ethanol and conventional ethanol is the source of fermentable sugars. In Figure 1, the fourth step is liquid/solid separation. In a conventional ethanol system, the solids would be not be fermented, but in cellulosic ethanol production, these solids are broken down into simple sugars and fermented with a special mix of enzymes. After this, the two pathways reconnect and the production again becomes quite similar to conventional ethanol.

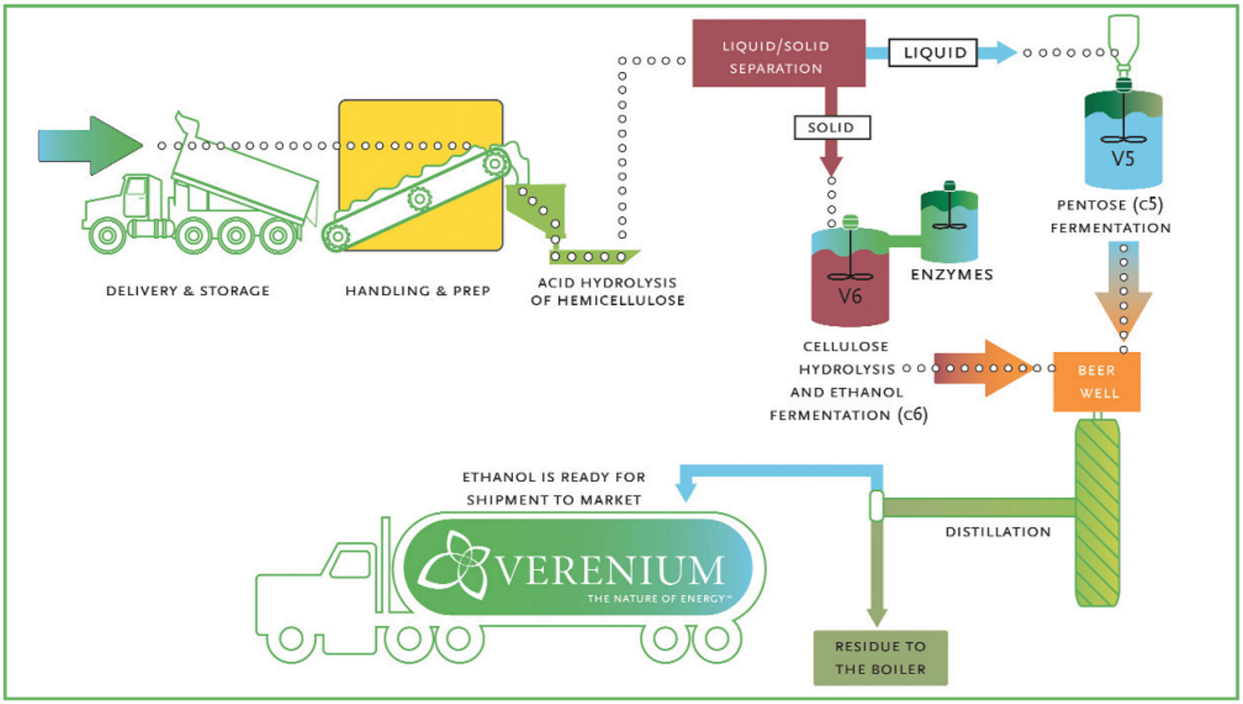

Figure 2 – Cellulosic ethanol production. Image source: Verenium

A third route for cellulosic ethanol production is thermochemical conversion, which is particularly advantageous for feedstocks with high lignin content, such as woody biomass like wood chips and hybrid poplar. This lignin is very difficult to convert biochemically. The feedstock is gasified to create a synthetic gas (known as syngas), and is then reassembled to create various products, including ethanol. Among the advantages of this method are more complete use of the feedstock and the various commercially valuable byproducts. Disadvantages include the heat that must be used in the process, although this can be overcome by reusing waste heat or converting biomass to heat to avoid electricity use. (NREL, 2007)

II. Introduction of Project

In order to determine whether cellulosic ethanol is an economically viable and environmentally sustainable alternative, I conducted an economic analysis based on a real company, Vercipia. Vercipia will produce cellulosic ethanol biochemically from a hybrid of sugarcane known as "energy cane".

The company and their model is the topic of this section; the section that follows outlines the production process at the facility. An explanation of the simple cash flow analysis that was performed to determine the viability of the economic model is in the subsequent section.

A. Why Vercipia

Vercipia was chosen as a basis for analysis for a number of reasons, all of which are explained below: its joint venture status; novel feedstock; availability of process data; and its existing production facility.

Vercipia is the result of a partnership of a cellulosic fuel company with a petroleum company—a rather unique combination in this field where cellulosic ethanol companies are typically biotechnology companies. This partnership could be an important precedent for others. Vercipia is a joint venture of BP and Verenium. BP is one of the world's largest energy companies with 18.1 barrels of oil equivalent in proven reserves (BP). In addition to petroleum, BP has invested in numerous advanced biofuel technologies in addition to Vericipia. They have a 50% stake in a company building sugarcane ethanol plants in Brazil, as well as investments with DuPont and British Sugar in the UK (BP). Verenium was formed in 2007 with the merger of Celunol and Diversa, a cellulosic ethanol and biotechnology company, respectively. In addition to cellulosic ethanol, Verenium focuses on enzyme production and has a number of licensed enzymes they currently sell to fuel producers and industrial clients. They also license their fuel production process technology to a company in Osaka, Japan, that produces fuel from wood construction waste. The joint venture to create Vericipia was announced February 18, 2009; there are still many areas that bear Verenium's name only. (Verenium, 2009). In this paper, Vercipia will refer strictly to the proposed plant in Highlands County, Florida, that is being used as the basis for this analysis.

The merging of the two specialty companies into a joint venture is an interesting model, as is the proposed feedstock: a special type of sugarcane known as energy cane discussed in more detail later.

The basic process used by Vercipia was used for the process description and the approximate input and output amounts were used as a basis for financial and throughput calculations. Where specific prices or quantities were not available because it was proprietary, regional and industry information was researched and used. Data sources are discussed in more detail in the cash flows section. Process data for the proposed Highlands County facility is available as a result of a publicly available air quality permit and is the basis for the process section of this paper.

Commercial cellulosic ethanol is a relatively novel undertaking in the United States; the demonstration-scale plant built by Verenium in Jennings, Louisiana, is the first cellulosic ethanol plant in the United States. The demonstration-scale plant was built in 2007 next door to a pilot-scale facility, which was a very small facility that produced quantities of cellulosic ethanol not viable for commercial sale but allowed Verenium to refine the processes before increasing the scale. Approximately 1.4 million gallons of cellulosic ethanol are produced from sugarcane at the facility. This facility allows Verenium to conduct research and development for its processes and enzymes outside a laboratory setting without the risks associated with investment in a larger facility. In addition, the facility is also used for training operators. (Verenium, 2009) The existence of this plant is evidence of Verenium's commitment and leadership in the cellulosic ethanol field, both of which bode well for the likelihood of success for a full-scale commercial operation.

B. Feedstock

Currently, the most common feedstock for ethanol production in the United States is corn and some companies are endeavoring to create cellulosic ethanol from corn stover in the Midwest. Verenium is the only company in the United States producing commercial cellulosic ethanol from sugarcane. This unique feedstock is viable only in tropical climates; hence it is only grown domestically in the southern United States and Hawaii. By choosing a crop that thrives in areas like south Florida, Vercipia is allowed proximity to markets that gives them a cost competitive advantage over ethanol producers in the Midwest that must truck their ethanol to more distant population centers. To increase the yield of ethanol, Vercipia will use energy cane instead of regular sugarcane.[1]

Energy cane is genetically modified sugarcane specially created at the University of Florida for cellulosic ethanol production. Sugarcane, a grass native to Asia of the genus *Saccharum*, has been cultivated more than 4,000 years (Baucum, 2009). Sugars in the cane can be used to create crystallized sugar, molasses, syrup, and rum, among other products. Because of this usage, sugarcane lines with higher sugar content, as compared to other lines, have historically been preferred. However, when producing cellulosic ethanol, the fiber (known as cellulose) is more valuable, therefore, a special hybrid, energy cane, was created to meet the desire for higher cellulose content.

Energy cane hybrids released in 2007 by the Agricultural Research Service, showed increased cellulose content as well as increased tolerance to cold, as compared to commercial varieties.

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[1] If needed, Vercipia will supplement energy cane with sorghum hybrids; the necessity of using this supplement or the ratio to energy cane is unknown. For the purpose of this analysis, it is assumed that any sorghum feedstock will have similar costs to cane feedstock and therefore will not be differentiated in the cash flow analysis.

Scientists are trying to increase the cold tolerance of sugarcane and have been incorporating the nearby relative grass species *Miscanthus* and *Erianthus*, both of which have relatively higher biomass yields and different optimal harvest times than sugarcane, and hence even more appeal as a feedstock on an integrated energy crop farm. (Richard, 2007) In a paper presented at the Southern Agricultural Economics Association Annual Meeting in 2009, yield estimates for two varieties of energy cane were as high as 34.6 and 38.9 wet (green) tons per acre, a 3 to 7 ton per acre increase over typical sugarcane yields (Mark, Darby, & Salassi). As this effort continues to evolve, increasingly robust feedstocks will likely continue to lower operating costs and increase yields.

C. Location

The new facility will be located in Highlands County, Florida. Highlands County is located in the south central part of the state and is located within 150 miles of numerous high population density areas, like Palm Beach, Miami, Orlando and St. Petersburg. The facility will be located on 97 acres approximately 20 miles northwest of Lake Okeechobee. Nearly 6.5 million people, or 36% of the state's population are estimated to live south of Lake Okeechobee as of 2005 (Cody, 2006). This proximity to population centers translates to nearby markets and thus lower transportation costs for the ethanol.

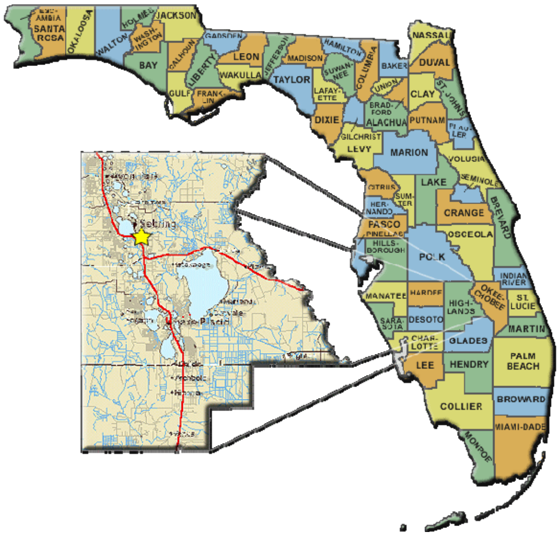


Figure 3 - Location of Highlands County, Florida
Image Source: Germaine Surveying, Inc.

The facility itself will be located in a rural and sparsely populated area of the county. Fields of the crops used as feedstock will surround the plant, thereby reducing the time and costs associated with transportation. Approximately 20,000 acres in the immediate area will be leased from Lykes Brothers Farms to grow the cane, the same group that will be growing and harvesting the cane (under a contract) as well as selling the land for the facility. This should favorably impact the final product cost. Sugarcane has historically been grown in the Lake Okeechobee region because of its rich soils and mild temperatures. In fact, Lake Okeechobee has a warming influence on the local climate, and killing freezes are rarely experienced in the area thus decreasing risk associated with feedstock reliability and costs. (Baucum, 2009)

D. Timeline

Although the Vercipia plant in Highlands County has not been constructed, this analysis assumed construction of a facility in 2007 and 2008 and assumed a fully functional facility running at capacity for 2009 and twenty years of useful life for most plant components. This time period was used to make the results of this analysis comparable to those done by NREL (Foust, Aden, Dutta, & Philips, 2009) and others. In addition, by assuming construction in 2007 and production in 2009, it allowed for the most amount of time to take advantage of the current government programs for cellulosic ethanol production which are discussed in the cash flows section.

III. Cellulosic Ethanol

Commercial cellulosic ethanol production through fermentation has two goals: 1) to extract as much sugar as possible from the feedstock, and 2) to convert as much of that sugar into ethanol as possible. The basics steps of the process are the intake of feedstocks, pretreatment, fermentation, distillation, and delivery. The following sections will elucidate these steps, especially the steps unique to cellulosic ethanol from sugarcane.

Cellulose Basics

Regular ethanol production makes alcohol by fermenting readily available sugars. Cellulosic ethanol also makes alcohol from sugars, but they are not as readily available. For those who want to understand the process fully, the following is intended as a brief primer on where the sugar for cellulosic ethanol comes from. Plants are composed of cellulose, hemicellulose and lignins; in fact, these three substances form the majority of biomass on earth. Cellulose is a regular, linear macromolecule composed of long chain sugars that has a tendency to form crystalline regions. It is rather rigid and provides form to the cell walls of plants. Hemicellulose, though having a similar name, is quite different from cellulose in form. It too is composed of sugars, but these are formed into amorphous, irregular chains that surround the cellulose and act as a sort of binding agent. Lignin links covalently with hemicellulose and because of this, lends strength to the cell walls. The lignin is hydrophobic in comparison to the other two and helps with water transport. (Lucia, 2007) The three of these must be broken down in order to obtain the sugars that will be fermented into ethanol; this is the purpose of the first three steps of production.

A. Production Processes

1. Feedstocks

Cane harvesters chop the long canes into what is known as billets, which are sections of cane approximately 10 inches long. The billets are brought to the plant by truck from adjacent farmland. Feedstock will not be stored on-site as it will be harvested on demand. The feedstock will be washed after being offloaded at the site. The Vercipia facility will be designed to receive 3,600 green tons per day (150 green tons per hour) of feedstock.

2. Pretreatment

Following the washing process, the cane will begin the process of being broken down in order to release the sugars. The first part of this process is known as hydrolysis. Hydrolysis converts the complex long chain sugars in the hemicellulose to fermentable simple sugars. The hydrolyzer will will use steam and dilute sulfuric acid in a single-stage process to produce the sugars. The product will be an acidic slurry (the aforementioned hydrolyzate) composed of cellulose and lignin solids and a liquid containing five and six chain sugars (pentoses and hexoses). These must be neutralized before fermentation.

3. Separation and Neutralization

In this stage, the solids and liquids are divided into separate streams through a series of three-stage screw presses. A feed tank is located on the inlet side of each press and a filtrate tank is on the discharge side for a total of six tanks. The hydrolyzate is sent through the presses, and the solids are then discharged to a mixer and the liquids are sent to a neutralization tank. Lime is then incorporated in the solids in the mixer and the liquid in the neutralization tank to neutralize the acids introduced during hydrolysis pretreatment. The stream of solids and liquids are then ready for fermentation.

A vapor capture system will collect the evaporative emissions that will be exhausted to a wet scrubber for treatment. The water used in the scrubber will be recycled in the neutralization tank as make-up water.

3. Fermentation, Distillation, Denaturization

At the Vercipia facility, the two separate streams are each fermented in a similar but separate set of four fermentation vessels. The cellulosic and lignin solids will be sent to one set of vessels where the cellulose will be saccharified and fermented simultaneously. This means the long chain sugars in the cellulose will be broken down into simple glucose sugar which will be fermented at that time. A proprietary enzyme will be used to release the glucose which will then be fermented with a proprietary bacterium that will produce a dilute ethanol beer. The material will be batch fermented and the resulting mash (a mixture of liquids and solids) will be passed to a beerwell after each batch is completed. The beer stored in the beerwell, which is a tank for holding the fermented liquid, will be transferred to a beer stripper that initiates the distillation process.

