Economic and Agricultural Impacts of Ethanol and Biodiesel Expansion

Study Report

by

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Executive Summary

This study was undertaken to examine the impacts of expanded levels of ethanol and biodiesel production and to provide a better understanding of the potential economic and agricultural impacts of this expansion. The study results indicate that producing 60 billion gallons of ethanol and 1.6 billion gallons of biodiesel from renewable resources by the year 2030 is projected to result in the development of a new industrial complex with nearly 35 million acres planted to dedicated energy crops. This industrial complex is estimated to have an economic impact in excess of $350 billion within the U.S., creating 2.4 million additional jobs, many in Rural America. Not only can U.S. agriculture meet the nation's food and feed demand, but it has sufficient resources to produce significant quantities of biofuels. Bioenergy allows for a potential win-win-win scenario for energy security, agriculture, and rural economic development.

Study Highlights

Achievement of 60 billion gallons of ethanol and 1.6 billion gallons of biodiesel per year:

- Can be achieved without using CRP lands,
- Will be fostered by research increasing agricultural productivity and commercialization of cellulosics to ethanol,
- Is projected to result in a cumulative increase in net farm income over the 2007-2030 period of $210 billion,
- Is estimated to impact the nation's economy by $350 billion and 2.4 million jobs, with much of these impacts occurring in the nation's rural economies,
- Will provide for displacement of more than 20% of the gasoline by 2030; potentially reducing oil imports by $52 billion, and
- Can result in cumulative displacement of 10.48 billion barrels of oil, and a potential import reduction of $629 billion through 2030.

Using POLYSYS, an agricultural simulation model developed at the University of Tennessee, and IMPLAN, an input output model, this report assesses the potential impacts of increasing production of ethanol and bio-diesel beyond current market levels and the levels specified in the recently enacted renewable fuel standard. Specifically, the objective of the study is to analyze the impacts on agriculture and the economy from increased ethanol (starch and cellulosic) production. The levels of production analyzed are 10, 30, and 60 billion gallons of ethanol by 2010, 2020 and 2030, respectively. In addition, sensitivity to the timing of cellulosic to ethanol commercial introduction and impacts cellulosic introduction has on the corn to ethanol industry are projected. The study also includes an assessment of the impacts of producing 1 billion gallons of biodiesel production by 2012.

For the agricultural sector, this new demand for agricultural cropland and crops implies an additional $11 billion of net farm income by 2030, and savings of more than $5 billion dollars in government payments in that year. Overall for the period 2007 to 2030, the estimated accumulated gains in net farm income are over $210 billion.

Between 2007 and 2012, corn grain is the primary feedstock for ethanol production at a little more than 12 billion gallons per year resulting in an increase in corn price of about $0.90/bushel in 2010. Cellulosic ethanol is assumed to be commercially viable in 2012 and initially wood from forest residues and mill wastes are used. By 2014, dedicated energy crops are utilized and become the primary cellulosic feedstock by 2017. Crop residues in the form of wheat straw and corn stover become significant feedstocks after 2020.

In order to meet the specified goals, if cellulosic ethanol is not commercially viable until 2015, 20 billion gallons of ethanol will need to come from corn. This results in the price of corn increasing to $4.65/bushel. This high corn price is likely prohibitive to attainment of the ethanol goal.

By 2030, agricultural exports are reduced by $3 billion, with most of the reduction occurring in the soybean market. However, in that same year, ethanol is projected to displace more than 20 percent of domestic gasoline consumption, potentially reducing oil imports by $52 billion dollars. For the entire period through 2030, the displacement would be 10.48 billion barrels of oil, and a potential import reduction of $629 billion dollars.

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Opportunities and Challenges of Expanding the Production and Utilization of Ethanol and Biodiesel

I. Introduction

Agriculture is uniquely positioned among the current renewable energy sources (Figure 1) to be a source of energy feedstock that can contribute to the production of both power (electricity) and transportation fuels (ethanol and biodiesel). It is also well positioned to be a good fit to utilize the current infrastructure of distribution and energy utilization, in both electricity generation and transportation engines. Furthermore, when referring to agricultural feedstock for energy, there is a diverse set of feedstock (Figure 2) like traditional starch and sugar crops, crop residues, dedicated energy crops, animal waste, forest residues, mill wastes, and food residues. This diversity of feedstock resources enables specific regions of the country to contribute with their unique set of resources. Use of bioenergy feedstocks could not only help reduce reliance on foreign oil, but could also provide significant environmental benefits and help invigorate rural economies. The purpose of this study is to project the impacts of expanded levels of ethanol and biodiesel production on U.S. agriculture and the economy. Impacts of meeting production targets of 60 billion gallons for ethanol and of 1.6 billion gallons for biodiesel by 2030 are projected.

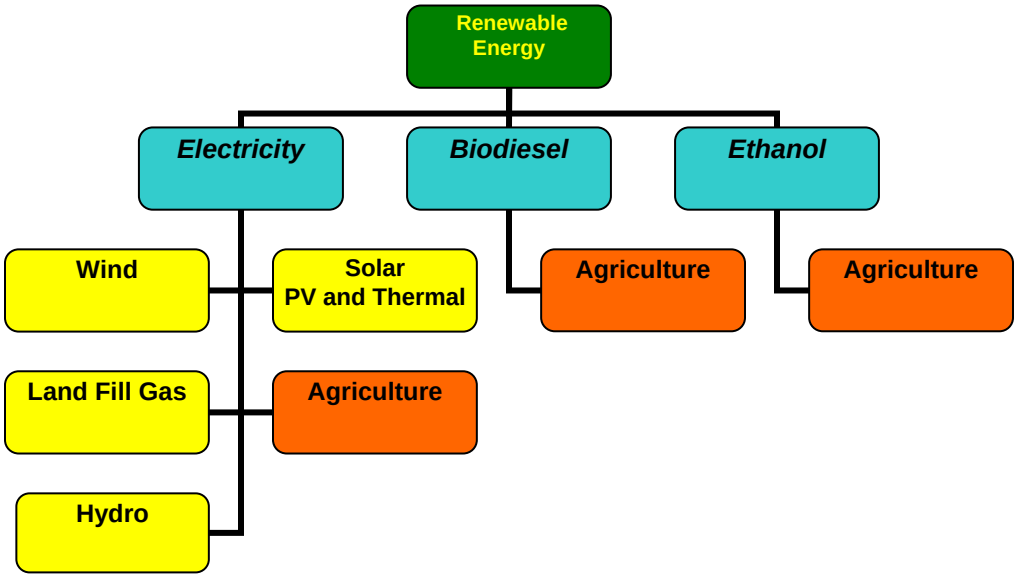


Figure 1. Renewable Energy Sources.

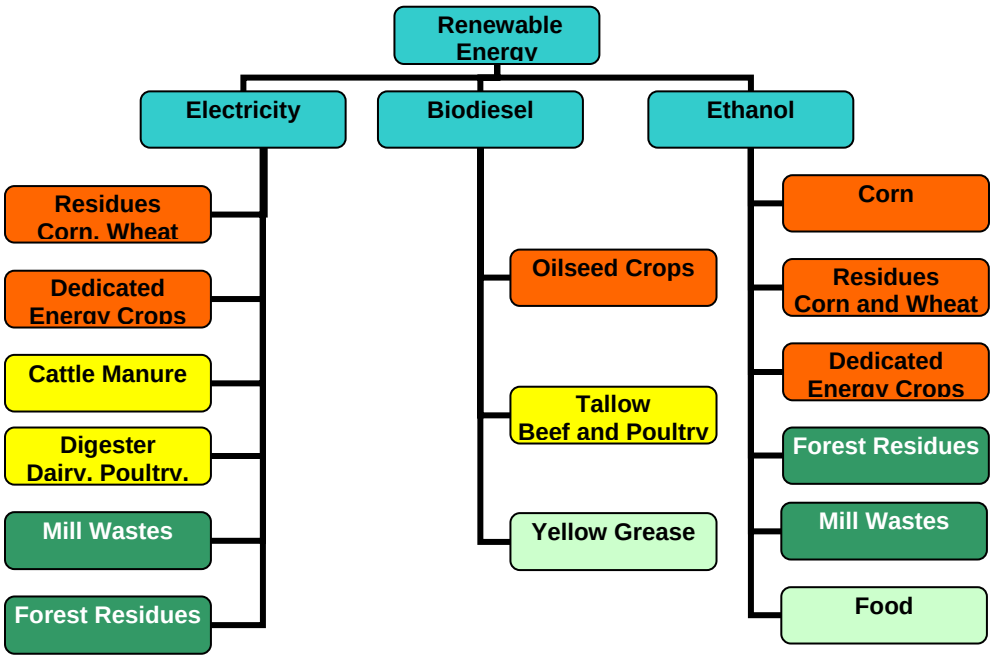


Figure 2. Bioenergy Sources.