The hemicellulosic liquids will be fermented in another set of four fermentation vessels by a proprietary bacterium to produce a similar ethanol beer. This beer will be sent to a beerwell and stripper separate from those used for the cellulosic materials.

The vapors from the strippers will be passed to a stripper/rectifier for continued distillation and then a molecular sieve system to dehydrate the product. Gasoline is introduced to denature the resulting ethanol, which makes it unsuitable for human consumption. The distilled ethanol will be mixed with gasoline to create a product that is 5% ethanol by weight.

The cellulosic and lignin solids that were not converted and fermented are separated and left at the bottom of the cellulosic beer stripper in a form known as stillage cake. This cake will be dewatered and then conveyed to the biomass boilers. Approximately 25 dry tons per hour of stillage cake will be produced per hour that will consist primarily of lignin and unhydrolyzed cellulose with a moisture content between 35 and 60%.

The proprietary bacteria and enzymes will be reproduced on site in a propagation system. These are produced by supplying nutrients to the existing bacteria and enzymes and providing a suitable environment for propagation. The following propagation nutrients will be used and stored on-site: Solka-Flok (a powdered cellulose), soy flour, ammonium sulfate, potassium phosphate, and urea. There will be three cellulosic enzyme and three bacterium propagators, and three hemicellulosic bacterium propagators.

The tanks, vessels and other equipment used in fermentation and propagation will be vented to a wet scrubber. This scrubber water will be returned to the cellulosic beer well as make-up water. Additionally, these tanks and vessels will require cleaning. This will be done with a clean-in-place (CIP) system that will use a disinfectant such as caustic soda or sodium hypochlorite to provide sanitary conditions for the enzymes and bacteria.

5. Transport

The finished product, the denatured ethanol, will be loaded on tank trucks at a rate of 600 gallons per minute. The vapors displaced from the tanks, which may be regular gasoline or an ethanol blend, will be exhausted to a flare. The trucks would then deliver the product to an unaffiliated blend or sales terminal.

6. Wastewater Treatment

An onsite wastewater treatment plant (WWTP) will process wastewater from the production process. Methane will be produced in the anaerobic treatment stage that will fuel the biomass boilers. If the biogas is not needed for combustion, it will be flared. The throughput will be 1,640 gallons per minute and the treated water will be reused at the facility or used to irrigate the surrounding farmland.

7. Secondary Energy Production

Two primary boilers will be used to produce steam for hydrolysis, bacteria and enzyme propagation, and final distillation and dehydration. The boilers will be based on fluidized bed technology and will be equipped to burn methane from the WWTP, stillage cake, and natural gas. A backup boiler will also be available that will have the ability to burn natural gas and methane from the WWTP. Natural gas will be burned for startups and flame stabilization. Each boiler will have a heat input capacity of 198MMBtu/hr.

B. Production Associated Storage and Equipment

1. Tanks

There will be numerous tanks onsite to store production, fermentation and propagation related liquids. Because enzyme propagation is proprietary, it is unknown what liquids will be used in the process and therefore these were not included in the table below.

Table 1 - Liquids stored at the site

Production Liquids	Fermentation Liquids
Sulfuric Acid, 98%	Corn Steep
	Lactose
	Glucose
	Anhydrous Ammonia
	Phosphoric Acid, 45%

2. Silos

The following dry materials will be stored on site in silos with fabric filters:

Table 2 - Dry materials stored at the site

Propagation Nutrients	Neutralization	Boilers
Solka Flok	Pebbled Lime	Ash
Soy Flour		Sand
Ammonium Sulfate		Limestone
Potassium Phosphate		Urea
Urea		

3. Emergency Backup

Four 2,000kW generators will be available to provide electricity in the event of a power outage. A backup 360hp diesel fire pump will also be available to provide water to extinguish fires during power outages. Each unit will use ultra low sulfur diesel or propane and will be limited to 500 hours per year of operation. They will be operated no more than 100 hours per year for testing and maintenance. Additionally, they will meet EPAs emissions standards for model year 2009 or later.

IV. Cash Flows Presentation

The purpose of the cash flow statement is to provide a framework to evaluate the economic feasibility of cellulosic ethanol produced from energy cane. The cash flow statements provide both a summary of input-output relationships as well as the relationship between revenue and costs. Some elements of the cash flows are generic, such as wages or the cost of land, but many others, such us the various credits and feedstock costs, are unique to this project.

The following section contains the values that were used to determine the economic value of the project, a description of the unique features of the cash flows and gives the reasoning behind the inclusion of the variables, associated assumptions, and demonstrates how the cash flow works. The base case cash flow to the project, company, bank, federal government, and economy are discussed first, followed by the data that supports the inputs and outputs. Tables for the first three years of each cash flow are provided in the following sections, and complete tables are provided in the Appendix.

A. Net Present Value

The net present value (NPV) is the sum of the present values of a series of cash flows over time. The NPV was used as the bases for determining the amount of benefit (in dollars) that could be expected.

The values in the table below indicate positive benefit to both the company and the government, and thus to the economy as a whole.

Table 3-Nominal Net Present Values

Cash Flow	NPV
Net Present Value to Vercipia	68,097,426
Net Present Value to Government	81,078,348
Net Present Value to Debt	-
Net Present Value to Economy	$149,175,774
Net Present Value of Project	$149,175,774

B. Cash Flow to the Project

Table 4-Nominal Cash Flow to Project, First Three Years of Project

Nominal Cash Flow to Project			
Calendar Year	2007	2008	2009
Project Year	0	1	2
Cash In			
Ethanol Cash Sales			82,465,473.11
Plant			
Equipment			
Land			
Total Cash In		-	82,465,473.11
Costs			
Plant	105,861,016.64		
Equipment	143,804,033.36		
Land	334,950.00		
Inputs			49,766,607.16
Labor			2,314,466.08
Total Cash Out	250,000,000.00	-	52,081,073.24
Cash Flow	$(250,000,000.00)	$ -	$30,384,399.87

Determining the cash flow to the entire project without regard to distribution, not only gives an initial first glimpse of the total cash flow, but also serves as a check for the consistency of any distributional analysis. The cash flow to the project accounts for ethanol sales, feedstock, enzyme, energy and labor costs. Also included are initial costs and liquidation values of the plant, equipment, and land. Not included in the cash flow to the project are flows in the economy between the entities: Vercipia, the government and the bank. Without these inter-institutional flows, we are left with the net flow of cash related to the project. The nominal NPV to the project is $149, 175, 774, identical to that of the NPV to the economy which indicates consistency for the distributional analysis that is undertaken as part of the cash flow to the economy.

C. Cash Flow to the Economy

Table 5-Nominal NPV to the Economy, First Three Years of Project

Nominal Cash Flow to Economy			
Calendar Year	2007	2008	2009
Project Year	0	1	2
Cash Flow to Company	(200,000,000.00)	(4,075,000.00)	26,309,399.87
Cash Flow To Government	-	-	-
Cash Flow to Debt	(50,000,000.00)	4,075,000.00	4,075,000.00
Cash Flow to Economy	(250,000,000.00)	-	30,384,399.87

The sum of the cash flow to the company, debt, and the government is the cash flow to the economy, which is equal to the cash flow to the project. The cash flow to the economy shows the distribution of the cash flows between the three.

D. Cash Flow to the Company, Vercipia

The cash flows to Vercipia include the direct sales of ethanol and possibly co-products, government subsidies, and proceeds if the land or equipment is sold. As for the cash out to the company, the value of the investments, including plant construction, equipment, and land, will be unique to the location and the nature of the business. The operating costs are unique to the business model of Vercipia.

Table 6-Nominal Cash Flows to Vercipia, First Three Years of Project

Nominal Cash Flows to Vercipia			
Calendar Year	2007	2008	2009
Project Year	-	1	2
Ethanol Sales	-	-	82,465,473
Loan Proceeds	50,000,000		
Liquidation Values:			
Land			
Plant			
Equipment			
Total Cash In	50,000,000	-	82,465,473
Investments:			
Plant Construction	105,861,017		
Equipment	143,804,033		
Land (Purchased)	334,950		
Operating Costs:			
Feedstock Costs			27,142,352

Enzyme Costs	-	-	19,480,034
Electricity			3,144,221
Labor			2,314,466
Interest Payments	-	4,075,000	4,075,000
Loan Repayment			
Taxes:			
State Corporate Income Tax	-	-	-
Federal Corporate Income Tax	-	-	-
Total Cash Out	250,000,000	4,075,000	56,156,073
Total Cash Flow to Vercipia	(200,000,000)	(4,075,000)	26,309,400

There are additional costs that would be realized for an operational plant, like the costs for chemicals for wastewater treatment and solids disposal. In the 2002 NREL document, these additional costs represent less than 5% of the total variable production costs. Given the difficult nature of assessing these costs and their expected negligible impact to the cash flow calculations, they were omitted from this analysis.

E. Cash Flow to Debt

The cash flow to the debt (also called the cash flow to the bank) is simply the loan proceeds, interest payments, and principal repayment at the end of the term. As mentioned previously, the payments were interest only, and the base case loan amount was based on a debt to asset ratio of 20%. The nominal cash flow to debt each year was $4,075,000 and full principal of $50,000,000 was repaid at the end of the project.

F. Cash Flow to Government

Table 7-Nominal Cash Flow to State and Federal Government

Nominal Cash Flow to Government/ Corporate Tax Computation			
State			
Calendar Year	2007	2008	2009
Project Year	0	1	2
Gross Income			
Sales	-	-	82,465,473
Less Tax Deductible Costs			
Operating Costs	-	-	51,905,227
Plant Tax Depreciation	-	-	160,509,661
Total Deductible Costs	-	4,075,000	216,489,888
Taxable Income Before Loss Carry Forward	-	(4,075,000)	(134,024,415)

Loss Carry Forward	-	-	(4,075,000)
Taxable Income	-	(4,075,000)	(138,099,415)
Add back of special 50% bonus depreciation, only in first year in service			(13,266,890)
Corporate Income Tax Before Credits	-	-	-
Florida Corporate Tax Credits Created Last Year	-	-	6,500,000
Tax Credits Since 2007	-	-	6,500,000
Tax credit Carry Forward until 2012	-	-	-
Total Tax Credits (incl. carry forwards)	-	-	6,500,000
Cash Flow to Government = State Corporate Income Tax	-	-	-
Federal			
Gross Income			
Sales	-	-	82,465,473
Less Tax Deductible Costs			
Operating Costs	-	-	51,905,227
Plant Tax Depreciation	-	-	160,509,661
Interest Paid	-	4,075,000	4,075,000
Property Tax (Fee-in-Lieu)			
State Income Taxes Paid	-	-	-
Total Deductible Costs	-	4,075,000	216,489,888
Taxable Income Before Loss Carry Forward	-	(4,075,000)	(134,024,415)
Loss Carry Forward	-	-	(4,075,000)
Taxable Income	-	(4,075,000)	(138,099,415)
Corporate Income Tax Before Credits	-	-	-
Small Ethanol Producer/Cellulosic Biofuel/Alcohol Fuel Tax Credits Created Last Year	-	-	37,860,000
Tax Credits Since 2008	-	-	37,860,000
Tax credit Carry Forward until 2012	-	-	-
Total Tax Credits (incl. carry forwards)	-	-	37,860,000
Cash Flow to Federal Government	-	-	-
Total Cash Flow to Governments	-	-	-

Approximate cash flows to the state and federal governments were calculated. For both tax calculations, many of the items were identical. The gross income was based on sales, which were identical to the cash inflow for the company. The deductible costs were the operating costs, plant depreciation, and interest paid on the loan. Losses from the previous year, if applicable, were carried forward to the current tax year. Vercipia would be eligible for state and federal tax credits that allow unused credits to be carried forward for a defined period of time. The final amount of taxable income, less the loss carry forward is then multiplied by the applicable corporate income tax rate. For Florida, the current corporate tax rate of 5.5% was used and 35% was used for the federal rate for each year to simplify the calculations, although the tax rate would be higher or lower for some of the years based on the current tax structure. The tax credits and other programs are discussed in the data and calculations section as well as Table 9.

1. State

Corporate Tax Credit

The State of Florida has instituted numerous programs to promote the in-state production of ethanol. A corporate tax credit is allowed for the lesser of up to 6.5 million dollars or 75% of all capital, operation and maintenance, and research and development costs. The unused amounts may be carried forward until 2012. Additionally, this legislation also created a sales tax refund for products relating to hydrogen-powered vehicles, commercial stationary hydrogen fuel cells, and materials used in distributing biodiesel and ethanol. (State of Florida, 2006)

In Florida, production and sales of renewable electricity, including that from biomass, is eligible for a corporate income tax credit of $0.01 per kilowatt hour energy. (State of Florida, 2007) However, at this time, Vercipia will be producing process steam and will not be producing or selling electricity, therefore this will not be considered in this analysis.

Depreciation in Florida

Florida has their depreciation system pegged to the federal system, so the calculations are identical to what is explained below in the federal section, with the exception of the 50% special bonus depreciation. In Florida, for 2008 and 2009 (and 2010 through 2013 expected to be the same), corporations who take the 50% bonus depreciation must add it back to the adjusted federal income calculations for Florida. (FL DOR, 2009)

2. Federal

Cellulosic Biofuel Producer Tax Credit

Cellulosic ethanol producers registered with the Internal Revenue Service are eligible for a production tax credit of up to $1.01 per gallon if the ethanol is used for commercial purposes regardless of whether blended or resold. If the ethanol qualifies for alcohol fuel tax credits, the credit amount is reduced to $0.46 per gallon and a $0.45 per gallon credit is allowed for being an alcoholic fuel. Current legislation only extends the credit to ethanol produced between January 1, 2008 and December 31, 2012. (RFA, 2008) Completing IRS form 6478 with assumption of 36 million gallons of 190 proof cellulosic ethanol gives a total tax credit of $37.86 million (IRS, 2008). An example of the completed IRS form is found in the Appendix.

Depreciation using the Modified Accelerated Cost-Recovery System

The Modified Accelerated Cost-Recovery System (MACRS) allows a number of renewable energy technology businesses to recover investments through depreciation deductions. MACRS establishes a set of class lives over which the property may be depreciated. For biomass projects such as cellulosic ethanol, the class life is seven years and the project is depreciated over eight years. Until 2013, the first year of service is eligible for a 50% depreciation allowance in addition to other depreciation as calculated under MACRS. (IRS, 2009) Because the plant is considered to be put in service in 2009, the bonus depreciation was taken for that year. The declining balance depreciation calculations are presented in the table below.