In order to project the agricultural and economic impacts of expanded ethanol and biodiesel production, two models are employed. The POLYSYS model (De La Torre Ugarte and Ray, 2000; Ray et al, 1998a; De La Torre Ugarte et al, 1998; Ray et al, 1998b) has the unique ability to provide annual estimates of changes in land use resulting from the demand generated by bioenergy industries, including changes in economic conditions that affect adjustment costs.

While maintaining a long-term analytical horizon, the proposed research emphasizes the challenges faced by increasing competition for land from bioenergy and traditional agricultural uses. This approach accounts for adoption and the identification of short-term requirements that a market or policy incentive mechanism must meet for agriculture to remain a reliable source of feedstocks for bioenergy, without imposing significant costs to consumers. Furthermore, the POLYSYS model is linked with an input-output model, IMPLAN, to project the economic impacts of ethanol and biodiesel feedstock production and conversion.

Recently, policy initiatives to spur the development and use of bioenergy and bioproducts using starch, cellulose, oil, etc. have been enacted or proposed. President Clinton signed Executive Order 13134 calling for tripling the use of bioproducts and bioenergy in the U.S. by 2010. The Agricultural Risk Protection Act of 2002 provides for the research and development of biobased industrial products. The National Energy Supply Diversification and Disruption Prevention Act, passed in 2005, encourages the development of more renewable energy and expedites the development of environmentally responsible renewable energy projects on federal lands. In addition, the Act established a renewable fuel content requirement for the nation's fuel pool mandating 7.5 billion gallons of renewable fuels by 2012. While ethanol is the primary focus, biodiesel is also defined as an eligible renewable fuel.

The Farm Security and Rural Investment Act of 2002 establishes, among other provisions, a Federal agency program to purchase bioproducts, provides biorefinery grants to support development of bioproducts and fuels, extends the termination date of the Biomass Research and Development Act of 2000, and expands the feedstocks list for use of CCC payments to eligible producers to purchase biomass feedstocks. The long term vision of the U.S. Department of Energy calls for an increase of biomass power from 2.7 quads (1 quadrillion btus) to 4.8 quads by 2030, and for the use of biobased transportation fuels from 0.5 percent of 2001 fuel consumption to 20 percent by 2030 (USDOE, 2002a).

Use of biomass feedstocks for transportation fuels, bioproducts, and power are increasingly being viewed as opportunities to enhance energy security, provide environmental benefits, and increase economic development particularly in rural areas. Several studies have addressed various aspects of these issues (USDA-OCE, 2002a; Urbanchuk, 2001; Wang et al, 1999; House et al, 1993; Petrulis et al, 1993; USDA-OCE, 2002b; Evans, 1997; CEC, 2001; Shapouri et al, 2002; Whitten, 2000; Sheehan et al, 2002a and 2002b; Walsh et al, 2003; De La Torre Ugarte et al, 2002; English et al, 2000; USDOE-EIA, 2001a and 2001b; Delucchi, 1997; McLaughlin et al, 2002; Mann and Spath, 2001a and 2001b; and Sheehan et al, 1996).

Previous economic modeling evaluating agriculture feedstocks for energy have been conducted in the context of carbon displacement potential (McCarl et al, 2000; McCarl et al, 2001; Adams et al, 1992; Adams et al, 1999) and have analyzed long-term and intermediate-run outcomes, that is, equilibrium situations that occur during twenty or more years. Adjustment costs incurred in the short-run for implementing new technologies and/or policies are not considered by these models (Schneider, 2000). Additionally, such long-term modeling is incapable of assessing the near-term challenges of adoption. Previous economic impact modeling experience using IMPLAN for agricultural feedstocks for energy have been conducted for evaluating the: 1) economic impacts of using alternative feedstocks for coal-fired plants in the southeastern United States (English, Menard, Walsh, and Jensen, 2004), 2) economic analysis of producing switchgrass and crop residues for use as a bioenergy feedstock (English, Menard, Wilson, and De La Torre Ugarte, 2004), and 3) the potential regional economic impacts of converting corn stover to ethanol (English et al, 2001). Results from these studies included intraregional transfers of economic activity resulting from displacement of traditional energy sources such as coal and examined the impacts to the regional and state economies for selected areas of the United States.

II. Objective

Bioenergy allows for a potential win-win-win-win scenario for energy security-agriculture – rural economic development- environmental benefits. The overall objective of this report is to assess the potential impacts of increasing production of ethanol and biodiesel beyond current market levels and the levels specified in the recently enacted renewable fuel standard, and to identify the opportunities and challenges associated with such an increase in the production of biofuels. Specifically, the objective of the study is to analyze the impacts on agriculture and the economy from increased ethanol (starch and cellulosic) production. The level of production analyzed is 10, 30, and 60 billion gallons of ethanol annually by 2010, 2020 and 2030, respectively. Sensitivity to the timing of cellulosic to ethanol commercial introduction and, once introduced, the impacts it has on the corn to ethanol industry is conducted. The study also includes an assessment of the impacts of producing 1 billion gallons of bio-diesel production by 2012.

III. Methodology

The methodology, schematically displayed in Figures 3 and 4, responds to the need to perform an in-depth analysis of the agricultural sector's ability to be a significant source of energy. Figure 3 is a schematic of the process to achieve the first objective that begins with the definition of the energy targets for energy produced with agricultural feedstocks. This information plus data on conversion costs for agricultural and forest feedstock is introduced into POLYSYS to estimate the quantity and type of energy to be produced from agriculture, as well as the price, income and other economic impacts derived from producing such a level of energy production. The second diagram, Figure 4, reflects the process to estimate the overall economic impacts of producing renewable energy from agricultural feedstock. This estimation seeks not only to quantify the impacts of producing the feedstock but also the impacts of the conversion processes on the overall economy.

From the diagrams it is clear that the key analytical instrument for the first objective is POLYSYS, a dynamic agricultural sector model. For the second objective the two main components are PII, the POLYSYS IMPLAN Integrator that takes information from POLYSYS, aggregates the information to a state level and modifies IMPLAN input files, and IMPLAN, an input-output model. These models are combined to provide a detailed picture of not only the agricultural sector and potential impacts of providing energy feedstocks, but also the impacts to the economy as these feedstocks are produced, transported, and converted to energy.

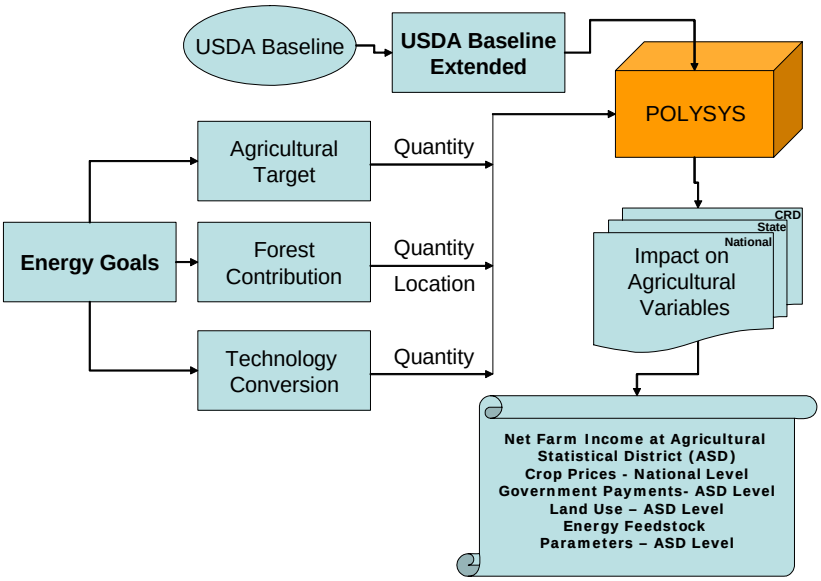


Figure 3. Process for Definition of Renewable Energy Targets and Impacts on Agricultural Variables.

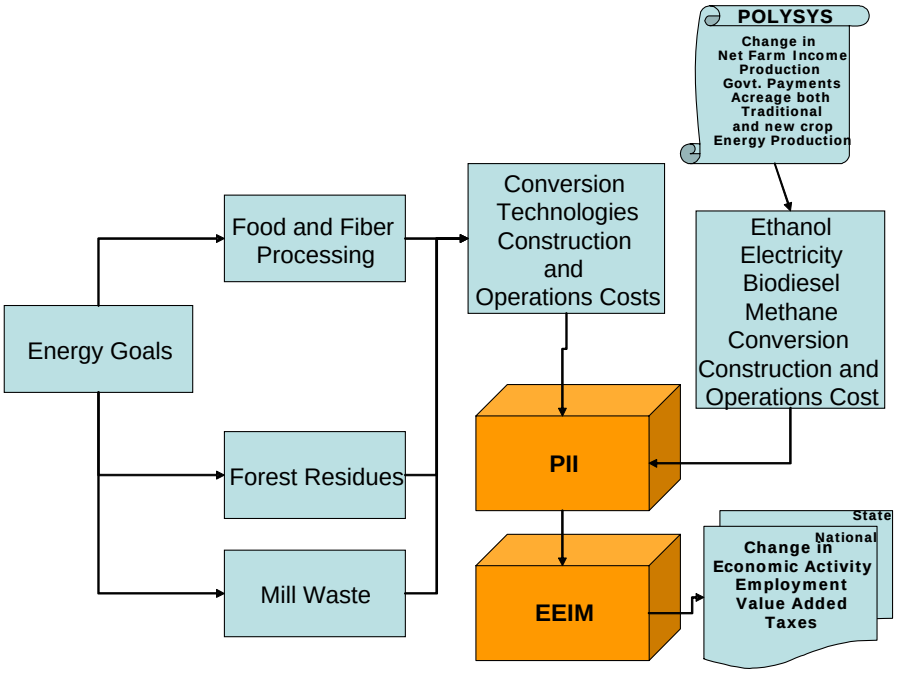


Figure 4. Process to Estimate the Economic Impacts of Producing Renewable Energy.