Table 8 – MACRS Rates

Year	Depreciation Rate	Depreciation (including first year 50% bonus)
1	14.29%	160,355,847
2	24.49%	21,813,232
3	17.49%	11,763,201
4	12.49%	6,931,141
5	8.93%	4,336,621
6	8.92%	3,944,938
7	8.93%	3,597,077
8	4.46%	1,636,095

Table 9 - Applicable Government Programs

Name	Financial Allowances	When	Applicable technologies	Additional Provisions/Restrictions
MACRS	Allows depreciation over 7 years	Since 1986	Numerous	
MACRS	Allows special allowance of 50% for first year in service	Must be placed in service between 12/20/06-1/1/13		
Cellulosic Biofuel Producer Tax Credit	Production Tax Credit of up to $0.91 per gallon of cellulosic biofuel	1/1/09-12/31/12	Cellulosic Biofuel Producers	
Small Ethanol Producer Tax Credit	Production tax credit of $0.10 per gallon of fuel	Expires 12/31/2010	Small ethanol producers (less than 60 million gallons capacity	Credit applicable for the first 15 million gallons each year
Florida Corporate Tax Credit	75% of all capital costs, operation and maintenance costs, and research and development costs, up to $6.5 million per year	7/1/2006-6/30/2010	(1) hydrogen-powered vehicles and hydrogen vehicle fueling stations; (2) commercial stationary hydrogen fuel cells; and (3) production, storage, and distribution of biodiesel and ethanol.	Unused amount may be carried forward and used in tax years beginning 1/1/2007 and ending 12/31/2012

Table 10 – Parameter Values

	Price($)/Unit	Annual Quantity		Rate of Growth
Feedstock Costs ($/ton)	31.6	800,000	tons	0.6%
Enzyme Costs ($/gallon)	0.5	36,000,000	units	1%
Electricity ($/kWh)	0.0776	36,000,000	kWh	3%
Ethanol Prices ($/gallon)	2.1	36,000,000	gallons	1.4%
Direct Labor ($/year)	2,138,620			1%
Inflation Rate	3%			
Federal Corporate Income Tax Rate	35%			
State Corporate Income Tax Rate	5.5%			
Discount Rate	5%			
Debt/Asset Ratio	20%			
Nominal Rate	8.15%			

	Initial	Liquidation Value
Plant Construction	105,861,017	0
Equipment	143,804,033	0
Land (Purchased)	334,950	24,740,797
Total Plant Cost	250,000,000	
Total Plant Cost without Land	249,665,050	
Loan Amount	50,000,000	
Payments, Interest Only	4,075,000	

G. Parameter Data

This section provides background about calculations and data sources for the parameters used in the cash flows that are presented in Table 10.

1. Revenues from Direct Sales

The Energy Information Administration lists the nominal wholesale price of ethanol in 2007 as $2.124 per gallon. This amount, multiplied by the total amount of ethanol produced constitutes sales revenue. The annual rate of growth was taken from the 2010 Annual Energy Outlook produced by the Energy Information Administration. They forecast a nominal increase of 1.4% from the period from 2008 through 2035. (EIA, 2010)

As noted in the previous section about the production process, it is denatured ethanol, ethanol that has been mixed with 5% gasoline that is sold from the plant. The calculation of the costs of adding the gasoline and the additional revenue for reselling it was omitted from this analysis as this was not expected to impact the cash flows. In addition, it allows easier direct comparison to similar analyses.

Byproducts

Relatively little is known about the value of the byproducts or coproducts of cellulosic ethanol production. In this particular system, some of the byproducts, in the form of stillage cake and biogas, will be used at the plant for production of energy to fire the boilers. An unknown amount of gypsum will be sent to the Lykes' Brothers farm, the same farm that is producing the feedstock. The USGS provided a value of $26.90 per ton of gypsum used in agricultural practices (USGS, 2007); however, a document produced by Foust, Aden, Dutta, and Phillips at the National Renewable Energy Laboratory state that "the gypsum waste stream…is very impure and must be disposed of as waste". Based on this and a general lack of information about marketable byproducts, the analysis did not assume a value or a disposal cost for gypsum or other, unknown, byproducts.

2. Liquidation Values

The liquidation values of the land are not assumed to be influenced by the use of the land for cellulosic ethanol production in this cash flow. The median of the annual increase in sales value per acre for agricultural pasture land in Highlands County Florida from 2000 through 2009 was approximately 36%. The values are included with the land sales data in the Appendix.

The plant and equipment liquidation values are unique in that they may have limited resale value because of the limited number of cellulosic ethanol facilities, although the equipment is similar or identical to that used by conventional ethanol producers as well as alcoholic beverage producers. The plant site itself (offices, concrete pads, roadways) is assumed to add little value to the land, due to location and the unique nature of the business. Therefore, a value was not included for liquidation of the plant. Liquidation values for ethanol equipment are difficult to predict, and equipment that has been used extensively may have very limited value at the end of the life cycle. Similar studies, such as those undertaken at NREL and Cornell do not assume a liquidation value for the equipment, (2002; 2009). This analysis assumes that any scrap revenue would be offset by equipment that would have to be disposed at a cost for no net gain at the end of the life.

3. Plant Construction, Equipment and Land

Estimated initial total project investment costs, including equipment and land, range from $250 to $300 million (Verenium Corporation, 2009). Land costs were estimated using data from Highlands County, Florida (Andres), which is included in the Appendix. Sales of agricultural pasture land from 2000 to 2009 were deflated to 2007 dollars and the approximate weighted average price for land is $3,500. This was multiplied by the total land purchased for the facility. To arrive at the percentage of the total cost that is installed equipment, numbers from the 2002 Aden et al. paper were used. In that paper, the total project investment was $197.4 million and of that $113.7 million was installed equipment cost. Multiplying the total investment amount by Vercipia, less the cost for land, by the percent of installed equipment cost to total project investment in the paper yields an estimated installed equipment cost for the project and a cost for the remainder of the plant construction.

4. Feedstock

Price

The specific model of Vercipia leases land from energy cane growers so that the company owns the crops and harvests on their schedule. They pay the farmers to lease the land, and to grow and harvest the crop on the company's schedule. To reduce assumptions, the estimated market value of the total amount of annual feedstock was used. Prices per short, wet ton of sugarcane sold for use as sugar in Florida were obtained from the USDA and deflated to 2007 dollars. The 2007 price was $31.60/short wet ton and the average growth rate for prices from 1981 through 2008 was 0.6%. Prices from 1972 through 1980 were volatile and the rates of growth ranged from -58% to 92%; these years were omitted to reduce the variability of the rates. The feedstock data is available in the Appendix.

Quantity

Vercipia estimates they can obtain 1,800 gallons of cellulosic ethanol per acre of energy cane; using yield estimates of 45 wet tons per acre, this would be approximately 900,000 tons per year to produce 36 million gallons (Verenium Corporation, 2009; Richard E. , 2009).

5. Enzymes

The enzyme costs will likely vary by company, and will be a large driver of the costs for the company. Different enzymes have distinct abilities: some work faster and decrease the amount of energy used to process the feedstock, but some may work slower but have increased yields of ethanol. Cost estimates vary widely; Novozymes, a leading enzyme company predicts prices between $0.50 to $1.50 per gallon of ethanol produced by 2010 (Novozymes, 2009). This price predicted by Novozymes is higher relative to the prices posited by NREL in two reports published in 2009 (Tao & Aden; Foust, Aden, Dutta, & Philips). Tao and Aden cite enzyme prices of

$0.30/gallon at the commercial scale for enzymes produced onsite as being "(r)ealistically…achievable in the near future by avoidance of transportation and formulation costs" based on a report by Merino and Cherry in 2007. Based on these numbers, a price of per $0.50 per gallon was chosen.

6. Energy costs

How a company plans to provide energy to the processes is also pertinent: the costs of natural gas and electricity vary. At most plants like this energy can also be produced onsite from biomass or other byproducts to power all or part of production. Vercipia plans to use biomass boilers to provide process heat. Natural gas may be used for boiler start-ups, although no estimates of needed amounts can be found. The amount is considered to be negligible as it was not provided in the air quality permit application. Based on this, the quantity and price of natural gas consumed at the facility was not included in the cash flow.

Electricity from the grid was chosen for calculating energy costs for this project for simplicity; however, the model could be changed to reflect the cost of natural gas or using onsite energy production if so desired. Data for real industrial prices of electricity in Florida from 1990 through 2007 were obtained (EIA, 2009). The 2007 price for electricity was $0.0776/kWh and the average annual growth rate was 3%. These are the values used in the cash flow analyses. This data is included in the Appendix.

Estimates of electricity consumption came from industry reporting for conventional ethanol as no estimates could be found for cellulosic ethanol (Wu, 2008). The mean reported amounts of electricity per gallon in kWh were 0.7 and 1.96 for wet and dry milling operations, respectively, with standard deviations of ±0.35 and ±0.67 (Wu, 2008). Based on these estimates and the fact that the Vercipia process is closer to wet rather than dry milling, a conservative estimate of 1 kWh per gallon of cellulosic ethanol produced was used in the cashflow.

Water input will vary with company and process technology, as well as location. At the Highlands County Vercipia plant, will be drawn from a private well on site. Water costs are included with electricity usage in this cashflow.

7. Labor

Vercipia estimates approximately 65 laborers will be employed full time at the plant once operational (Verenium, 2009). Using the number of workers and the most recent data for production workers in Nonmetropolitan South Florida from the Bureau of Labor Statistics, a lump sum estimate of average wages was calculated. The table of wages is available in the Appendix.

8. Debt

Debt/Asset Ratio

A debt-to-asset ratio of 20% was used. This number is a reasonable estimate based on the amount of debt actually reported by Verenium in their 10-K statement to the government in 2008, as well as financial documents for ethanol companies from the State of Minnesota and another ethanol company, Pacific Ethanol (Verenium Corporation, 2009; State of Minnesota, 2008; and Pacific Ethanols, Inc., 2009).

Interest Rate

According to "A Guide for Evaluating the Requirements of Ethanol Plants", developed by the Clean Fuels Development Coalition and Nebraska Ethanol Board in cooperation with the USDA, the interest rate for ethanol cooperatives is typically 2 to 2.5 above prime. The interest rate on the loan was assumed equal to the discount rate. The payments were interest only with the initial loan amount due in a lump sum payment at the end of the time period.

9. Taxes

The discussion of the calculation of the tax payments can be found in the previous section about the cash flow to the government.

H. Sensitivity Analysis

In order to determine the sensitivity of the net present value to changes in the parameters, a basic sensitivity analysis was conducted. Sensitivity analysis sheds light on the relationships between the inputs and outputs. In this case, the impact on the net present value of the project from changes in costs of the plant, enzymes, feedstock and ethanol selling prices was assessed. These variables were chosen for analysis because they are the largest inputs to the net present value. The analysis consisted of changing each of the base assumptions by the same percentage and then assessing the corresponding percentage change in the net present value of the economy. Results are in the table below.

Table 11 - Sensitivity Analysis Results

	-20%	-10%	Base Case	10%	20%
Plant Costs	0.34	0.17	0	-0.17	-0.34
Enzyme	0.31	0.15	0	-0.15	-0.31
Feedstock	0.41	0.21	0	-0.21	-0.41
Ethanol	-1.34	-0.67	0	0.67	1.34

The values of the parameters on the left of the table, such as plant costs, were changed by each of the percentages in the first row. The number in the table is the corresponding percent change in the value of the net present value to the economy. For example, a 20% decrease in the upfront plant costs to $200 million would mean an increase in the net present value of 34%. A decrease in any of the three costs to the company analyzed corresponds to a increase in the net present value, and a decrease in the value of the final product, ethanol, results in a decrease in the net present value.

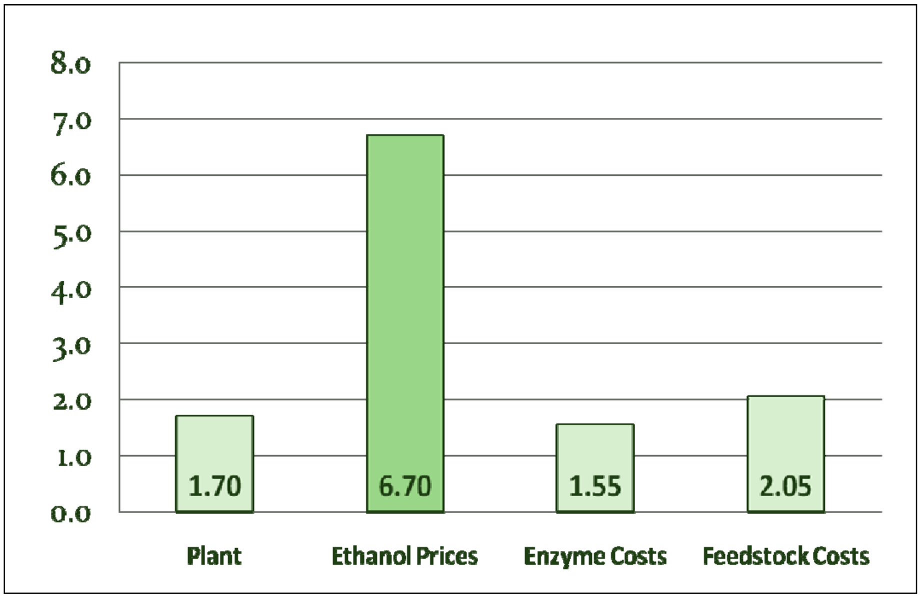
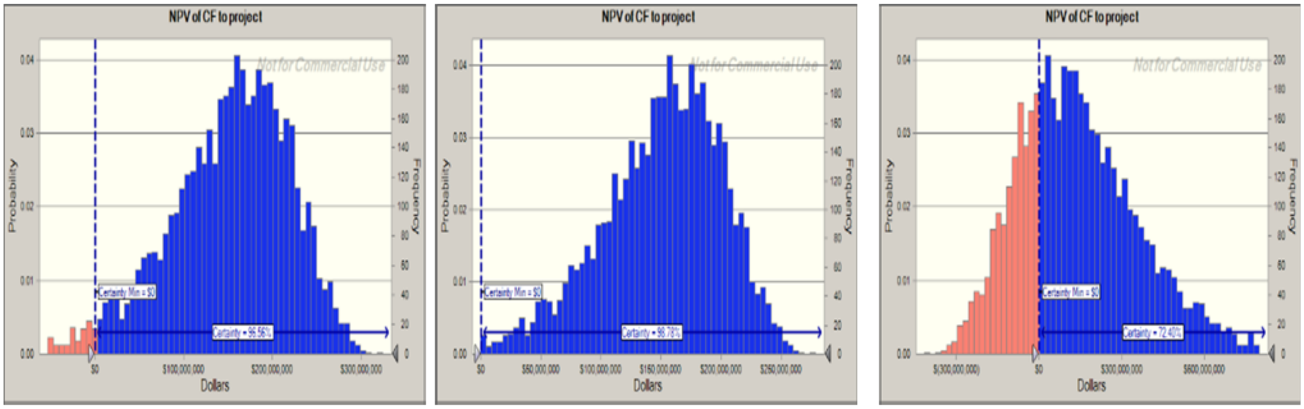


Figure 4-Absolute elasticities of selected parameters to NPV

The chart above is a graphical representation of the absolute elasticity of the net present value to the selected parameters. The elasticity is the ratio of the percent change in the input to the percent change in the net present value. The absolute elasticity was used in the graph to make comparison easier; the actual elasticities of the plant, enzyme and feedstock costs compared to net present value are negative—an increase in these costs would correspond to a decrease in the net present value, as stated previously. The relationship is greatest for ethanol prices, indicating the net present value is most sensitive to changes in the price of ethanol. This is interesting in light of the fact that many studies such as Aden et al. cite the high costs of enzymes to be the most important element with respect to costs.; however, this difference may be explained by the recent, dramatic, decreases in enzyme production that postdate these studies and because this is an analysis of net present value, and not just costs.

I. Monte Carlo Simulation

Due to inherent uncertainty, Monte Carlo analysis was used to determine how robust the net present value is to continuous changes in the parameters. To determine the robustness of the assumed parameter values, a Monte Carlo simulation was performed using Crystal Ball software. The feedstock and enzyme costs as well as ethanol prices were assigned continuous lognormal distributions with standard deviations equal to the assumed value for each year of the project. Each parameter was evaluated individually, for example, the feedstock cost distributions were assigned for each year of the project and one thousand random numbers from the distribution were assigned to determine the expected net present value. This means the analysis was run three times for one thousand trials each time. The results of the trials are presented graphically in Figure 5.



Feedstock Costs **Enzyme Costs** **Ethanol Price**

Figure 5-Monte Carlo Analysis Expected Values

The probability of profits greater than $0 is quite high for feedstock and enzyme costs, the standard deviation from the mean is relatively low, and the coefficient of variability is also relatively low, all demonstrating robust assumptions. Given the assumptions, the risk premium seems to be with the ethanol price. The following table shows the figures associated with the three runs of the model.

Table 12-Monte Carlo Analysis Results

	Mean NPV	Std. Dev. of NPV	Probability of NPV>0	Coeff. Var. of Probability
Feedstock Cost	$149,007,123	$72,246,046	96%	0.48
Enzyme Cost	$149,067,634	$53,278,484	99%	0.36
Ethanol Price	$149,549,775	$231,191,224	72%	1.55

J. What-If Analysis

Finally, a what-if analysis was run using Microsoft Excel. A simple goal seek scenario of zero NPV through manipulation of the initial enzyme and feedstock costs and ethanol price was setup. Holding all other parameters the same and changing only the selected initial parameter, the breakeven cost for enzymes was $0.83 per gallon and breakeven feedstock costs were $46.8 per wet ton. Using the same method, the initial ethanol breakeven price was $1.78 per gallon.

V. Emissions

After analyzing the economic impacts of ethanol, the focus of the paper now turns to the environmental impacts. There is an imperative need to understand how cellulosic ethanol production and use will affect air quality (EPA, 2009). The goal of this section is to highlight the possible reductions in GHGs in the U.S. through the use of ethanol versus regular gasoline, and to examine air toxics that may become more prevalent as a result of cellulosic ethanol use.

The EPA estimates that GHG emissions for the life cycle of cellulosic ethanol relative to gasoline can be reduced by over 90% (EPA, 2007). Because there are numerous routes for producing ethanol, different feedstocks, and different models for estimating inputs and emissions, life cycle analyses produces different estimates of total GHG and other emissions. Life cycle analysis allows assessesment of the environmental impact of a product throughout the entire life cycle of the project or part of the life cycle by considering the inputs such as energy and water, and the outputs such as air emissions and energy.

The papers reviewed below highlight the aformentioned advantages, as well as some others that are more relevant when conducting life cycle analyses. No published papers were found that examine the emissions related to cellulosic ethanol production from sugarcane or energycane. Among the advantages over conventional gasoline, feedstock production can remove CO_2 from the atmosphere. Over the life cycle of ethanol, the production of the plant-based feedstocks allows for the removal of CO_2 through plant uptake of CO_2 from the atmosphere, albeit at different rates for different feedstocks. In some instances where the land use is changed to accommodate the feedstock crop, CO_2 reduction through plant-based sources may actually decrease. If electricity from the grid is used to produce the ethanol, the electricity's production method and the amount used in ethanol production affects the amount of emissions over the life cycle of the fuel. Finally, the energy intensity of production of the crop, including factors such as the number of times the field is tilled pre- and post-production, the fertilizer application rate, and the transportation of feedstock and fuel can all affect the amount of emissions.

A. GHG Emissions

In the brief paper by Farrel et al, they reviewed six studies of fuel ethanol. In order to directly compare the data in a meaningful way a model was developed: the Energy and Resources Group (ERG) Biofuel Analysis Meta-Model (EBAMM). Data sources and methods for each study were compared and parameterized, and net energy, GHG emissions and primary energy inputs were calculated. In doing so, they calculate that net energy from cellulosic ethanol is approximately 23 times that of conventional gasoline while GHG emissions are approximately nine times smaller. The estimates are based on only one dataset, and that itself is an estimate. This, obviously, limits the robustness of the data. However, the other estimates produced for conventional ethanol are in line with other estimates of energy input and GHG emissions which demonstrates the estimates for cellulosic ethanol can be considered at least somewhat reliable based on the reliability of the other estimates.

Another study by Schmerr et al focused specifically on switchgrass grown on a collective 67 hectares on ten different existing farms over a five year period in the northern Great Plains of the U.S. The goal of the study was to accurately determine agriculture energy inputs to produce realiable life cycle estimates of total energy input and GHG emissions. This study also used EBAMM. The five years of real farm data provides a more reliable estimate than previous studies; the cellulosic ethanol yields, however, are again estimated. In addition, the estimated amount of GHGs displaced by cellulosic ethanol from switchgrass also includes the amount of carbon sequestered by conversion of croplands to grasslands over a 100-year time period. Predictions of sequestered carbon remain controversial because of the variety of estimation methods. This is a limit to the robustness of the data. Despite this limitation, the estimated amounts of GHG reduction estimates are similar to the EPA and Farrel et al: approximately 110% at a maximum and 60% at a minimum.

A particularly well-suited study to answer the question of air quality impacts from cellulosic ethanol production is that completed by Hill et al in 2008. The study compared conventional gasoline, corn-based conventional ethanol and cellulosic ethanol from various feedstocks. Life cycle costs of GHG emissions and fine particulate matter of less than 2.5 micrometers in diameter ($PM_{2.5}$) were monetized and compared for gasoline and ethanol; because of the uncertainty surrounding the costs of climate change and health impacts, the costs are not included here but the relative ranking is as that is unaffected by the uncertaintly of the costs (that is, the ranking depends on the amount of GHGs and $PM_{2.5}$ produced regardless of cost). Again in this study estimates were based on near-term predictions for yields because cellulosic ethanol is not being produced at commercial-scale at this time. They assumed all production occurs in the U.S. and that if additional cropland is brought into production, it comes from the Cropland Reserve Programs perennial grasslands or existing croplands (for corn stover). As in the 90% reduction estimate cited for EPA in the preceding pages, this group also used the Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model. Because $PM_{2.5}$ is a relatively localized air pollutant when compared to GHGs, this data was analyzed further with EPA's Envrionmental Benefits Mapping and Analysis Program to estimate the human health impacts of the $PM_{2.5}$ and associated health costs. This allowed the analysis to account for the differences in surrounding population density for ethanol production facilities and conventional gasoline refineries. The study determined that cellulosic ethanol had significantly lower GHG emissions than either gasoline or conventional ethanol, especially when the feedstock was a relatively high biomass crop like *miscanthus* or required low nitrogen fertilizer inputs, like diverse prairie grasses. They found that corn ethanol, regardless of the source of process heat (coal, natural gas, or corn stover) produces more $PM_{2.5}$ compared to gasoline, although cellulosic ethanol typically produces less, as demonstrated in Figure 2. Interestingly, the production and use of cellulosic ethanol improves $PM_{2.5}$ pollution on the West Coast due to the expected decrease in SO_x emissions from the decreased production and use of fertilizer and the decrease in refining gasoline, as well as the electricity produced by cellulosic biorefineries that would displace some coal-based electricity production. While this study provides us with important relative

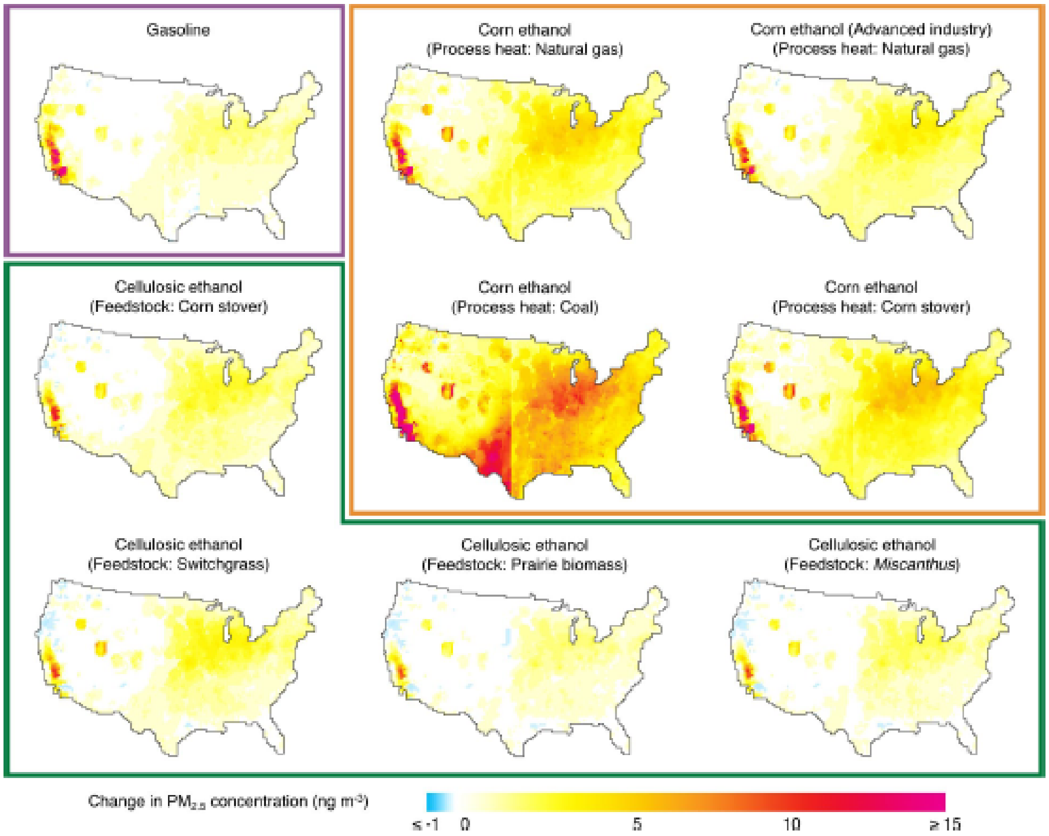


Figure 6 – Change in Average Annual Atmospheric $PM_{2.5}$ Concentration from Producing and Combusting Additional Billion Gallons of Ethanol or an Energy-Equivalent Volume of Gasoline. Image Source: Hill, et al., 2008

estimates of the decrease of GHG emissions and $PM_{2.5}$, it does not provide additional insight into hazardous air pollutants or air toxics.

It should be reiterated that this review does not intend to take into account carbon sequestration by using lands for growing cellulosic ethanol feedstocks—as stated before, this is a difficult and variable calculation. The preceding and following literature reviews do not attempt this calculation, unless noted. Indeed, one paper reviewed but not included in this paper finds that if American corn fields were converted to switchgrass, the land use change would trigger GHG emissions that would increase emissions over 30 years by 50% (Searchinger, et al., 2008). The paper does not elucidate or document how this figure was arrived at nor does it provide figures for croplands that are not in active production. This paper aims to stay away from this issue as it is so contentious.

B. Air Toxic Emissions

Thus far, the conclusion of the majority of papers reviewed for life cycle analysis estimates is that cellulosic ethanol production provides a net decrease in GHG emissions and PM2.5, although the exact reduction is unknown due to the fact that there are no commercial cellulosic ethanol facilities in operation today. Despite the assumption that overall air quality will increase over the production life cycle as compared to conventional gasoline, actual estimates of emissions produced by burning ethanol or ethanol blends in combustion engines does not seem to be very well documented. In fact, only two appropriate studies were found when searching: a 2001 study by Winebrake, Wang and He and a 1997 study by Gaffney et al. The final study that will e discussed is by Jacobson. It was published in 2007 and assesses the potential mortality associated with increased E85 usage.

Winebrake, Wang and He conducted upstream and downstream and urban/rural life cycle analyses of four known carcinogenic air toxics—primary acetaldehyde, benzene, 1,3-butadiene, and formaldehyde. They highlight the importance of studying these toxics as alternative fuels become more prevalent—as of 1996, the EPA estimates on-highway vehicles account for 29% of total acetaldehyde emissions, 48% of benzene emissions, 42% of butadiene emissions, and 24% of formaldehyde emissions. Their study used the GREET model to compare these toxic emissions from vehicles using different fuel sources, including ethanol, reformulated gasoline and electricity. Data sources for upstream emissions include: (1) the Factor Information Retrieval (FIRE) database (2) *Compilation of Air Pollutant Emission Factors* (commonly called the AP-42 document) and (3) locating and estimating emissions documents for each pollutant. Downstream emission data sources relied on existing studies. Compared to conventional gasoline, all fuel sources were found to reduce levels of 1,3-butadiene; however, the use of E85 or reformulated gasoline leads to increase primary acetaldehyde emissions and may result in increased formaldehyde emissions. These increases are offset by lower benzene and butadiene emissions. As the authors point out in their conclusions, the quality of the datasets is an issue for both up and downstream emission sources. The datasets were pre-2001, and as cellulosic ethanol is still developing, the state of the technology at that time was quite different. In addition, only four known air toxics were assessed which leaves numerous air toxics to be assessed, including mercury and lead.

The study in Albuquerque focused on atmospheric non-criteria pollutant concentrations of peroxyacetyl nitrate (PAN) and aldehydes, although measurements were also taken for ozone, oxides of nitrogen, carbon monoxide, and organic acids. The study was in response to an EPA mandate to use oxygenated fuels in the winter in the Albuquerque area, beginning in 1994. The data baseline was the summer of 1993, which does not allow for direct comparison because of the difference in seasons, but does provide a close approximation. The combustion of ethanol results in increased amounts of primary acetaldehyde, which reacts with OH in urban atmospheres to form peroxyacetyl radicals that react with NO_2 to form PAN. PAN is a potential mutagen and eye irritant as well as a plant toxin more potent than ozone, according to Gaffney, Marley, and Prestbo in *The Handbook of Environmental Chemistry.* Elevated levels of acetaldehyde occurred with more frequency in the winter months than summer, and more of the elevated concentrations occurred during peak traffic hours in the winter. The results show increased concentrations of other anthropogenic pollutants such as PAN in the winter; however, the data is not consistent for both winters as some concentrations were higher in the summer of 1993. The winter of 1994 was milder, and the wind came from a different direction for most of the winter of 1995. These meteorological differences, and a significant decrease in the number of analyses from 1993 to 1995 (sometimes a decrease of two to three times the number taken in

1995 compared to 1993), point to a need for additional assessment. Despite this weakness of the data, the preliminary evidence of an increase in PAN and aldehydes warrant additional study to determine the potential effects.

Jacobson used the global-through-urban GATOR-GCOMM model to study effects on cancer, mortality, and hospitalization from converting from gasoline to E85 in the U.S. and in Los Angeles (L.A.) in particular. The model determined that increased use of E85 could result in a 9% increase in L.A. ozone-related mortality, hospitalization, and asthma and 4% increase in the U.S., after accounting for increased emissions reduction technology. This increase was found to be partially offset by decreases in the southeast. PAN was also expected to increase, but not to change the cancer risk. They conclude that E85 is unlikely to improve overall emissions, an obvious contradiction with all other sources. The modelers used projected vehicle technology from 2020, when they predicted the majority of vehicles would be able to use E85 fuel. This study differs from the others because it does not account for upstream emissions which may offset increases in the downstream emissions. As a purely downstream assessment, however, the data seems robust although it only points with certainty to the possibility that increased ethanol use may provide no emissions decrease compared to conventional gasoline.

VI. Conclusions

A. Economic

The net present value analysis indicates a net benefit to the economy, as well as Vercipia and the government. The net present value is most sensitive to changes in the ethanol prices and the expected net present value is robust given the assumptions made in the analysis. Given these results, the Vercipia model seems to be economically beneficial to the governments and the economy.