There are five major methodological steps before the analytical tool kit can be utilized to obtain the estimates defined in the objectives. These are:

1. **Biofuels Energy Goals**-definition of biofuels goals
2. **Conversion Technologies**-collection of the data on the conversion technologies available,
3. **POLYSYS**-update and expansion of POLYSYS, and
4. **PII/IMPLAN**-update and expansion of PII to modify IMPLAN.
5. **Defining Key Assumptions**

3.1. Biofuels Goals

As was stated in the objectives section, the biofuels goals for the study are:

- For ethanol, the goal is to reach 10 billion gallons by 2010, 30 billion by 2020, and 60 billion gallons by 2030. The distribution of this goal is presented in Figure 5, and
- For biodiesel, the goal is to reach a billion gallons by 2012. This goal and further expansion of biodiesel is presented in Figure 6.

Both Figures 5 and 6 can be compared with the recently passed renewable fuels standard of 7.5 billion gallons by 2012 for ethanol and biodiesel. A portion of this must be made of cellulosic ethanol by 2013.

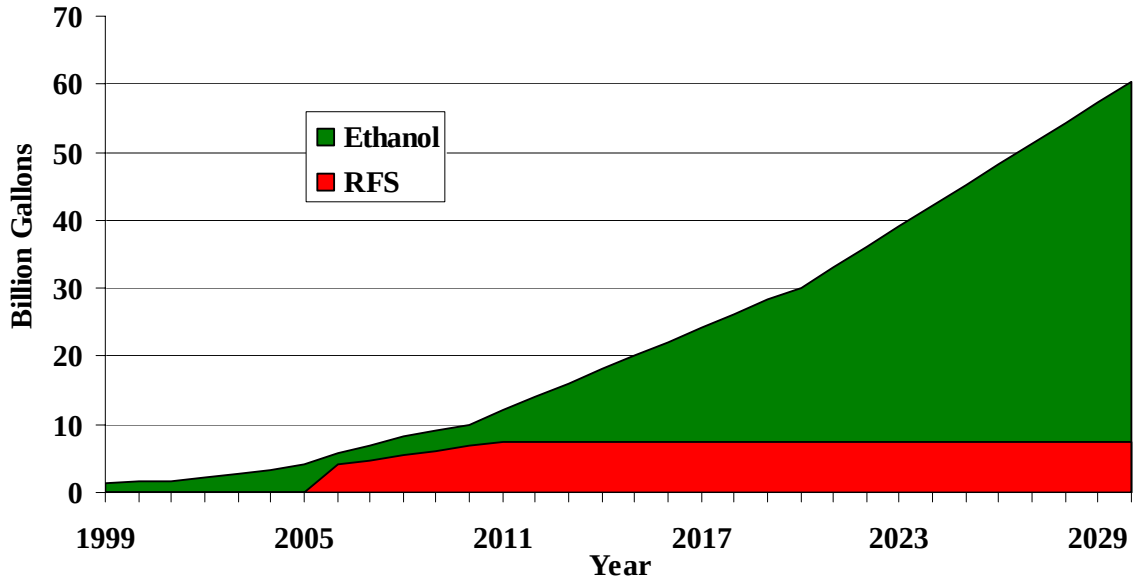


Figure 5. Ethanol Production and Production Targets with the Current Renewable Fuel Standard, 1999-2030.

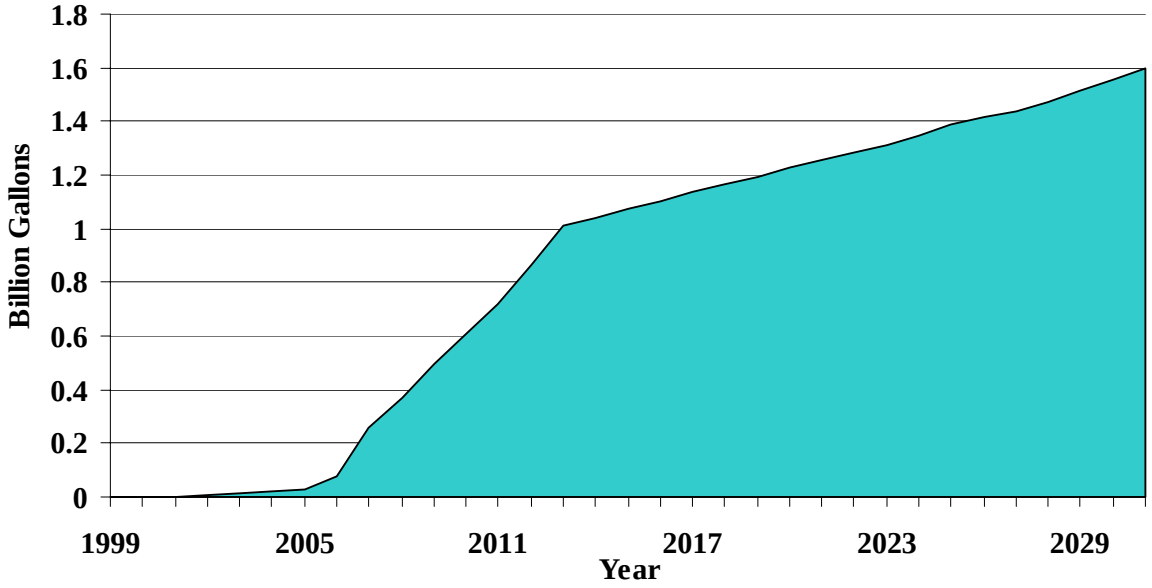


Figure 6. Biodiesel Production and Production Targets, 1999-2030.

3.2. Conversion Technologies

3.2.1 Modeling Methodology

The renewable energy conversion technologies used in the analysis and as modeling inputs for IMPLAN are discussed in this section of the report. Studies existing in the literature which provide sufficient cost data for each technology were used in allocating expenditures to the appropriate IMPLAN sectors. A summary of the conversion technologies, facility size, total industry output, employees, and cost information sources is presented in Table 1, while the detailed examples for each conversion technology are presented in Appendix A. At the top of each table in Appendix A, the conversion technology is listed, along with the total industry output for a particular type and size of facility and the number of employees. The source from which the expenditure data are constructed is also provided. Total Industry Output (TIO), an IMPLAN term, represents the annual dollar value of production of an industry. It is calculated simply as price x quantity (for example, price of ethanol per gallon x the gallon capacity of the plant).

Each table provides information regarding expenditures on investment, operating, depreciation, and byproducts. The IMPLAN sector in which the expenditure would be made to produce the particular type of energy and the sector description are provided in each table. In the far right hand column of each table, the dollar amount of the expenditure in a given sector is shown. The allocation of expenditures to each of the sectors listed is based on engineering cost data provided from the studies sourced at the top of each table. Expenditures for value added (employee compensation, proprietary income, other property income, and indirect business taxes) vary by state and are excluded from the tables.

Using the conversion technologies presented, for illustrative purposes the prices per gallon for ethanol and biodiesel were $2.11/gallon and $2.52/gallon, respectively. State averages of ethanol and biodiesel were developed from several sources. For ethanol, where splash prices were available, the state average price per gallon was used. For states where the average was not available, the average of the states in the region is used. For regions where data were not available, the average of nearby regions is used. For states where the spot was available but not rack, the spot is multiplied by 1.04, which is the average ratio of rack to spot prices for certain available cities (OPIS, 2005). The same procedure was used for estimating state-by-state wholesale prices for B-100.

Feedstock costs for ethanol from cellulosic materials are for corn stover. This value would change depending on the feedstock used to produce ethanol (dedicated energy crop, rice straw, and/or wheat straw). Likewise, for co-firing of cellulosic residues with coal, the feedstock cost is for corn stover and would change if wheat straw, dedicated energy crops, or forest, mill, and urban residues were used. The state level prices of feedstocks from dedicated crops, crop residues, and forestry resides will be recalculated by POLYSYS, but in this set of tables are assumed to be $30/dry ton.

3.2.2 Outlook for a cellulose-to-ethanol industry.

In reviewing the outlook of the cellulose ethanol industry, it may be helpful to explain some of the basic concepts involved in the process. From then it is possible to identify some of the most important players and initiatives, and eventually try to develop a timeline of next steps in the process of commercialization. It is important to point out that there are two distinctive technological pathways being pursued, enymatic breakdown and gasification.