B. Environmental

The scientific conclusions seem to be that overall this technology would be beneficial compared to conventional gasoline. Life cycle analyses of cellulosic ethanol using best estimates of current and future technology point to an overall decrease in GHG emissions. However, the three papers reviewed for toxics demonstrate a potential increase in air toxics relative to conventional gasoline usage. The lack of analysis of possible downstream effects of increased ethanol usage is lacking and warrants additional study, particularly because of the RFS2 aggressive mandates for increased ethanol production. Studies for cellulosic ethanol would be more accurate if they were localized, as early stage production will almost certainly need to have all the inputs and outputs in close proximity to be the most cost effective as the technology is developing.

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APPENDICES

Appendix A
Cash Flows

Nominal Cash Flow to Economy

Calendar Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Project Year	0	1	2	2	4	5	6	7	8	9
Cash Flow to Company	(200,000,000.00)	(4,075,000.00)	26,309,399.87	27,920,704.46	29,612,138.00	31,387,506.23	33,250,788.70	33,486,988.06	35,221,613.65	24,839,743.42
Cash Flow To Government	-	-	-	-	-	-	-	1,719,158.36	2,036,316.13	14,570,943.43
Cash Flow to Debt	(50,000,000.00)	4,075,000.00	4,075,000.00	4,075,000.00	4,075,000.00	4,075,000.00	4,075,000.00	4,075,000.00	4,075,000.00	4,075,000.00
Cash Flow to Economy	(250,000,000.00)	-	30,384,399.87	31,995,704.46	33,687,138.00	35,462,506.23	37,325,788.70	39,281,146.42	41,332,929.78	43,485,686.85

Real Cash Flow to Economy

Calendar Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Project Year	0	1	2	3	4	5	6	7	8	9
Inflation Factor	1.00	1.03	1.06	1.09	1.13	1.16	1.19	1.23	1.27	1.30
Cash Flow to Company	(200,000,000.00)	(3,956,310.68)	24,799,132.69	25,551,399.81	26,310,001.08	27,075,138.59	27,847,012.06	27,227,985.73	27,804,267.06	19,037,594.99
Cash Flow To Government	-	-	-	-	-	-	-	1,397,833.07	1,607,486.76	11,167,414.85
Cash Flow to Debt	(50,000,000.00)	3,956,310.68	3,841,078.33	3,729,202.26	3,620,584.72	3,515,130.80	3,412,748.35	3,313,347.91	3,216,842.63	3,123,148.18
Cash Flow to Economy	(250,000,000.00)	-	28,640,211.02	29,280,602.07	29,930,585.80	30,590,269.39	31,259,760.40	31,939,166.71	32,628,596.45	33,328,158.02

Nominal NPV		Real NPV	
Net Present Value to Vercipia	68,097,426	Net Present Value to Vercipia	68,097,426
Net Present Value to Government	81,078,348	Net Present Value to Government	81,078,348
Net Present Value to Debt	-	Net Present Value to Debt	-
Net Present Value to Economy	149,175,774	Net Present Value to Economy	149,175,774

Nominal Cash Flow to Economy

Calendar Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Project Year	10	11	12	13	14	15	16	17	18	19	20
Cash Flow to Company	25,595,288.89	27,050,559.44	28,577,016.63	30,177,994.96	31,856,979.16	33,617,610.58	35,463,694.01	37,399,204.65	39,428,295.43	41,555,304.61	38,469,395.06
Cash Flow To Government	16,073,883.09	16,987,795.37	17,946,412.96	18,951,829.97	20,006,234.78	21,111,914.18	22,271,257.58	23,486,761.41	24,761,033.72	26,096,798.95	27,496,902.88
Cash Flow to Debt	4,075,000.00	4,075,000.00	4,075,000.00	4,075,000.00	4,075,000.00	4,075,000.00	4,075,000.00	4,075,000.00	4,075,000.00	4,075,000.00	54,075,000.00
Cash Flow to Economy	45,744,171.98	48,113,354.81	50,598,429.59	53,204,824.93	55,938,213.93	58,804,524.76	61,809,951.59	64,960,966.06	68,264,329.15	71,727,103.56	120,041,297.94

Real Cash Flow to Economy

Calendar Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Project Year	10	11	12	13	14	15	16	17	18	19	20
Inflation Factor	1.34	1.38	1.43	1.47	1.51	1.56	1.60	1.65	1.70	1.75	1.81
Cash Flow to Company	19,045,298.71	19,541,899.69	20,043,344.50	20,549,746.11	21,061,216.16	21,577,865.00	22,099,801.65	22,627,133.88	23,159,968.12	23,698,409.56	21,299,571.32
Cash Flow To Government	11,960,478.60	12,272,344.82	12,587,252.98	12,905,274.01	13,226,478.04	13,550,934.35	13,878,711.42	14,209,876.91	14,544,497.69	14,882,639.78	15,224,368.44
Cash Flow to Debt	3,032,182.70	2,943,866.70	2,858,123.01	2,774,876.71	2,694,055.06	2,615,587.44	2,539,405.28	2,465,442.02	2,393,633.03	2,323,915.56	29,940,016.41
Cash Flow to Economy	34,037,960.01	34,758,111.21	35,488,720.48	36,229,896.83	36,981,749.26	37,744,386.78	38,517,918.35	39,302,452.80	40,098,098.83	40,904,964.90	66,463,956.17

Time Path of Real Prices

Calendar Year	2007	2008	2009	2010	2011	2012	2013	2014	2015
Project Year	0	1	2	3	4	5	6	7	8
Feedstock Costs ($/ton)	31.60	31.79	31.98	32.17	32.37	32.56	32.75	32.95	33.15
Enzyme Costs ($/gallon)	0.50	0.51	0.51	0.52	0.52	0.53	0.53	0.54	0.54
Electricity ($/kWh)	0.078	0.080	0.082	0.085	0.087	0.090	0.093	0.095	0.098
Direct Labor ($/year)	2,138,620.00	2,160,006.20	2,181,606.26	2,203,422.32	2,225,456.55	2,247,711.11	2,270,188.22	2,292,890.11	2,315,819.01
Ethanol Prices ($/gallon)	2.10	2.13	2.16	2.19	2.22	2.25	2.28	2.31	2.35
Land									

Time Path of Nominal Prices

Calendar Year	2007	2008	2009	2010	2011	2012	2013	2014	2015
Project Year	0	1	2	3	4	5	6	7	8
Inflation Factor	1.00	1.03	1.06	1.09	1.13	1.16	1.19	1.23	1.27
Feedstock Costs ($/ton)	31.60	32.74	33.93	35.16	36.43	37.75	39.11	40.53	41.99
Enzyme Costs ($/gallon)	0.50	0.52	0.54	0.56	0.59	0.61	0.63	0.66	0.69
Electricity ($/kWh)	0.078	0.082	0.087	0.093	0.098	0.104	0.111	0.117	0.125
Direct Labor ($/year)	2,138,620.00	2,224,806.39	2,314,466.08	2,407,739.07	2,504,770.95	2,605,713.22	2,710,723.46	2,819,965.62	2,933,610.23
Ethanol Prices ($/gallon)	2.10	2.19	2.29	2.39	2.50	2.61	2.73	2.85	2.97
Land									

Nominal Values

Calendar Year	2007	2008	2009	2010	2011	2012	2013	2014	2015
Project Year	0	1	2	3	4	5	6	7	8
Feedstock Costs ($/ton)			27,142,352.13	28,124,362.43	29,141,901.86	30,196,255.87	31,288,756.41	32,420,783.61	33,593,767.57
Enzyme Costs ($/gallon)			19,480,033.62	20,265,078.97	21,081,761.66	21,931,356.65	22,815,190.33	23,734,642.50	24,691,148.59
Electricity ($/kWh)			3,144,221.412	3,335,704.496	3,538,848.899	3,754,364.797	3,983,005.613	4,225,570.655	4,482,907.908
Direct Labor ($/year)			2,314,466.08	2,407,739.07	2,504,770.95	2,605,713.22	2,710,723.46	2,819,965.62	2,933,610.23

Time Path of Real Prices											
Calendar Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Project Year	10	11	12	13	14	15	16	17	18	19	20
Feedstock Costs ($/ton)	33.55	33.75	33.95	34.16	34.36	34.57	34.77	34.98	35.19	35.40	35.62
Enzyme Costs ($/gallon)	0.55	0.56	0.56	0.57	0.57	0.58	0.59	0.59	0.60	0.60	0.61
Electricity ($/kWh)	0.104	0.107	0.111	0.114	0.117	0.121	0.125	0.128	0.132	0.136	0.140
Direct Labor ($/year)	2,362,366.97	2,385,990.64	2,409,850.55	2,433,949.05	2,458,288.54	2,482,871.43	2,507,700.14	2,532,777.14	2,558,104.91	2,583,685.96	2,609,522.82
Ethanol Prices ($/gallon)	2.41	2.45	2.48	2.52	2.55	2.59	2.62	2.66	2.70	2.73	2.77
Land											24,740,796.97

Time Path of Nominal Prices											
Calendar Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Project Year	10	11	12	13	14	15	16	17	18	19	20
Inflation Factor	1.34	1.38	1.43	1.47	1.51	1.56	1.60	1.65	1.70	1.75	1.81
Feedstock Costs ($/ton)	45.09	46.72	48.41	50.16	51.97	53.85	55.80	57.82	59.91	62.08	64.33
Enzyme Costs ($/gallon)	0.74	0.77	0.80	0.84	0.87	0.90	0.94	0.98	1.02	1.06	1.10
Electricity ($/kWh)	0.140	0.149	0.158	0.167	0.178	0.188	0.200	0.212	0.225	0.239	0.253
Direct Labor ($/year)	3,174,823.66	3,302,769.06	3,435,870.65	3,574,336.24	3,718,381.99	3,868,232.78	4,024,122.56	4,186,294.70	4,355,002.38	4,530,508.98	4,713,088.49
Ethanol Prices ($/gallon)	3.24	3.39	3.54	3.69	3.86	4.03	4.21	4.40	4.59	4.80	5.01
Land											44,684,631.36

Nominal Values											
Calendar Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Project Year	10	11	12	13	14	15	16	17	18	19	20
Feedstock Costs ($/ton)	36,068,586.57	37,373,548.03	38,725,723.00	40,126,819.66	41,578,608.00	43,082,922.03	44,641,662.15	46,256,797.49	47,930,368.42	49,664,489.15	51,461,350.37
Enzyme Costs ($/gallon)	26,721,355.81	27,798,226.45	28,918,494.98	30,083,910.32	31,296,291.91	32,557,532.47	33,869,601.03	35,234,545.96	36,654,498.16	38,131,674.43	39,668,380.91
Electricity ($/kWh)	5,045,552.345	5,352,826.483	5,678,813.616	6,024,653.365	6,391,554.755	6,780,800.440	7,193,751.186	7,631,850.634	8,096,630.337	8,589,715.125	9,112,828.776
Direct Labor ($/year)	3,174,823.66	3,302,769.06	3,435,870.65	3,574,336.24	3,718,381.99	3,868,232.78	4,024,122.56	4,186,294.70	4,355,002.38	4,530,508.98	4,713,088.49

Operating Costs											
Calendar Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Project Year	0	1	2	3	4	5	6	7	8	9	10
Direct Labor Cost			2,138,620.00	2,407,739.07	2,504,770.95	2,605,713.22	2,710,723.46	2,819,965.62	2,933,610.23	3,051,834.73	3,174,823.66
Direct Input Expenses			49,766,607.16	51,725,145.90	53,762,512.42	55,881,977.32	58,086,952.35	60,380,996.76	62,767,824.06	65,251,308.95	67,835,494.73
Operating Costs			51,905,227.16	54,132,884.96	56,267,283.37	58,487,690.54	60,797,675.81	63,200,962.38	65,701,434.29	68,303,143.68	71,010,318.39

Operating Costs										
Calendar Year	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Project Year	11	12	13	14	15	16	17	18	19	20
Direct Labor Cost	3,302,769.06	3,435,870.65	3,574,336.24	3,718,381.99	3,868,232.78	4,024,122.56	4,186,294.70	4,355,002.38	4,530,508.98	4,713,088.49
Direct Input Expenses	70,524,600.97	73,323,031.60	76,235,383.35	79,266,454.66	82,421,254.95	85,705,014.37	89,123,194.08	92,681,496.92	96,385,878.71	100,242,560.06
Operating Costs	73,827,370.03	76,758,902.25	79,809,719.59	82,984,836.65	86,289,487.73	89,729,136.94	93,309,488.78	97,036,499.30	100,916,387.69	104,955,648.55

Nominal Cash Flow to Government/ Corporate Tax Computation										
State										
Calendar Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Project Year	0	1	2	3	4	5	6	7	8	9
Gross Income										
Sales	-	-	82,465,473	86,128,589	89,954,421	93,950,197	98,123,465	102,482,109	107,034,364	111,788,831
Less Tax Deductible Costs										
Operating Costs	-	-	51,905,227	54,132,885	56,267,283	58,487,691	60,797,676	63,200,962	65,701,434	68,303,144
Plant Tax Depreciation	-		160,509,661	21,834,155	11,774,484	6,937,789	4,340,780	3,948,722	3,600,528	1,637,664
Interest Paid	-	4,075,000	4,075,000	4,075,000	4,075,000	4,075,000	4,075,000	4,075,000	4,075,000	4,075,000
Total Deductible Costs	-	4,075,000	216,489,888	80,042,040	72,116,767	69,500,480	69,213,456	71,224,684	73,376,962	74,015,808
Taxable Income Before Loss Carry Forward	-	(4,075,000)	(134,024,415)	6,086,550	17,837,654	24,449,717	28,910,008	31,257,425	33,657,402	37,773,022
Loss Carry Forward	-	-	(4,075,000)	(13,266,890)	(7,180,340)	-	-	-	-	-
Taxable Income	-	(4,075,000)	(138,099,415)	(7,180,340)	10,657,314	24,449,717	28,910,008	31,257,425	33,657,402	37,773,022
Add back of special 50% bonus depreciation, only in first year in service			(13,266,890)							
Corporate Income Tax Before Credits	-	-	-	-	586,152	1,344,734	1,590,050	1,719,158	1,851,157	2,077,516
Florida Corporate Tax Credits Created Last Year	-	-	6,500,000	6,500,000	6,500,000	6,500,000	6,500,000	-	-	-
Tax Credits Since 2007	-	-	6,500,000	13,000,000	19,500,000	26,000,000	32,500,000	-	-	-
Tax credit Carry Forward until 2012	-	-	-	6,500,000	19,500,000	17,569,113	22,479,063	-	-	-
Total Tax Credits (incl. carry forwards)	-	-	6,500,000	13,000,000	18,913,848	24,069,113	28,979,063		-	-
Cash Flow to Government = State Corporate Income Tax	-	-	-	-	-	-	-	1,719,158	1,851,157	2,077,516
Federal										
Gross Income										
Sales	-	-	82,465,473	86,128,589	89,954,421	93,950,197	98,123,465	102,482,109	107,034,364	111,788,831
Less Tax Deductible Costs										
Operating Costs	-	-	51,905,227	54,132,885	56,267,283	58,487,691	60,797,676	63,200,962	65,701,434	68,303,144
Plant Tax Depreciation	-	-	160,509,661	21,834,155	11,774,484	6,937,789	4,340,780	3,948,722	3,600,528	1,637,664
Interest Paid	-	4,075,000	4,075,000	4,075,000	4,075,000	4,075,000	4,075,000	4,075,000	4,075,000	4,075,000
Property Tax (Fee-in-Lieu)										
State Income Taxes Paid	-	-	-	-	-	-	-	1,719,158	1,851,157	2,077,516
Total Deductible Costs	-	4,075,000	216,489,888	80,042,040	72,116,767	69,500,480	69,213,456	72,943,843	75,228,119	76,093,324
Taxable Income Before Loss Carry Forward	-	(4,075,000)	(134,024,415)	6,086,550	17,837,654	24,449,717	28,910,008	29,538,266	31,806,245	35,695,506
Loss Carry Forward	-	-	(4,075,000)	(138,099,415)	(132,012,865)	(114,175,211)	(89,725,494)	(60,815,485)	(31,277,219)	-
Taxable Income	-	(4,075,000)	(138,099,415)	(132,012,865)	(114,175,211)	(89,725,494)	(60,815,485)	(31,277,219)	529,026	35,695,506
Corporate Income Tax Before Credits	-	-	-	-	-	-	-	-	185,159	12,493,427
Small Ethanol Producer/Cellulosic Biofuel/Alcohol Fuel Tax Credits Created Last Year		-	37,860,000	37,860,000	37,860,000	37,860,000	-	-	-	-
Tax Credits Since 2008	-	-	37,860,000	75,720,000	113,580,000	151,440,000	-	-	-	-
Tax credit Carry Forward until 2012	-	-	-	37,860,000	75,720,000	113,580,000				
Total Tax Credits (incl. carry forwards)	-	-	37,860,000	75,720,000	113,580,000	151,440,000				
Cash Flow to Federal Government	-	-	-	-	-	-	-	-	185,159	12,493,427
Total Cash Flow to Governments	-	-	-	-	-	-	-	1,719,158	2,036,316	14,570,943

Nominal Cash Flow to Government/ Corporate Tax Computation											
State											
Calendar Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Project Year	10	11	12	13	14	15	16	17	18	19	20
Gross Income											
Sales	116,754,490	121,940,725	127,357,332	133,014,545	138,923,051	145,094,012	151,539,089	158,270,455	165,300,828	172,643,491	180,312,315
Less Tax Deductible Costs											
Operating Costs	71,010,318	73,827,370	76,758,902	79,809,720	82,984,837	86,289,488	89,729,137	93,309,489	97,036,499	100,916,388	104,955,649
Plant Tax Depreciation											
Interest Paid	4,075,000	4,075,000	4,075,000	4,075,000	4,075,000	4,075,000	4,075,000	4,075,000	4,075,000	4,075,000	4,075,000
Total Deductible Costs	75,085,318	77,902,370	80,833,902	83,884,720	87,059,837	90,364,488	93,804,137	97,384,489	101,111,499	104,991,388	109,030,649
Taxable Income Before Loss Carry Forward	41,669,172	44,038,355	46,523,430	49,129,825	51,863,214	54,729,525	57,734,952	60,885,966	64,189,329	67,652,104	71,281,667
Loss Carry Forward	-	-	-	-	-	-	-	-	-	-	-
Taxable Income	41,669,172	44,038,355	46,523,430	49,129,825	51,863,214	54,729,525	57,734,952	60,885,966	64,189,329	67,652,104	71,281,667
Add back of special 50% bonus depreciation, only in first year in service											
Corporate Income Tax Before Credits	2,291,804	2,422,110	2,558,789	2,702,140	2,852,477	3,010,124	3,175,422	3,348,728	3,530,413	3,720,866	3,920,492
Florida Corporate Tax Credits Created Last Year	-	-	-	-	-	-	-	-	-	-	-
Tax Credits Since 2007	-	-	-	-	-	-	-	-	-	-	-
Tax credit Carry Forward until 2012	-	-	-	-	-	-	-	-	-	-	-
Total Tax Credits (incl. carry forwards)	-	-	-	-	-	-	-	-	-	-	-
Cash Flow to Government = State Corporate Income Tax	2,291,804	2,422,110	2,558,789	2,702,140	2,852,477	3,010,124	3,175,422	3,348,728	3,530,413	3,720,866	3,920,492
Federal											
Gross Income											
Sales	116,754,490	121,940,725	127,357,332	133,014,545	138,923,051	145,094,012	151,539,089	158,270,455	165,300,828	172,643,491	180,312,315
Less Tax Deductible Costs											
Operating Costs	71,010,318	73,827,370	76,758,902	79,809,720	82,984,837	86,289,488	89,729,137	93,309,489	97,036,499	100,916,388	104,955,649
Plant Tax Depreciation											
Interest Paid	4,075,000	4,075,000	4,075,000	4,075,000	4,075,000	4,075,000	4,075,000	4,075,000	4,075,000	4,075,000	4,075,000
Property Tax (Fee-in-Lieu)											
State Income Taxes Paid	2,291,804	2,422,110	2,558,789	2,702,140	2,852,477	3,010,124	3,175,422	3,348,728	3,530,413	3,720,866	3,920,492
Total Deductible Costs	77,377,123	80,324,480	83,392,691	86,586,860	89,912,313	93,374,612	96,979,559	100,733,217	104,641,912	108,712,253	112,951,140
Taxable Income Before Loss Carry Forward	39,377,368	41,616,245	43,964,641	46,427,685	49,010,737	51,719,401	54,559,529	57,537,238	60,658,916	63,931,238	67,361,175
Loss Carry Forward	-	-	-	-	-	-	-	-	-	-	-
Taxable Income	39,377,368	41,616,245	43,964,641	46,427,685	49,010,737	51,719,401	54,559,529	57,537,238	60,658,916	63,931,238	67,361,175
Corporate Income Tax Before Credits	13,782,079	14,565,686	15,387,624	16,249,690	17,153,758	18,101,790	19,095,835	20,138,033	21,230,621	22,375,933	23,576,411
Small Ethanol Producer/Cellulosic Biofuel/Alcohol Fuel Tax Credits Crea	-	-	-	-	-	-	-	-	-	-	-
Tax Credits Since 2008	-	-	-	-	-	-	-	-	-	-	-
Tax credit Carry Forward until 2012											
Total Tax Credits (incl. carry forwards)											
Cash Flow to Federal Government	13,782,079	14,565,686	15,387,624	16,249,690	17,153,758	18,101,790	19,095,835	20,138,033	21,230,621	22,375,933	23,576,411
Total Cash Flow to Governments	16,073,883	16,987,795	17,946,413	18,951,830	20,006,235	21,111,914	22,271,258	23,486,761	24,761,034	26,096,799	27,496,903

Real Cash Flow to Government/ Corporate Tax Computation										
State										
Calendar Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Project Year	0	1	2	3	4	5	6	7	8	9
Inflation Factor	1.00	1.03	1.06	1.09	1.13	1.16	1.19	1.23	1.27	1.30
Gross Income										
Sales			77,731,618	78,819,860	79,923,338	81,042,265	82,176,857	83,327,333	84,493,915	85,676,830
Less Tax Deductible Costs										
Operating Costs		-	48,925,654.78	49,539,258.17	49,992,752.49	50,451,995.64	50,917,096.33	51,388,166.02	51,865,318.94	52,348,672.19
Plant Tax Depreciation	-		151,295,750	19,981,345	10,461,476	5,984,598	3,635,335	3,210,672	2,842,290	1,255,133
Interest Paid	-	3,956,311	3,841,078	3,729,202	3,620,585	3,515,131	3,412,748	3,313,348	3,216,843	3,123,148
Total Deductible Costs	-	3,956,311	204,062,483	73,249,805	64,074,814	59,951,724	57,965,180	57,912,186	57,924,451	56,726,954
Taxable Income Before Loss Carry Forward	-	(3,956,311)	(126,330,865)	5,570,055	15,848,525	21,090,541	24,211,677	25,415,147	26,569,464	28,949,876
Loss Carry Forward	-	-	(4,075,000)	(13,266,890)	(7,180,340)	-	-	-	-	-
Taxable Income	-	(3,956,311)	(130,405,865)	(7,696,835)	8,668,185	21,090,541	24,211,677	25,415,147	26,569,464	28,949,876
Add back of special 50% bonus depreciation, only in first year in service			(9,209,239)							
Corporate Income Tax Before Credits	-	-	-	-	520,789	1,159,980	1,331,642	1,397,833	1,461,321	1,592,243
Florida Corporate Tax Credits Created Last Year	-	-	6,126,873	5,948,421	5,775,166	5,606,957	5,443,648	-	-	-
Tax Credits Since 2007	-	-	6,126,873	12,075,294	17,850,460	23,457,417	28,901,065	-	-	-
Tax credit Carry Forward until 2012	-	-	-	5,948,421	17,325,497	15,155,271	18,825,861	-	-	-
Total Tax Credits (incl. carry forwards)	-	-	6,126,873	11,896,842	16,804,709	20,762,229	24,269,509	-	-	-
Cash Flow to Government = State Corporate Income Tax	-	-	-	-	-	-	-	1,397,833	1,461,321	1,592,243
Federal										
Gross Income										
Sales			77,731,618	78,819,860	79,923,338	81,042,265	82,176,857	83,327,333	84,493,915	85,676,830
Less Tax Deductible Costs										
Operating Costs	-	-	48,925,655	49,539,258	49,992,752	50,451,996	50,917,096	51,388,166	51,865,319	52,348,672
Plant Tax Depreciation	-	-	151,295,750	19,981,345	10,461,476	5,984,598	3,635,335	3,210,672	2,842,290	1,255,133
Interest Paid	-	3,956,311	3,841,078	3,729,202	3,620,585	3,515,131	3,412,748	3,313,348	3,216,843	3,123,148
State Income Taxes Paid	-	-	-	-	-	-	-	1,397,833	1,461,321	1,592,243
Total Deductible Costs	-	3,956,311	204,062,483	73,249,805	64,074,814	59,951,724	57,965,180	59,310,019	59,385,772	58,319,197
Taxable Income Before Loss Carry Forward	-	(3,956,311)	(126,330,865)	5,570,055	15,848,525	21,090,541	24,211,677	24,017,314	25,108,143	27,357,633
Loss Carry Forward	-	-	(3,841,078)	(126,380,528)	(117,291,721)	(98,488,540)	(75,143,689)	(49,448,555)	(24,690,526)	-
Taxable Income	-	(3,956,311)	(130,171,943)	(120,810,472)	(101,443,196)	(77,397,999)	(50,932,012)	(25,431,241)	417,618	27,357,633
	-	-	-	-	-	-	-	-	-	-
Corporate Income Tax Before Credits	-	-	-	-	-	-	-	-	146,166	9,575,172
Small Ethanol Producer/Cellulosic Biofuel/Alcohol Fuel Tax Credits Created Last Yea		-	35,686,681	34,647,263	33,638,120	32,658,369	-	-	-	-
Tax Credits Since 2008	-	-	35,686,681	69,294,526	100,914,359	130,633,474	-	-	-	-
Tax credit Carry Forward until 2012	-	-	-	34,647,263	67,276,239	97,975,106	-	-	-	-
Total Tax Credits (incl. carry forwards)	-	-	35,686,681	69,294,526	100,914,359	130,633,474				
Cash Flow to Federal Government	-	-	-	-	-	-	-	-	146,166	9,575,172
Total Cash Flow to Governments	-	-	-	-	-	-	-	1,397,833	1,607,487	11,167,415

Real Cash Flow to Government/ Corporate Tax Computation											
State											
Calendar Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Project Year	10	11	12	13	14	15	16	17	18	19	20
Inflation Factor	1.34	1.38	1.43	1.47	1.51	1.56	1.60	1.65	1.70	1.75	1.81
Gross Income											
Sales	86,876,306	88,092,574	89,325,870	90,576,432	91,844,502	93,130,325	94,434,150	95,756,228	97,096,815	98,456,171	99,834,557
Less Tax Deductible Costs											
Operating Costs	52,838,345.81	53,334,462.90	53,837,149.66	54,346,535.50	54,862,753.12	55,385,938.64	55,916,231.62	56,453,775.27	56,998,716.43	57,551,205.77	58,111,397.86
Plant Tax Depreciation											
Interest Paid	3,032,183	2,943,867	2,858,123	2,774,877	2,694,055	2,615,587	2,539,405	2,465,442	2,393,633	2,323,916	2,256,229
Total Deductible Costs	55,870,529	56,278,330	56,695,273	57,121,412	57,556,808	58,001,526	58,455,637	58,919,217	59,392,349	59,875,121	60,367,627
Taxable Income Before Loss Carry Forward	31,005,777	31,814,245	32,630,597	33,455,020	34,287,694	35,128,799	35,978,513	36,837,011	37,704,466	38,581,049	39,466,931
Loss Carry Forward	-	-	-	-	-	-	-	-	-	-	-
Taxable Income	31,005,777	31,814,245	32,630,597	33,455,020	34,287,694	35,128,799	35,978,513	36,837,011	37,704,466	38,581,049	39,466,931
Add back of special 50% bonus depreciation, only in first year in service											
Corporate Income Tax Before Credits	1,705,318	1,749,783	1,794,683	1,840,026	1,885,823	1,932,084	1,978,818	2,026,036	2,073,746	2,121,958	2,170,681
Florida Corporate Tax Credits Created Last Year	-	-	-	-	-	-	-	-	-	-	-
Tax Credits Since 2007	-	-	-	-	-	-	-	-	-	-	-
Tax credit Carry Forward until 2012	-	-	-	-	-	-	-	-	-	-	-
Total Tax Credits (incl. carry forwards)	-	-	-	-	-	-	-	-	-	-	-
Cash Flow to Government = State Corporate Income Tax	1,705,318	1,749,783	1,794,683	1,840,026	1,885,823	1,932,084	1,978,818	2,026,036	2,073,746	2,121,958	2,170,681
Federal											
Gross Income											
Sales	86,876,306	88,092,574	89,325,870	90,576,432	91,844,502	93,130,325	94,434,150	95,756,228	97,096,815	98,456,171	99,834,557
Less Tax Deductible Costs											
Operating Costs	52,838,346	53,334,463	53,837,150	54,346,535	54,862,753	55,385,939	55,916,232	56,453,775	56,998,716	57,551,206	58,111,398
Plant Tax Depreciation	-	-	-	-	-	-	-	-	-	-	-
Interest Paid	3,032,183	2,943,867	2,858,123	2,774,877	2,694,055	2,615,587	2,539,405	2,465,442	2,393,633	2,323,916	2,256,229
State Income Taxes Paid	1,705,318	1,749,783	1,794,683	1,840,026	1,885,823	1,932,084	1,978,818	2,026,036	2,073,746	2,121,958	2,170,681
Total Deductible Costs	57,575,846	58,028,113	58,489,956	58,961,438	59,442,631	59,933,610	60,434,455	60,945,253	61,466,095	61,997,079	62,538,308
Taxable Income Before Loss Carry Forward	29,300,460	30,064,461	30,835,915	31,614,994	32,401,871	33,196,715	33,999,695	34,810,975	35,630,720	36,459,092	37,296,249
Loss Carry Forward	-	-	-	-	-	-	-	-	-	-	-
Taxable Income	29,300,460	30,064,461	30,835,915	31,614,994	32,401,871	33,196,715	33,999,695	34,810,975	35,630,720	36,459,092	37,296,249
	-	-	-	-	-	-	-	-	-	-	-
Corporate Income Tax Before Credits	10,255,161	10,522,561	10,792,570	11,065,248	11,340,655	11,618,850	11,899,893	12,183,841	12,470,752	12,760,682	13,053,687
Small Ethanol Producer/Cellulosic Biofuel/Alcohol Fuel Tax Credits	-	-	-	-	-	-	-	-	-	-	-
Tax Credits Since 2008	-	-	-	-	-	-	-	-	-	-	-
Tax credit Carry Forward until 2012	-	-	-	-	-	-	-	-	-	-	-
Total Tax Credits (incl. carry forwards)											
Cash Flow to Federal Government	10,255,161	10,522,561	10,792,570	11,065,248	11,340,655	11,618,850	11,899,893	12,183,841	12,470,752	12,760,682	13,053,687
Total Cash Flow to Governments	11,960,479	12,272,345	12,587,253	12,905,274	13,226,478	13,550,934	13,878,711	14,209,877	14,544,498	14,882,640	15,224,368