3.2.2.1 Enzymatic Breakdown

We will begin by an overview of enzymatic breakdown. First let's try to define the overall technological problem of this pathway. Cellulose is a complex carbohydrate with hundreds of long molecular chains bound to each other. The cellulose is present in many agricultural materials. i.e. corn stover, wheat and rice straw, dedicated energy crops, wood and wood residues among others. The process of converting the cellulosic material to ethanol involves two key phases. The first phase is to break the long chains of cellulose molecules into glucose and other sugars. The second phase is to ferment these sugars into ethanol. These processes as they occur in nature are performed by different organisms: fungi and bacteria that use enzymes to free the sugar in cellulose; and other organisms, like yeasts, that ferment the sugars into ethanol.

Thus far the main challenge in producing cellulosic ethanol has been improving the biological efficiency and the cost of breaking down the cellulose into sugars. The key is to find and/or develop microbes or enzymes that can reduce the number of steps in the conversion process. However, this is not the only challenge. Once the enzyme has been developed, and its production mastered, and the system optimized to handle different sugars and to tolerate maximum levels of ethanol, then the process will be ready for commercial implementation. The ideal organisms would do it all: break down cellulose like a bacterium, ferment sugar like yeast, tolerate high concentrations of ethanol, and dedicate most of its metabolic resources to produce just ethanol.

Significant progress has been made in improving this process recently. In October of 2004, two firms working independently but both with support from the National Renewable Energy Laboratory (NREL) developed a genetically modified organism that produce large amounts of cellulose enzymes that digest cellulose efficiently. These companies were *Novozymes* a Denmark based company and *Genecor* a firm based in California. This development marked a milestone, because these enzymes were able to reduce the cost cellulose-digesting enzymes from 5 dollars per gallon in 2001 to 10-18 cents per gallon of ethanol; reducing the gap between the total cost of cellulosic ethanol and that of corn grain ethanol to 50 cents per gallons, given comparable cost of feedstock.

To keep improving the economic efficiency of the process, the new enzymes have to be integrated with more efficient pretreatment and fermentation steps. The purpose of the pre-treatment is to remove the complex hemicellulose and lignin compounds that surround plant material as a protective sheath around the cellulose. In this way the cellulose becomes more accessible to the enzymes that convert it into glucose. The improvements on the fermentation need to increase the ethanol concentration resulting from it. *Abengoa Bioenergy* an ethanol producer based in Spain will test *Novozymes*'s process at a 0.53 million gallon capacity pilot plant in York, Nebraska.

In another front, a collaborative effort between Dartmouth University and University Stellenbosch in South Africa, lead by Dartmouth professor Lee Lynd, are working in collapsing the many biological intermediate steps in the production of ethanol into a single one. They have reported significant progress in developing a yeast that can survive on cellulose alone, breaking down the complex molecules and fermenting the resultant glucose into ethanol. The group has also developed a "thermophilic" bacterium (one that naturally lives in high-temperature environments, where commercial celluloses work best) whose only fermentation product is ethanol. This technologies are been marketed by *Mascoma Corporation*, a startup company in Cambridge Massachusetts. In fact, *Mascoma Corporation* and *Tamarack Energy, In*c. of Essex

Connecticut, have agreed to collaborate on the joint development of cellulosic ethanol facilities in New York, and follow-up projects in Pennsylvania, and the New England states.

Synthetic Genomics, from Rockville Maryland, is in search for a bacterium that will do every thing. It is funding the work that scientist at the J. Craig Venter Institute to build new organisms that would produce ethanol and other biofuels.

Another significant event is the announcement by *Xethanol Corporation* of NewYork to build a 50 million gallon/year cellulosic ethanol plant in Augusta Georgia. *Xethanol* will partner with *PRAJ Technology* an India based world leader in bio-ethanol technology. The plant would be designed to process multiple cellulosic feedstocks; however it would start with the process of residues from forestry operations.

BlueFire Ethanol, a California base company has announced its intentions to build 20 cellulosic to ethanol plants in the next 6 years, with total capacity of 1.5 billion gallons of ethanol per year. For this purpose it has signed a memorandum of understanding with *MECS, Inc.* as its leads engineering and procurement contractor. *BlueFire Ethanol* was established to deploy the *Arkenol* process for the conversion of wood residues, urban-waste, and agricultural residues into ethanol.

Dupont and *Chevron* have also announced independent joint ventures to advance the conversion of cellulosic ethanol into biofuels. *Dupont* and ethanol producer *Broin* announce plans to produce biofuels from corn stover. Broin is planning to convert one of its six corn-to-ethanol plants in Iowa into a biorefinery that will use both corn grain and corn stover. *Chevron* and NREL signed a five year agreement for research and development of new production technologies for converting biomass, such as forestry and agricultural waste, into ethanol.

Iogen Corporation from Ottawa, Canada is teaming up with *Royal Dutch Shell* and *Goldman Sachs*, to expand its Ottawa pilot plant experience into a larger commercial operation. The pilot experience indicates that a larger, commercial plant will be capable of producing cellulosic ethanol at a starting price of $1.35 a gallon. That would be competitive with current gasoline prices, although it is still more expensive than the ethanol from a modern corn-ethanol plant, which the Energy Department figures at about $1 a gallon.

Toronto, Ontario-based *SunOpta Inc*. has sold a continuous process system for the conversion of biomass-to-ethanol to Dedham, Mass.-based *Celunol Corp*. The patented pretreatment and hydrolysis technology will prep and convert sugar cane biogasse and possibly hard wood waste to ethanol at a plant in Jennings, Louisiana. *Celunol/BC International* has been conducting research and development in Jennings with a small-scale pilot cellulose conversion system at an existing facility where much of the necessary infrastructure is already in place. *BC International* was renamed *Celunol* less than four months ago, and with four new venture capitalists on board the company is financially well-backed. The list of investors includes *Vinod Khosla*, founder of *Sun Microsystems*, who has heavily endorsed cellulosic ethanol as key to the future of transport fuels in the United States.

3.2.2.2 Gasification

The second pathway being pursued is through gasification of biomass through a thermo-chemical process. Through gasification the feedstock is subject to very high temperatures and converted into a synthetic gas. From there *Fischer-Tropsch* fuels are produced. The *Fischer-Tropsch* (FT) process was first developed in Germany in the 1920's. It was used in Germany during WWII and was brought to prominence by *Sasol* in South Africa to produce oil and

gasoline from coal, referred to as coal to liquids (CTL), when they were boycotted during apartheid and where it is still used. *Exxon*, *Rentech*, *Sasol* and *Shell* offer commercial processes.

The FT process requires a feed stream consisting largely of carbon monoxide and hydrogen. Thus gasification is the first step of coal liquefication or production of *Fischer-Tropsch* fuels from biomass such as corn stover (corn stalks), wood or switch grass. The feed gas, referred to as syngas, is produced in a gasifier by heating the gas to temperatures greater than than 700°C. By carefully controlling the oxygen content the hydrocarbons in the feedstock are broken down to carbon monoxide and hydrogen.

The *Fischer-Tropsch* process converts the feed gas into liquid organic compounds, carbon dioxide and water. The conversion takes place in the presence of a catalyst, usually iron or cobalt. The temperature, pressure and catalyst determine whether a light or heavy syncrude is produced. For example at 330C mostly gasoline and olefins are produced whereas at 180 to 250C mostly diesel and waxes are produced.

The *Princeton Environmental Institute* at Princeton University has been doing research on large-scale gasification and the co-production of Fischer-Tropsch fuels and electricity. Many of the component technologies of plants that could produce these fuels are commercially established. For others, some additional commercial-scale demonstration efforts are required to bring the technologies to commercial readiness, but there are no fundamental research hurdles. Key commercial demonstration needs relate to reliable feeding of low bulk-density biomass into a pressurized gasifier vessel without excessive feeding-energy requirements, high-reliability operation of commercial-scale oxygen-blown fluidized-bed gasification, complete cracking of tars by primary and/or secondary treatments, and tight process heat integration and control for maximum recovery and use of process waste heat.

This similar process in combination with coal to liquid fuels, and the integration of biomass into the process, are been explored in the state on Montana. The integrated utilization of coal and biomass, to generate syngas, the recuperation of the resulting CO2 to be employed in early oil recovery efforts presented a novel integrated generation of multiple energy production.

From the information presented here, it is evident that the cellulosic-to-ethanol technology is evolving rapidly towards commercial implementation. In most cases the different pieces of the technical puzzle are patented information, and consequently it is hard to asses the immediacy and the speed in which this industry would evolve. However, it is clear that the technological barriers are being overcome, and many processes are ready for the demonstration and even commercial phase. More than likely specifically targeted incentives and/or loan guarantees would energize the commercialization of these technologies.