Nominal Cash Flow to Debt

Calendar Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Project Year	0	1	2	3	4	5	6	7	8	9
Principal										
Interest		$4,075,000.00	$4,075,000.00	$4,075,000.00	$4,075,000.00	$4,075,000.00	$4,075,000.00	$4,075,000.00	$4,075,000.00	$4,075,000.00
Less Loan Proceeds to Firm	50,000,000.00									
Equals Cash Flow to Debt	(50,000,000.00)	$4,075,000.00	$4,075,000.00	$4,075,000.00	$4,075,000.00	$4,075,000.00	$4,075,000.00	$4,075,000.00	$4,075,000.00	$4,075,000.00
Nominal NPV to Debt	-									
Real NPV to Debt	-									

Real Cash Flow to Debt

Calendar Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Project Year	0	1	2	3	4	5	6	7	8	9
Principal										
Interest		$3,956,310.68	$3,841,078.33	$3,729,202.26	$3,620,584.72	$3,515,130.80	$3,412,748.35	$3,313,347.91	$3,216,842.63	$3,123,148.18
Less Loan Proceeds to Firm	50,000,000.00									
Equals Cash Flow to Debt	(50,000,000.00)	$3,956,310.68	$3,841,078.33	$3,729,202.26	$3,620,584.72	$3,515,130.80	$3,412,748.35	$3,313,347.91	$3,216,842.63	$3,123,148.18

Nominal Cash Flow to Debt

Calendar Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Project Year	10	11	12	13	14	15	16	17	18	19	20
Principal											50,000,000.00
Interest	$4,075,000.00	$4,075,000.00	$4,075,000.00	$4,075,000.00	$4,075,000.00	$4,075,000.00	$4,075,000.00	$4,075,000.00	$4,075,000.00	$4,075,000.00	$4,075,000.00
Less Loan Proceeds to Firm											
Equals Cash Flow to Debt	$4,075,000.00	$4,075,000.00	$4,075,000.00	$4,075,000.00	$4,075,000.00	$4,075,000.00	$4,075,000.00	$4,075,000.00	$4,075,000.00	$4,075,000.00	$54,075,000.00
Nominal NPV to Debt											
Real NPV to Debt											

Real Cash Flow to Debt

Calendar Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Project Year	10	11	12	13	14	15	16	17	18	19	20
Principal											2768378771%
Interest	$3,032,182.70	$2,943,866.70	$2,858,123.01	$2,774,876.71	$2,694,055.06	$2,615,587.44	$2,539,405.28	$2,465,442.02	$2,393,633.03	$2,323,915.56	$2,256,228.70
Less Loan Proceeds to Firm											
Equals Cash Flow to Debt	$3,032,182.70	$2,943,866.70	$2,858,123.01	$2,774,876.71	$2,694,055.06	$2,615,587.44	$2,539,405.28	$2,465,442.02	$2,393,633.03	$2,323,915.56	$29,940,016.41

Nominal Cash Flows to Vercipia										
Calendar Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Project Year	-	1	2	3	4	5	6	7	8	9
Ethanol Sales	-	-	82,465,473	86,128,589	89,954,421	93,950,197	98,123,465	102,482,109	107,034,364	111,788,831
Loan Proceeds	50,000,000									
Liquidation Values:										
Land										
Plant										
Equipment										
Total Cash In	50,000,000	-	82,465,473	86,128,589	89,954,421	93,950,197	98,123,465	102,482,109	107,034,364	111,788,831
Cash out to CE Company										
Investments:										
Plant Construction	105,861,017									
Equipment	143,804,033									
Land (Purchased)	334,950									
Operating Costs:										
Feedstock Costs			27,142,352	28,124,362	29,141,902	30,196,256	31,288,756	32,420,784	33,593,768	34,809,190
Enzyme Costs	-	-	19,480,034	20,265,079	21,081,762	21,931,357	22,815,190	23,734,642	24,691,149	25,686,202
Electricity			3,144,221	3,335,704	3,538,849	3,754,365	3,983,006	4,225,571	4,482,908	4,755,917
Labor			2,314,466	2,407,739	2,504,771	2,605,713	2,710,723	2,819,966	2,933,610	3,051,835
Interest Payments	-	4,075,000	4,075,000	4,075,000	4,075,000	4,075,000	4,075,000	4,075,000	4,075,000	4,075,000
Loan Repayment										
Taxes:										
State Corporate Income Tax	-	-	-	-	-	-	-	1,719,158	1,851,157	2,077,516
Federal Corporate Income Tax	-	-	-	-	-	-	-	-	185,159	12,493,427
Total Cash Out	250,000,000	4,075,000	56,156,073	58,207,885	60,342,283	62,562,691	64,872,676	68,995,121	71,812,750	86,949,087
Total Cash Flow to Vercipia	(200,000,000)	(4,075,000)	26,309,400	27,920,704	29,612,138	31,387,506	33,250,789	33,486,988	35,221,614	24,839,743

Nominal Cash Flows to Vercipia											
Calendar Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Project Year	10	11	12	13	14	15	16	17	18	19	20
Ethanol Sales	116,754,490	121,940,725	127,357,332	133,014,545	138,923,051	145,094,012	151,539,089	158,270,455	165,300,828	172,643,491	180,312,315
Loan Proceeds											
Liquidation Values:											
Land											44,684,631
Plant											
Equipment											
Total Cash In	116,754,490	121,940,725	127,357,332	133,014,545	138,923,051	145,094,012	151,539,089	158,270,455	165,300,828	172,643,491	224,996,946
Cash out to CE Company											
Investments:											
Plant Construction											
Equipment											
Land (Purchased)											
Operating Costs:											
Feedstock Costs	36,068,587	37,373,548	38,725,723	40,126,820	41,578,608	43,082,922	44,641,662	46,256,797	47,930,368	49,664,489	51,461,350
Enzyme Costs	26,721,356	27,798,226	28,918,495	30,083,910	31,296,292	32,557,532	33,869,601	35,234,546	36,654,498	38,131,674	39,668,381
Electricity	5,045,552	5,352,826	5,678,814	6,024,653	6,391,555	6,780,800	7,193,751	7,631,851	8,096,630	8,589,715	9,112,829
Labor	3,174,824	3,302,769	3,435,871	3,574,336	3,718,382	3,868,233	4,024,123	4,186,295	4,355,002	4,530,509	4,713,088
Interest Payments	4,075,000	4,075,000	4,075,000	4,075,000	4,075,000	4,075,000	4,075,000	4,075,000	4,075,000	4,075,000	4,075,000
Loan Repayment											50,000,000
Taxes:											
State Corporate Income Tax	2,291,804	2,422,110	2,558,789	2,702,140	2,852,477	3,010,124	3,175,422	3,348,728	3,530,413	3,720,866	3,920,492
Federal Corporate Income Tax	13,782,079	14,565,686	15,387,624	16,249,690	17,153,758	18,101,790	19,095,835	20,138,033	21,230,621	22,375,933	23,576,411
Total Cash Out	91,159,201	94,890,165	98,780,315	102,836,550	107,066,071	111,476,402	116,075,395	120,871,250	125,872,533	131,088,187	186,527,551
Total Cash Flow to Vercipia	25,595,289	27,050,559	28,577,017	30,177,995	31,856,979	33,617,611	35,463,694	37,399,205	39,428,295	41,555,305	38,469,395

Real Cash Flows to Vercipia										
Calendar Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Project Year	-	1	2	3	4	5	6	7	8	9
Inflation Factor	1.00	1.03	1.06	1.09	1.13	1.16	1.19	1.23	1.27	1.30
Ethanol Sales	-	-	77,731,618	78,819,860	79,923,338	81,042,265	82,176,857	83,327,333	84,493,915	85,676,830
Loan Proceeds	50,000,000									
Liquidation Values:										
Land										
Plant										
Equipment										
Total Cash In	50,000,000	-	77,731,618	78,819,860	79,923,338	81,042,265	82,176,857	83,327,333	84,493,915	85,676,830
Cash out to CE Company										
Investments:										
Plant Construction	105,861,017									
Equipment	143,804,033									
Land (Purchased)	334,950									
Operating Costs:										
Feedstock Costs	-	-	25,584,270	25,737,776	25,892,202	26,047,556	26,203,841	26,361,064	26,519,230	26,678,346
Enzyme Costs	-	-	18,361,800	18,545,418	18,730,872	18,918,181	19,107,363	19,298,436	19,491,421	19,686,335
Electricity	-	-	2,963,730	3,052,642	3,144,221	3,238,548	3,335,704	3,435,776	3,538,849	3,645,014
Labor	-	-	2,181,606	2,203,422	2,225,457	2,247,711	2,270,188	2,292,890	2,315,819	2,338,977
Interest Payments	-	3,956,311	3,841,078	3,729,202	3,620,585	3,515,131	3,412,748	3,313,348	3,216,843	3,123,148
Loan Repayment	-	-	-	-	-	-	-	-	-	-
Taxes:										
State Corporate Income Tax	-	-	-	-	-	-	-	1,397,833	1,461,321	1,592,243
Federal Corporate Income Tax	-	-	-	-	-	-	-	-	146,166	9,575,172
Total Cash Out	250,000,000	3,956,311	52,932,485	53,268,460	53,613,337	53,967,126	54,329,845	56,099,347	56,689,648	66,639,235
Total Cash Flow to Vercipia	(200,000,000)	(3,956,311)	24,799,133	25,551,400	26,310,001	27,075,139	27,847,012	27,227,986	27,804,267	19,037,595

Real Cash Flows to Vercipia											
Calendar Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Project Year	10	11	12	13	14	15	16	17	18	19	20
Inflation Factor	1.34	1.38	1.43	1.47	1.51	1.56	1.60	1.65	1.70	1.75	1.81
Ethanol Sales	86,876,306	88,092,574	89,325,870	90,576,432	91,844,502	93,130,325	94,434,150	95,756,228	97,096,815	98,456,171	99,834,557
Loan Proceeds											
Liquidation Values:											
Land											24,740,797
Plant											
Equipment											
Total Cash In	86,876,306	88,092,574	89,325,870	90,576,432	91,844,502	93,130,325	94,434,150	95,756,228	97,096,815	98,456,171	124,575,354
Cash out to CE Company											
Investments:											
Plant Construction											
Equipment											
Land (Purchased)											
Operating Costs:											
Feedstock Costs	26,838,416	26,999,446	27,161,443	27,324,412	27,488,358	27,653,288	27,819,208	27,986,123	28,154,040	28,322,964	28,492,902
Enzyme Costs	19,883,198	20,082,030	20,282,851	20,485,679	20,690,536	20,897,441	21,106,416	21,317,480	21,530,655	21,745,961	21,963,421
Electricity	3,754,365	3,866,996	3,983,006	4,102,496	4,225,571	4,352,338	4,482,908	4,617,395	4,755,917	4,898,595	5,045,552
Labor	2,362,367	2,385,991	2,409,851	2,433,949	2,458,289	2,482,871	2,507,700	2,532,777	2,558,105	2,583,686	2,609,523
Interest Payments	3,032,183	2,943,867	2,858,123	2,774,877	2,694,055	2,615,587	2,539,405	2,465,442	2,393,633	2,323,916	2,256,229
Loan Repayment	-	-	-	-	-	-	-	-	-	-	27,683,788
Taxes:											
State Corporate Income Tax	1,705,318	1,749,783	1,794,683	1,840,026	1,885,823	1,932,084	1,978,818	2,026,036	2,073,746	2,121,958	2,170,681
Federal Corporate Income Tax	10,255,161	10,522,561	10,792,570	11,065,248	11,340,655	11,618,850	11,899,893	12,183,841	12,470,752	12,760,682	13,053,687
Total Cash Out	67,831,007	68,550,674	69,282,526	70,026,686	70,783,286	71,552,460	72,334,348	73,129,094	73,936,847	74,757,761	103,275,783
Total Cash Flow to Vercipia	19,045,299	19,541,900	20,043,344	20,549,746	21,061,216	21,577,865	22,099,802	22,627,134	23,159,968	23,698,410	21,299,571

Appendix B
Parameter Calculations

Land Prices Source: Highlands County Florida, Personal Correspondence with Mike Andres

Year	Acres	Price	Real Prices, 2007 $
2000	442	1275	1528
	561	1800	2157
	144	2077	2489
	312	1367	1638
	279	952	1141
	246	1006	1205
	97	2190	2624
	1200	1028	1232
	442	944	1131
	250	3040	3642
	71	2562	3070
	196	1786	2140
	140	1843	2208
2001	271	1311	1536
	50	1850	2168
	71	1685	1974
	472	2224	2606
	120	1500	1758
	264	1708	2001
	1214	1493	1749
	167	1463	1714
	90	2255	2642
	3110	1173	1374
	407	1842	2158
	118	3285	3850
2002	2302	2822	3254
	241	1400	1614
	86	1546	1783
	100	2296	2647
	80	1850	2133
	966	502	579
	110	1783	2056
	140	1855	2139
	446	2135	2462
	452	1552	1790
	3649	1400	1614
	108	1661	1916
	788	1798	2073
2003	64	3291	3715
	73	1988	2244
	950	1476	1666
	79	3000	3386
	49	2400	2709
	129	4110	4639
	10	15625	17636
	74	4001	4516
	114	4298	4851
	159	2364	2668
	71	3371	3805
	264	2460	2777
	81	1973	2227
	82	2437	2751
	262	3591	4053
	398	2983	3367
	80	1506	1700
	101	1728	1950
	50	7000	7901
	71	3303	3728
2004	180	5310	5828
	1136	2148	2358
	71	918	1008
	112	1342	1473
	50	4000	4390
	91	1933	2122
	21	21640	23752
	345	3477	3816
	4370	1987	2181
	1362	1469	1612
	401	2992	3284
	767	2530	2776
	51	4733	5195
	160	1875	2058
	155	1287	1413
	345	2898	3181
	141	5762	6324
	600	2901	3185
	57	4751	5215
	48	10260	11262
	1277	7050	7738
	95	3266	3585
	3055	3666	4024
	521	3462	3800
	110	5909	6486
	281	8185	8984
	53	7943	8718
	299	6524	7161
	519	5782	6346
2005	1136	3797	4033
	65	5501	5842
	98	4297	4564
	347	8720	9262
	1136	7518	7985
	188	6209	6595
	1516	5248	5574
	1516	8579	9112
	115	17338	18415
	253	5437	5775
	75	10667	11330
	157	15323	16275
	229	10920	11599
	209	16747	17788
2006	165	15487	15931
	52	6170	6347
2007	1943	5090	5090
	229	16214	16214
2008	104	1033	1011
2009	51	4902	4743
	400	3250	3145
	81	3046	2947
	1996	1720	1665