3.3. POLYSYS

POLYSYS is an U.S. agricultural sector policy simulation model that includes national demand, regional supply, livestock, and aggregate income modules (De La Torre Ugarte, et al, 1998). POLYSYS is anchored to published baseline projections for the agricultural sector and simulates deviations from the baseline. In this study, a 2006 10-year United States Department of Agriculture (USDA) baseline for all crop prices, yields, and supplies (except hay) is used. This baseline, which runs through the year 2015, was extended to 2030 using the assumptions presented in Appendix B. All dollar values presented in the results on the agricultural sector impacts are in nominal dollars through 2015 and in 2015 dollars thereafter.

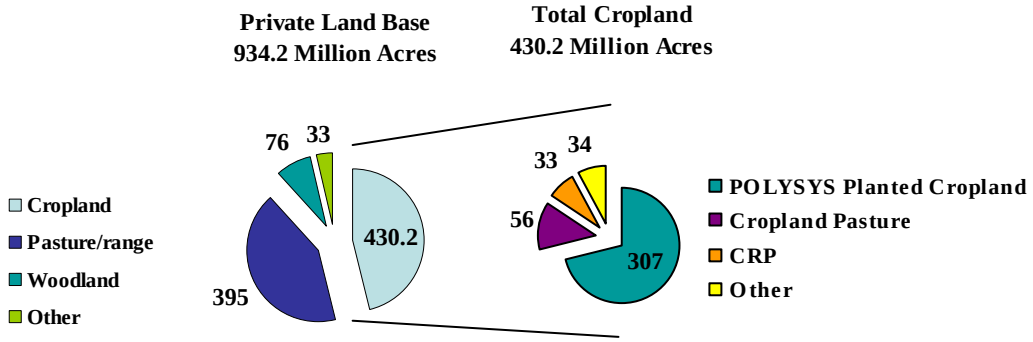
The POLYSYS model includes the eight major crops (corn, grain sorghum, oats, barley, wheat, soybeans, cotton, and rice), as well as dedicated energy crops and hay (alfalfa and other hay included). Corn and wheat residue costs and returns are added to the corresponding crop returns if profitable. POLYSYS is structured as a system of interdependent modules of crop supply, livestock supply, crop demand, livestock demand and agricultural income. The supply modules are solved first, then crop and livestock demand are solved simultaneously, followed by the agricultural income module. This project includes a bioproducts module which fills exogenous

Table 1. Summary of Conversion Technologies and Cost Information Sources.

Conversion Technology	Facility Size-Output	Facility Size-Feedstock Use	Cost Information Source
Ethan3ol from Shelled Corn (Dry Mill)	48 MM Gal/ year	17,105,455 bushels	McAloon, A., F. Taylor, W. Yee, K. Ibsen, and R. Wooley. 2000. "Determining the Cost of Producing Ethanol from Corn Starch and Lignocellulosic Feedstocks". National Renewable Energy Laboratory (NREL/TP-580-28893). Joint study sponsored by USDA and DOE; e-mail correspondence from Dr. Vernon R. Eidman
Ethanol from Cellulosic Residues (Stover, Switchgrass, Rice Straw, and Wheat Straw)	69.3 MM Gal/year	Stover 772,333 dry tons Switchgrass 984,375 dry tons Rice Straw 670,573 dry tons Wheat Straw 1,061,538 dry tons	Aden, A., M. Ruth, K. Ibsen, J. Jechura, K. Neeves, J. Sheehan, B. Wallance, L. Montague, A. Slayton, and J. Lukas. 2002. "Lignocellulosic Biomass to Ethanol Design and Economics Utilizing Co-Current Dilute Acid Prehydrolysis and Enzymatic Hydrolysis for Corn Stover". National Renewable Energy Laboratory & Harris Group (NREL/TP-510-32438).
Ethanol from Food Residues	69.3 MM Gal/year	984,375 dry tons	Aden, A., M. Ruth, K. Ibsen, J. Jechura, K. Neeves, J. Sheehan, B. Wallance, L. Montague, A. Slayton, and J. Lukas. 2002. "Lignocellulosic Biomass to Ethanol Design and Economics Utilizing Co-Current Dilute Acid Prehydrolysis and Enzymatic Hydrolysis for Corn Stover". National Renewable Energy Laboratory & Harris Group (NREL/TP-510-32438).
Ethanol from Wood Residues	32.4 MM Gal/year	500,036 dry tons	BBI International. 2002. "State of Maine Ethanol Pre-Feasibility Study". Prepared for Finance Authority of Maine.
Biodiesel from Soybeans	13.0 MM Gal/year	9,000,000 bushels	English, B., K. Jensen, and J. Menard in cooperation with Frazier, Barnes & Associates, Llc. 2002. "Economic Feasibility of Producing Biodiesel in Tennessee".
Biodiesel from Yellow Grease	10.00 MM Gal/year	80,000,000 pounds	Fortenberry, T. 2005. "Biodiesel Feasibility Study: An Evaluation of Biodiesel Feasibility in Wisconsin". University of Wisconsin-Madison, Department of Agricultural & Applied Economics. Staff Paper No. 481.

demands from the feedstock sources. The bioproducts module captures the dynamics of corn grain and cellulosic feedstocks competing to fill ethanol demand by using a searching by iteration method to find the optimal allocation of feedstocks to satisfy these demands.

There are 938 million acres within the United States that are either owned or in the hands of agricultural producers. The 2002 Census of Agriculture has determined that 430.2 million acres can be classified as cropland, while 395 million acres is classified as pastureland or rangeland (Figure 7). Of this total cropland, POLYSYS has 307 million acres available for the 8 major crops and for hay. Additionally, cropland pasture can come into production if the loss of regional pasture can be made up with additional hay production. This analysis does not include the possibility of planting and harvesting dedicated energy crops in acreage enrolled in the Conservation Reserve Program (CRP), nor does it include land currently classed as pasture/rangeland. The objective of the model is to fill projected energy demands from corn grain, soybeans, dedicated energy crops, crop residue and wood residue supplies and estimate the effects upon production, prices, acreage, government payments and net returns of all model crops and livestock.



Source: USDA, National Agricultural Statistical Service, 2004

Figure 7. Land Use by Major Use Category, 2002.

3.3.1. Crop Supply Module

The regional crop supply module consists of 305 independent linear programming regional models that correspond to USDA's Agricultural Statistical Districts (ASD). Each ASD is characterized by relatively homogeneous production. The purpose of the crop supply module is to allocate acreage at the regional level to the model crops given baseline information for regional acreage of the model crops, regional enterprise budgets for each crop, lagged prices and a set of allocation rules.

Regional baseline acreage is anchored to a national baseline, which is disaggregated to a regional level based on historical crop production and supply patterns. Once the total acreage available for crop production in each ASD is determined, the supply module allocates acres to competing crops using a linear programming model that maximizes expected returns using one-year-lagged naive price expectations.

Production from each of the 305 ASDs is determined independently and aggregated to obtain national production. Allocation rules are utilized to limit the acreage that can switch from production of one crop to another or removed from production in each ASD. These allocation rules prevent corner solutions and simulate the inelastic nature of agricultural supply. For a full description of the land allocation rules, see the methodology section of *The Economic Impacts of Bioenergy Crop Production of U.S. Agriculture* (De La Torre Ugarte, et al, 2003).

In regions where dedicated energy crops are determined to be profitable, some pasture can be made available to both dedicated energy crops and any other crop. Additionally, in order for pasture acreage to come into production, the loss of regional forage production must be replaced with new regional hay production. The Agricultural Census of 2002 (USDA, 2004) lists 56 million acres as "crop acreage in pasture". This application makes these lands available to be converted into other crop production. A condition for this to occur is that hay acreage must replace the lost forage productivity regionally of the lost pasture acreage. Regional pasture yields are taken from English, et al, 1989. For each region annually, the amount of pasture that can potentially switch into other crops is determined by:

$$P_{out} = \%H_{avail} * H_{acres} * H_{yield} / P_{yield}$$
$$H_{in} = P_{out} * P_{yield} / H_{yield}$$
$$NG_{pot} = P_{out} - H_{in}$$

where:

P_{out}	is the amount of pasture that can come out of pasture if available,
$\%H_{avai}$	is the percentage of current hay total acreage that can expand,
H_{acres}	is the current hay total acreage,
H_{yield}	is the yield per acre of hay,
P_{yield}	is the yield per acre of pasture,
H_{in}	is the acres of hay that will come in to replace $P_{out,}$ and
NG_{pot}	is the potential net gain in acreage.

The actual net gain in land available to other crops from pastureland is constrained through several mechanisms: 1) only pasture classified as historical cropland is available, 2) pasture can only come in at the rate at which hay acreage can grow, 3) hay lands must replace lost forage production at regional hay yield levels, and 4) there must be a crop with positive net expected income to absorb the new land available. Through this filtering process, substantially less than the 56 million acres of "crop acreage in pasture" actually comes into production and less still into production of other crops besides hay.

3.3.2. Crop Demand Module

The crop demand module estimates national-level demand quantities and prices using elasticities and changes in baseline prices. Crop utilization is estimated for domestic demand (food, feed, and industrial uses), exports, and stock carryovers. Derivative products such as soybean oil and meal are also included. Demand quantities are estimated as a function of own and cross price elasticities and selected non-price variables such as livestock production. The crop prices are estimated using price flexibilities and stock carryovers are estimated as the residual element. The income module uses information from the crop supply, crop demand, and livestock modules to estimate cash receipts, production expenses, government outlays, net returns, and net realized farm income.

3.3.3. Livestock Module

The livestock module is an integrated version of the Economic Research Service (ERS) econometric livestock model (Weimar and Stillman, 1996) that interacts with the crop supply and demand modules to estimate livestock production, feed use, and market prices. Livestock production levels are a function of lagged livestock and feed own and cross prices, as well as the baseline levels and exogenously determined variables such as livestock exports. The livestock sector is linked to the supply and demand modules principally through the feed grain component. Livestock quantities affect feed grain demand and price, and feed grain prices and supply affect livestock production decisions. Exports and imports of livestock products are exogenous to the model.

3.3.4. Biomass Feedstock Sources

While forest residues, wood from fuel reduction forest management practices, and mill wastes are included in the analysis, the potential for forestry is understated in this analysis. Standing timber is not incorporated into the potential supplies of cellulosic materials (Figure 5).

Much of the land that is suitable for timber may not be suitable for dedicated energy crops such as switchgrass. In the South where pulpwood stumpage fees are on the decline and an additional market for these managed forests is being sought, this acreage will likely play a role in meeting the nation's renewable energy needs. Because of limitations in the model and data related to forestry, no standing trees were used to meet the renewable energy goal. With 33 percent of the United States' land area in forests and with 58 percent of the forest land in nonindustrial private land ownership, the use of such for energy conversion would, of course, impact the degree of change in crop acreages and, no doubt, other study outcomes.

3.3.4.1. Dedicated Energy Crop

Energy crops may come from a variety of sources in the future. Examples of such crops include switchgrass, hybrid poplar, energy cane, giant reed, giant miscanthus, and napier grass. Since 1975, the Department of Energy has been conducting feedstock selection experiments. In the 1990's under budgetary constraints, DOE decided to focus their efforts on switchgrass. For the purposes of this study, switchgrass is selected as a model crop representing all the various alternative dedicated energy crops. Switchgrass is a perennial native grass that has a large native range. Switchgrass can be grown from Colorado to the East Coast of the U.S. and from the Gulf Coast into Canada. Switchgrass yields in some areas can exceed 10 tons per acre and does not require large amounts of inputs. It should be noted that other crops such as hybrid poplar, energy cane, giant reed, giant miscanthus, Napier Grass, and willows could provide higher yields at a lower cost in some areas of the country.

To evaluate the potential of dedicated energy crops to provide feedstocks to the bioproduct market, potential geographic range, yields, and enterprise budgets of switchgrass are incorporated within POLYSYS. For the purpose of this analysis, the geographic ranges where production can occur are limited to areas where switchgrass can be produced with high productivity under rain-fed moisture conditions. Geographic regions and yields are based chiefly on those contained in the Oak Ridge Energy Crop County Level Database (Graham, et al, 1996). The production of switchgrass included in this analysis is assumed suitable on 368 million of the total 430.2 million acres included in POLYSYS. Switchgrass yields, by ASD, range from an annual rate of 2 to 6.75 dry tons per acre (dt/ac) depending on location. Switchgrass is not a crop option in western arid regions.

In this application, switchgrass is not available in the first two years of simulation. Currently, in the United States, switchgrass is not produced as a dedicated energy feedstock, although it is grown on some CRP acres and on hay acres as a forage crop. The lack of large-scale commercial production plus the lack of switchgrass seed necessitates a lag time before switchgrass can become a feedstock for ethanol or other bioproduct production. A minimum of two years to begin large scale switchgrass production is assumed.

Switchgrass expected prices are a function of one year lagged market prices. Once planted, the expected yields for switchgrass remain fixed for the life of the production rotation. Also, once acres are planted into switchgrass, they remain in switchgrass through the end of the simulation.

3.3.4.2. Crop Residues

To evaluate the potential of crop residues to provide feedstocks to the bioproduct markets, POLYSYS includes corn stover and wheat straw response curves that estimate stover and straw quantities (dt/ac) as a function of corn and wheat grain yields, and stover and straw production costs as a function of yields of removable residue (dt/ac). The removal of corn stover and wheat straw raises environmental quality issues such as erosion, carbon levels, tilth, moisture, and long-run productivity. The analysis accounts for quantities of stover and straw that must remain on the field to keep erosion at less than or equal to the tolerable soil loss level. The methodology for estimating quantities that must remain takes into account soil types, slope, crop rotations, type and timing of tillage plus other management practices, including climate zones among other factors (Nelson, 2002). The estimated response curves incorporated into POLYSYS were obtained through the DOE Oak Ridge National Laboratory (ORNL) (Walsh et al, 2003).

The quantities of corn stover and wheat straw that can be removed are the amounts of stover or straw produced minus the highest of the estimated residue quantities needed to control for rain and wind erosion, along with soil carbon. Corn and wheat grain yields (bushel/acre) are converted to biomass quantities (dt/ac) using standard grain weights (lb/bu), moisture content, and residue to grain ratios (Heid, 1984; Larson, et al, 1979). Corn and wheat yield quantities are those used in POLYSYS. Total quantities of corn stover and wheat straw that can be collected in each county are estimated for each tillage and dominant crop rotation scenario and weighted by the number of acres using each tillage practice (Conservation Tillage Information Center, 2004).

The costs of collecting corn stover and wheat straw include baling and staging (loading on bale wagon and moving to field edge). Cost of nutrient replacement is included in the estimated collection costs. Costs are estimated as a function of the residue that can be removed (dt/ac).

The choice of whether residues are harvested from a particular county is determined by figuring the difference between the cost of collecting residues to the edge-of-field and the market revenue generated. If positive, the residues are harvested from all county corn or wheat acres. Expected prices are current year residue prices. Current year prices are used because the choice to harvest residues can be made on already planted acres.

3.3.4.3. Wood Residues

Forest residues, mill wastes, fuel treatments and forestland thinnings are included in the model as wood residues for conversion to bioenergy. We assume 46 million dry tons (mil dt) of forest residues, 67 mil dt of mill residues, 60 mil dt of fuel treatments and 52 mil dt of

forestlands thinnings are available for a total of 352 million dry tons. The price at which these feedstocks come into use is determined by regional harvesting costs plus transportation costs.

3.3.4.4. Yellow Grease and Tallow

Along with yellow grease, tallow from beef, food and poultry waste is used as a feedstock for bio-diesel production. Beef and poultry wastes are modeled as a function of beef and poultry cash receipts, respectively. Yellow grease from food waste is a function of population.

3.3.5. Optimal Feedstock Allocation

POLYSYS was modified to allow the biomass feedstocks (dedicated energy crops, corn stover, wheat straw, wood residue) to compete with corn grain feedstock in the production of ethanol. Because ethanol demand is such a large user of agricultural feedstocks, changes in feedstock mix will affect the market price of feedstocks and, therefore, total ethanol costs. An iterative process is used to find the annual feedstock mix where the cost of producing ethanol from corn grain is equal to the cost of producing ethanol from biomass.

Figure 8 shows the process of balancing the feedstock quantities so as to arrive at an equivalent price of ethanol from either corn grain or biomass. In the first iteration, ethanol demand is filled with corn grain. The crop module then responds with a high corn price resulting from the increased level of corn demand. At this point, the price of ethanol made from corn grain is used to figure a corresponding price for biomass that would produce ethanol at the equivalent price. The corresponding price of biomass is derived by the following equation:

$$CORPRC_{biomass} = (Pcorn / TECH_{corn} + CONV_{corn} - CONV_{biomass}) * TECH_{biomass}$$

Where:

$CORPRC_{biomass}$	is the corresponding price of biomass,
P_{corn}	is the price of corn grain,
$TECH_{corn}$	is gallons of ethanol per bushel of corn grain,
$CONV_{corn}$	is the conversion cost of corn grain to ethanol per gallon,
$CONV_{biomass}$	is the conversion cost of biomass to ethanol per gallon, and
$TECH_{biomass}$	is the gallons of ethanol per dry ton of biomass.