Land Price Rate of Growth Calculation

Year	Amount of land sold (acres)	GDP Deflator	Annual Rate of Growth
2000	4378.40	0.83	
2001	6354.25	0.85	1%
2002	6354.25	0.87	18%
2003	9466.56	0.89	45%
2004	16672.80	0.91	24%
2005	7038.46	0.94	113%
2006	216.99	0.97	76%
2007	2171.91	1.00	-54%
2008	103.55	1.02	-84%
2009	2528.26	1.03	98%
		Median Growth Rate (2000-2007)	24%
		Real Weighted Average=	3524.91

Sugarcane Prices

Sugarcane for sugar: price per ton, by State

Source: "Agricultural Prices," Agricultural Statistics Board, NASS, USDA.
Last Updated: 8/10/2009

Florida					
	Dollars per short ton	GDP	GDP Deflator	Real Dollars/Short Ton	Rate of Growth
1972	14.22	26.634	0.251	56.71	
1973	27.35	28.112	0.265	103.33	92.3%
1974	47.50	30.664	0.289	164.53	73.7%
1975	19.80	33.563	0.316	62.66	-58.3%
1976	15.10	35.489	0.334	45.19	-23.7%
1977	19.60	37.751	0.355	55.15	29.8%
1978	20.50	40.400	0.380	53.90	4.6%
1979	30.30	43.761	0.412	73.54	47.8%
1980	39.40	47.751	0.450	87.64	30.0%
1981	28.60	52.225	0.492	58.17	-27.4%
1982	28.20	55.412	0.522	54.05	-1.4%
1983	28.60	57.603	0.542	52.74	1.4%
1984	28.90	59.766	0.563	51.36	1.0%
1985	28.20	61.576	0.580	48.64	-2.4%
1986	29.00	62.937	0.593	48.94	2.8%
1987	30.90	64.764	0.610	50.68	6.6%
1988	32.60	66.988	0.631	51.69	5.5%
1989	30.70	69.518	0.655	46.91	-5.8%
1990	31.50	72.201	0.680	46.34	2.6%
1991	31.00	74.760	0.704	44.04	-1.6%
1992	29.80	76.533	0.721	41.36	-3.9%
1993	30.40	78.224	0.736	41.28	2.0%
1994	30.60	79.872	0.752	40.69	0.7%
1995	30.60	81.536	0.768	39.86	0.0%
1996	29.40	83.088	0.782	37.58	-3.9%
1997	28.70	84.555	0.796	36.05	-2.4%
1998	29.50	85.511	0.805	36.64	2.8%
1999	27.20	86.768	0.817	33.30	-7.8%
2000	28.60	88.647	0.835	34.27	5.1%
2001	31.70	90.650	0.853	37.14	10.8%
2002	31.70	92.118	0.867	36.55	0.0%
2003	31.90	94.100	0.886	36.01	0.6%
2004	30.30	96.770	0.911	33.26	-5.0%
2005	28.00	100.000	0.941	29.74	-7.6%
2006	31.10	103.257	0.972	31.99	11.1%
2007	31.60	106.214	1.000	31.60	1.6%
				Average Rate of Growth	0.6%

Industrial Electricity Prices, Florida

Source: EIA. (2009, April). *Florida Electricity Profile*. Retrieved December 29, 2009, from U.S. Energy Information Administration: http://www.eia.doe.gov/cneaf/electricity/st_profiles/florida.html

	Industrial	GDP	GDP Deflator	Real Industrial for electricity, cents/kWh	$/kWh	Rate of Growth
1990	5.08	72.201	0.679769	7.473125	0.074731	
1991	5.19	74.76	0.703862	7.373604	0.073736	2%
1992	5.02	76.533	0.720555	6.966855	0.069669	-3%
1993	5.26	78.224	0.736475	7.142126	0.071421	5%
1994	5.13	79.872	0.751991	6.821888	0.068219	-2%
1995	5.16	81.536	0.767658	6.721745	0.067217	1%
1996	5.11	83.088	0.78227	6.532273	0.065323	-1%
1997	5.04	84.555	0.796081	6.33101	0.06331	-1%
1998	4.81	85.511	0.805082	5.974545	0.059745	-5%
1999	4.77	86.768	0.816917	5.839028	0.05839	-1%
2000	4.84	88.647	0.834607	5.799133	0.057991	1%
2001	5.18	90.65	0.853466	6.069371	0.060694	7%
2002	5.23	92.118	0.867287	6.0303	0.060303	1%
2003	5.41	94.1	0.885947	6.106458	0.061065	3%
2004	5.84	96.77	0.911085	6.409939	0.064099	8%
2005	6.46	100	0.941495	6.861424	0.068614	11%
2006	7.71	103.257	0.97216	7.930793	0.079308	19%
2007	7.76	106.214	1	7.76	0.0776	1%
				Average	0.066746	3%

Labor Data

Area: South Florida nonmetropolitan area
Period: May 2008

Occupation (SOC code)	Employment(1)	Annual mean wage(2)	Annual median wage(2)	Median /Mean	Percent difference between mean and median	Workers Needed	Total estimated wages (mean)	Total estimated wages (median)
First-Line Supervisors/Managers of Production and Operating Workers(511011)	230	55220	56000	1.01413	1%	5	276100	280000
Structural Metal Fabricators and Fitters(512041)	(8)-	27380	27610	1.0084	1%	1	27380	27610
Team Assemblers(512092)	40	24650	26150	1.06085	6%		0	0
Machinists(514041)	40	30830	28570	0.92669	-7%		0	0
Welders Cutters Solderers and Brazers(514121)	130	34230	31190	0.91119	-9%		0	0
Water and Liquid Waste Treatment Plant and System Operators(518031)	180	42190	40080	0.94999	-5%	20	843800	801600
Separating Filtering Clarifying Precipitating and Still Machine Setters Operators and Tenders(519012)	100	29980	25590	0.85357	-15%	5	149900	127950
Mixing and Blending Machine Setters Operators and Tenders(519023)	110	23860	19510	0.81769	-18%	5	119300	97550
Helpers--Production Workers(519198)	(8)-	23280	22820	0.98024	-2%		0	0
Production Workers All Other(519199)	60	25750	23560	0.91495	-9%	20	515000	471200
Footnotes:						56	1,931,480	1,805,910

(1) Estimates for detailed occupations do not sum to the totals because the totals include occupations not shown separately. Estimates do not include self-employed workers.

(2) Annual wages have been calculated by multiplying the hourly mean wage by 2080 hours; where an hourly mean wage is not published the annual wage has been directly calculated from the reported survey data.

(8) Estimate not released.

SOC code: Standard Occupational Classification code -- see http://www.bls.gov/soc/home.htm

Data extracted on February 1 2010

Area: South Florida nonmetropolitan area

Period: May 2008

Occupation (SOC code)	Employment(1)	Annual mean wage(2)	Annual median wage(2)	Median/ Mean	Percent difference between mean and median	Workers Needed	Total estimated wages (mean)	Total estimated wages (median)
Administrative Services Managers(113011)	110	76060	71000	0.93347	-7%	1	76060	71000
Financial Managers(113031)	140	99650	89870	0.90186	-10%		0	0
Human Resources Training and Labor Relations Specialists All Other(131079)	90	52580	50580	0.96196	-4%	1	52580	50580
Accountants and Auditors(132011)	650	63080	58100	0.92105	-8%	1	63080	58100
Janitors and Cleaners Except Maids and Housekeeping Cleaners(372011)	1410	23120	21920	0.9481	-5%	2	46240	43840
Bill and Account Collectors(433011)	410	27200	26350	0.96875	-3%	2	54400	52700
Bookkeeping Accounting and Auditing Clerks(433031)	1700	29990	26920	0.89763	-10%	1	29990	26920
Payroll and Timekeeping Clerks(433051)	70	29600	29580	0.99932	0%	1	29600	29580
Footnotes:						9	351,950	332,720

(1) Estimates for detailed occupations do not sum to the totals because the totals include occupations not shown separately. Estimates do not include self-employed workers.

2,283,430 2,138,630

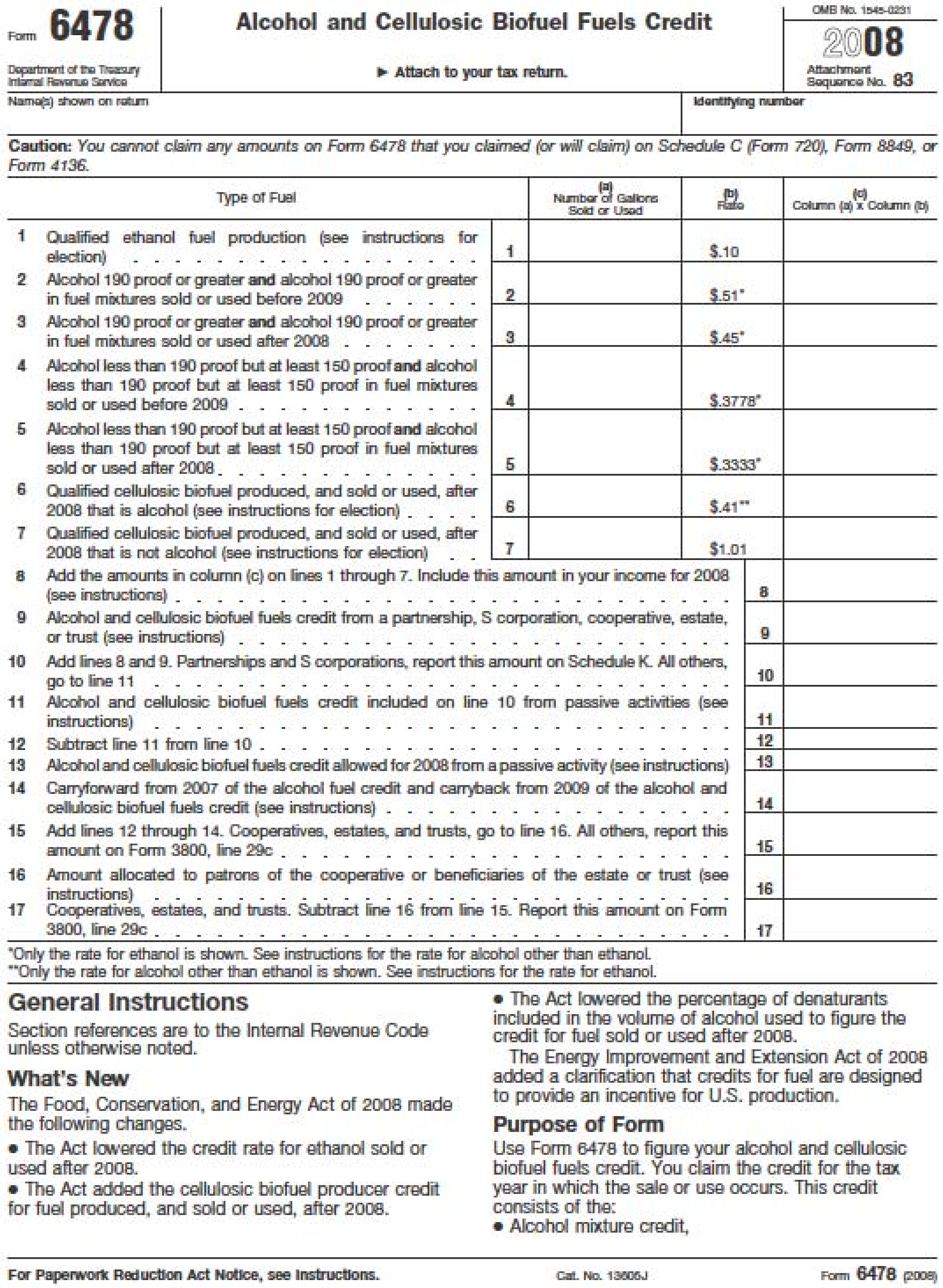
(2) Annual wages have been calculated by multiplying the hourly mean wage by 2080 hours; where an hourly mean wage is not published the annual wage has been directly calculated from the reported survey data.

http://www.bls.gov/soc/home.htm

Data extracted on February 1 2010

Appendix C
Tax Credit Worksheet

Tax Credits
IRS Form 6478



Form **6478**

Department of the Treasury
Internal Revenue Service

Alcohol and Cellulosic Biofuel Fuels Credit

▶ **Attach to your tax return.**

OMB No. 1545-0231

2008

Attachment
Sequence No. 83

Name(s) shown on return

Identifying number

Caution: *You cannot claim any amounts on Form 6478 that you claimed (or will claim) on Schedule C (Form 720), Form 8849, or Form 4136.*

	Type of Fuel		(a) Number of Gallons Sold or Used	(b) Rate	(c) Column (a) x Column (b)
1	Qualified ethanol fuel production (see instructions for election)	1		$.10	
2	Alcohol 190 proof or greater **and** alcohol 190 proof or greater in fuel mixtures sold or used before 2009	2		$.51*	
3	Alcohol 190 proof or greater **and** alcohol 190 proof or greater in fuel mixtures sold or used after 2008	3		$.45*	
4	Alcohol less than 190 proof but at least 150 proof **and** alcohol less than 190 proof but at least 150 proof in fuel mixtures sold or used before 2009	4		$.3778*	
5	Alcohol less than 190 proof but at least 150 proof **and** alcohol less than 190 proof but at least 150 proof in fuel mixtures sold or used after 2008	5		$.3333*	
6	Qualified cellulosic biofuel produced, and sold or used, after 2008 that is alcohol (see instructions for election)	6		$.41**	
7	Qualified cellulosic biofuel produced, and sold or used, after 2008 that is not alcohol (see instructions for election)	7		$1.01	

8	Add the amounts in column (c) on lines 1 through 7. Include this amount in your income for 2008 (see instructions)	8	
9	Alcohol and cellulosic biofuel fuels credit from a partnership, S corporation, cooperative, estate, or trust (see instructions)	9	
10	Add lines 8 and 9. Partnerships and S corporations, report this amount on Schedule K. All others, go to line 11	10	
11	Alcohol and cellulosic biofuel fuels credit included on line 10 from passive activities (see instructions)	11	
12	Subtract line 11 from line 10	12	
13	Alcohol and cellulosic biofuel fuels credit allowed for 2008 from a passive activity (see instructions)	13	
14	Carryforward from 2007 of the alcohol fuel credit and carryback from 2009 of the alcohol and cellulosic biofuel fuels credit (see instructions)	14	
15	Add lines 12 through 14. Cooperatives, estates, and trusts, go to line 16. All others, report this amount on Form 3800, line 29c	15	
16	Amount allocated to patrons of the cooperative or beneficiaries of the estate or trust (see instructions)	16	
17	Cooperatives, estates, and trusts. Subtract line 16 from line 15. Report this amount on Form 3800, line 29c	17	

*Only the rate for ethanol is shown. See instructions for the rate for alcohol other than ethanol.
**Only the rate for alcohol other than ethanol is shown. See instructions for the rate for ethanol.

General Instructions

Section references are to the Internal Revenue Code unless otherwise noted.

What's New

The Food, Conservation, and Energy Act of 2008 made the following changes.

- The Act lowered the credit rate for ethanol sold or used after 2008.
- The Act added the cellulosic biofuel producer credit for fuel produced, and sold or used, after 2008.
- The Act lowered the percentage of denaturants included in the volume of alcohol used to figure the credit for fuel sold or used after 2008.

The Energy Improvement and Extension Act of 2008 added a clarification that credits for fuel are designed to provide an incentive for U.S. production.

Purpose of Form

Use Form 6478 to figure your alcohol and cellulosic biofuel fuels credit. You claim the credit for the tax year in which the sale or use occurs. This credit consists of the:

- Alcohol mixture credit,

For Paperwork Reduction Act Notice, see Instructions. Cat. No. 13605J Form **6478** (2008)