The extra cost of transporting biomass feedstocks from the farm gate to the production facilities is added to all biomass bioproduct conversion costs. The transportation cost is estimated at $8.85 per ton based on 2005 transportation cost estimates provided by Dager (2005) and assumes a one way maximum distance of 50 miles. The corresponding price of biomass is compared to the current iteration's price of biomass. If the corresponding price is higher than the iteration price, then it indicates that ethanol made from corn grain is more expensive than ethanol made from biomass. In this situation, the price of biomass is increased and the next iteration takes place. The higher biomass price will result in a positive supply response in the next iteration, thereby displacing some of the corn grain demand and lowering corn grain price. The iterations continue until the corresponding price of biomass is equal to current iteration biomass price. Once this is achieved and equivalent ethanol costs of production exist, the model has determined the optimal market level of feedstock quantities. But if biomass price can continue to drop below the corresponding corn price and still fill ethanol demand, it is allowed to do so. In

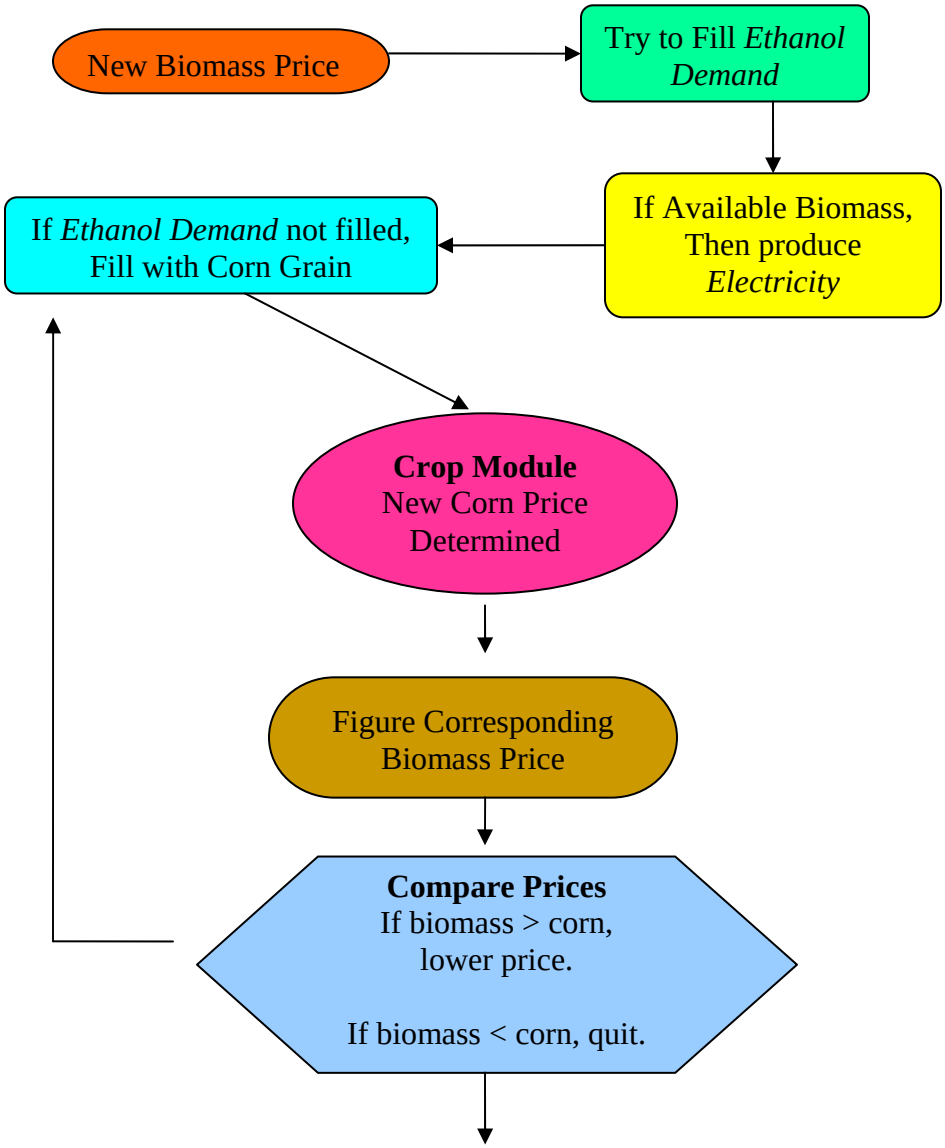


Figure 8. Schematic of the Methods Employed to Determine Feedstock Price Required to Meet Ethanol Demand.

this situation, corn grain use for ethanol cannot fall below the previous year's use. This results in biomass filling all increases in ethanol production because it can produce ethanol cheaper than corn grain.

Because ethanol is the dominant bioproduct that can use either biomass or corn grain, its feedstock allocation determines market prices. In instances where the iterative solution results in a price that brings in slightly more biomass than is necessary to fill ethanol demand, the excess is used in electricity production.

Distiller's dry grains from ethanol production and soybean meal from biodiesel production are integrated within the model to evaluate how their quantities and prices affect the

final market equilibrium. For every bushel of corn grain (56 pounds) used in ethanol production, 18.3 pounds of distiller dry grains are produced. It is assumed that distillers dry grains substitutes for livestock corn grain demand. One ton of distillers dry grain displaces 35.71 bushels of corn feed demand (Bullock, 2006).

Credit from the market revenue of distiller's dry grains to the production of ethanol reduced total production costs of ethanol. The market price of distiller's dry grains is estimated by the following equation:

$$DDG_{prc} = 22.7 + 30.80 * (Corn_{prc})$$

$$(R^2 = .96)$$

Where:

DDG_{prc} is the price per ton of distillers dry grains, and
$Corn_{prc}$ is the price per bushel of corn grain.

For every bushel of soybeans (60 pounds) used in biodiesel production, 45.5 pounds of soybean meal are produced. The soybean meal byproduct enters into the POLYSYS soybean product module where price are endogenously determined. The revenue from the sale of soybean meal is credited to the production of biodiesel and acts to reduce the total production costs.

3.3.6. Conversion Costs and Coefficients

The conversion costs and technical coefficients used in the model can be found in the document entitled, Economic Implications to the Agricultural Sector of Increasing the Production of Biomass Feedstocks to Meet Bio-power, Bio-fuels, and Bio-product Demands (De La Torre Ugarte et. al., 2006). A few technical improvements are assumed for the extension through 2030. Conversion coefficients of cellulose to ethanol were increased linearly for stover, straw and dedicated energy crops from 2015 to 2030 to final coefficients of 87.9, 83.2 and 90.2 gals per ton respectively. The conversion of corn grain to ethanol is assumed to increase from 2.7 gals per bushel in 2014 to 3.0 gals per bushel in 2019, and thereafter remain steady. Biodiesel is also assumed to increase from 1.4 gals per bushel in 2014 to 1.5 gals per bushel in 2019 and thereafter remain steady. Wood residue is also added as a feedstock for conversion to ethanol. Wood residue technical coefficients were derived by adjusting dedicated energy crops coefficients by the difference in BTU content. The ratio of dedicated energy crops to wood BTU content is assumed at 1.0625.

3.4. PII / IMPLAN

3.4.1. IMPLAN

IMPLAN employs a regional social accounting system and can be used to generate a set of balanced economic/social accounts and multipliers (MIG, 2006). The social accounting system is an extension of input-output analysis[1]. The model uses regional purchase coefficients generated by econometric equations that predict local purchases based on a region's

[1] Input-output (I-O) analysis, also know as inter-industry analysis, is the name given to an analytical work conducted by Wassily Leontief (1936) in the late 1930's. The fundamental purpose of the I-O framework is to analyze the interdependence of industries in an economy through market-based transactions.

characteristics. Output from the model includes descriptive measures of the economy including total industry output, employment, and value-added for over 500 industries in state's economy. Total industry output is defined as the value of production by industry per year. In the economic impacts results, total industry output is expressed in 2006 dollars.

The model also can be used for predictive purposes by providing estimates of multipliers. Multipliers measure the response of the economy to a change in demand or production. Multiplier analysis generally focuses on the impacts of exogenous changes on: a) output of the sectors in the economy, b) income earned by households because of new outputs, and c) jobs that are expected to be generated because of the new outputs. The notion of multipliers rests upon the difference between the initial impact of an exogenous change in final demand (final use and purchases of goods and services produced by industries) and the total impacts of the change.

Direct impacts measure the response of a given industry to a change in final demand for the industry. Indirect impacts represent the response by all industries in the economy to a change in final demand for a specific industry. Induced impacts represent the response by all industries in the economy to increased expenditures of new household income and inter-institutional transfers generated from the direct and indirect impacts of the change in final demand for a specific industry.

This study uses Type I and Type SAM (Social Accounting Matrix) multipliers. Type I multipliers are calculated by dividing direct plus indirect impacts by the direct impacts. Type SAM multipliers are calculated by adding direct, indirect, and induced impacts and then dividing by the direct impacts. The Type SAM multipliers take into account the expenditures resulting from increased incomes of households as well as inter-institutional transfers resulting from the economic activity. Therefore, Type SAM multipliers assume that, as final demand changes, incomes increase along with inter-institutional transfers. Increased expenditures by people and institutions lead to increased demands from local industries.

A variety of economic impacts would result with a movement away from non-renewable energy sources to renewable ones. There are numerous annual impacts that occur to the agricultural sector as a result of projected changes in crop acreage, crop prices, and government payments by POLYSYS, and the addition of an energy crop (switchgrass). The operation of the bioenergy conversion facilities also has an annual impact on the economy. New facilities will require employees, expenditures on inputs, and will increase the total industry output of the renewable energy sector. There will also be one-time construction impacts. Transportation of the energy feedstocks and the output from these firms will also occur. These impacts can not be estimated until firms are actually located. Knowledge of the available infrastructure and the methods (for example, truck, train, or barge) used to transport the commodities are needed before impacts to the economy as a result of energy transportation can be determined.

Switchgrass, an energy feedstock, is not currently produced as a dedicated energy source in the United States, although it is grown on some CRP acres and on hay acres as a forage crop. The lack of large-scale commercial production results in dedicated energy crops not being identified in the IMPLAN model. Thus, its production must be added to the IMPLAN state models if POLYSYS projects dedicated energy crops production to occur in that particular state. This is achieved through a weighted aggregation scheme. Expenses by IMPLAN sector are summed over each region within a state and divided by total sales of dedicated energy crops using the following equation:

$$GAC_{m,i,j} = \sum_{j=1}^{n}(COSTi,j,k * ACRE_{m,j,k}) / \sum_{j=1}^{n}(Q_{m,j} * P)$$

i = 1 to 48 for the number of states,
j = 1 to n for the number of ASD's with in a state,
k = 1 to 509 for the number of IMPLAN sectors,
m = POLYSYS' solution year – 2005 through 2013,

where:

$GAC_{m,i,j}$ is the gross absorption coefficient representing the amount spent in year (m) in sector (k) in state (i) per dollar of output,

$COST_{i,j,k}$ is the amount spent in IMPLAN sector (k) in state (i) and ASD (j) in dollars per acre,

$ACRE_{m,j,k}$ is the acres planted in dedicated energy crops in state (i) and ASD (j),

$Q_{m,j}$ is the quantity of dedicated energy crops produced in state (i) and ASD (j) in tons, and

P is the national price for dedicated energy crops in dollars per ton.

These coefficients represented a state's bio-feedstock production function and are inserted into a blank industrial sector in IMPLAN. The state model is then solved with a bio-feedstock total industry output equaling the gross returns determined from the POLYSYS solution for each ASD aggregated to the state.

3.4.2. POLYSYS/IMPLAN Integrator (PII)

Economic impacts resulting from national policy changes can be evaluated using state IMPLAN models. Numerous publications have taken results from a national model and used those results in IMPLAN to show what impacts would occur to a state or a region's economy. However, in this study, there is a need to take the impacts from an interregional multi-state model that is national in scope and project the potential impacts changes in policy has on the nation's economy. The interface program, the POLYSIS/IMPLAN Integrator (PII), developed at The University of Tennessee, takes POLYSYS acreage, price, change in government programs, and cost output and makes two major types of changes to IMPLAN databases (English, Menard, Wilson, and De La Torre Ugarte, 2004). First, the program adds an energy crop sector to IMPLAN based on production and cost information supplied by the POLYSYS results for each of the 48 contiguous states. Next, agricultural impacts that occur as a result of projected changes in the agricultural sectors are placed in each state's IMPLAN model incorporating POLYSYS projected changes in crop production, prices, and income. A renewable energy sector is added to each state's model, and the impacts from the renewable energy sector are estimated. The model can also estimate the investment impacts of developing the renewable energy sector.

The integrator, PII, written in Visual Basic and taking advantage of IMPLAN's data structure, provides a method to solve IMPLAN at the state level and determine regional economic impacts as a result of changes in agricultural production practices, policies, prices, government payments, and/or technology adoption. The resulting reports generated from the analysis summarize, via graphs and maps, the economic impacts as measured by changes in total industry output, employment, and value added. In addition, tabular information is presented for use in the analysis. For the purposes of this report, three impacts are reported: a) the impacts to the agricultural sector, b) the impacts to the renewable energy sector, and c) the impacts that occur as a result of interstate commerce. The impacts that occur from interstate commerce can not be allocated to any particular state, and consequently, the maps do not incorporate these

impacts. They occur as a result of input purchases across state lines, as well as the impacts that occur as a result of a flow of income from one state to another.

3.4.2.1. Impacts to the Agricultural Sector

Production, prices, and acreage from each of the 305 (ASD) are determined independently and aggregated to obtain information at the state level for barley, corn, cotton, hay, oats, rice, sorghum, soybeans, dedicated energy crops, wheat, corn stover, and wheat straw. In addition, information on the cost of production of dedicated energy crops by ASD is transferred from the POLYSYS solution, along with national energy production estimates for electricity generated from fuel sources, including animal waste, food waste, and wood; ethanol generated from corn, corn stover, wheat straw, dedicated energy crops, and wood; and biodiesel from yellow grease and soybeans. To incorporate the POLYSYS data into IMPLAN for the agricultural (non forest) impacts, the following procedure was followed: 1) the change in Total Industry Output (TIO) is calculated for corn, sorghum, oats, barley, wheat, soybeans, cotton, and rice including changes in proprietary income and government payments; 2) for states growing dedicated energy crops and/or using corn stover and wheat straw, TIO, Employment, Total Value Added (employee compensation), and the Gross Absorption Coefficients (GACs) are calculated for a new agricultural fuel feedstock industry; 3) Total Revenue (TR) from POLYSYS is equated to TIO and is calculated by multiplying the price of the cellulose by the quantity produced; 4) the demands for inputs are represented by GACs and are developed by dividing cellulose input expenditures by TIO; and 5) labor costs and the number of employees are estimated (English, Menard, Wilson, De La Torre Ugarte, 2004).

3.4.2.2. Impacts to the Renewable Energy Sector

Based on information from POLYSYS and the non-agricultural energy goals plus the target goal, a renewable energy sector is created consisting of a weighted mix of conversion facilities. Quantities of electricity, ethanol, and biodiesel produced in each state from agricultural and non-agricultural renewable fuel types are estimated. These quantities are then used as weights to develop the estimated input expenditures required to meet the projected state level of production and inserted as GAC's into the model. Based on 2002-2004 energy prices, the total industry output is estimated and the sector impacted by that amount to determine induced and indirect effects. Finally, investment impacts are estimated using the number of facilities required to meet electric demand in each state assuming that the impacts occurred in the year that the facility was needed to meet renewable energy demand.

3.4.2.3. Impacts That Occur As A Result Of Interstate Commerce

Production of energy will result in interstate commerce, which results in leakages in a state model, but increased economic activity in a national model. To capture these effects, the US model is constructed in manner similar to each of the state models. The results are then compared to the sum of the state model impacts and the difference is assumed to occur as a result of interstate commerce.

3.5. Key Study Assumptions

Rapid development of the bioenergy sector will be reliant on a strong investment in agricultural research and technology. This will not only increase the competitiveness of bioenergy products, but it will also reduce the cost of the transition to this new industry. In this

analysis, the impacts of development of the bioenergy sector with increased agricultural productivity from research and development are compared with impacts under the baseline.

A summary of key assumptions and descriptions of these assumptions is provided below in Table 2. The text following the table provides more detail regarding several of these key assumptions.

Table 2. Key Study Assumptions and Descriptions.

Key Assumptions	Descriptions
Ethanol and Biodiesel Goals	Ethanol-10 billion gallons by 2010, 30 billion by 2020, and 60 billion by 2030. Biodiesel-1 billion gallons by 2012, with an additional .6 billion gallons from yellow grease and tallow by 2030.
Cellulose to Ethanol Availability	Cellulosic to ethanol technology becomes commercially available in 2012.
Dedicated Energy Crops	Switchgrass serves as a proxy for dedicated energy crops. Hybrid poplar and willow, along with many other species, are potential energy crops in certain areas of the country.
Dedicated Energy Crops Yield	Yields increase over time at rates ranging from 1.5 percent to 5 percent, depending on region.
No Till Adoption	Adoption of no tillage increases from 20 percent to 55 percent over time.
Land Base	Includes 307 million acres of cropland in major crops plus hay and 56.2 million acres of cropland in pasture.
Yield of Traditional Crops	Yields increase over time. The rate of increase between 2006 and 2015 is taken from the USDA Baseline. From 2015 to 2030, the rate of yield increase is 50 percent above the USDA trend.
Agricultural Feedstocks	Ethanol-Corn grain, corn stover, wheat straw, dedicated energy crops (switchgrass). Biodiesel-Soybeans, tallow, and yellow grease.
Wood Based Feedstocks	Ethanol-Forest residues, mill wastes, fuel treatment and forestland thinnings. Future development as wood (willow and hybrid poplar) for dedicated energy is proxied by switchgrass in this study. Harvesting of standing stock for feedstocks is not included.
Distiller's Dry Grains (DDG)	Maximum usage of DDG's in food animal diets is 30 percent for beef cattle and 10 percent for dairy cattle, hogs, and broilers.

3.5.1. Dedicated Energy Crops Yield

To date, most of the seed improvement in switchgrass has been limited to seed selection, but there are significant gains that can be achieved from the use of modern seed improvement

research and technology. To reflect this potential, dedicated energy crops base yields are increased each year, starting in the first year of dedicated energy crops production (2012). The rates of yield increase vary regionally (Table 3). To account for increased harvesting costs as yields rise, total costs are increased at the rate of 5 percent per ton increase in yield.

Table 3: Changes in Dedicated Energy Crop Yields Assumed Through the Year 2030.

REGION	Base Yield	Annual Breeding Gains	Projected Yields 10 Years	Projected Yields 20 Years
		Tons/Acre		
Northeast	4.87	1.5%	5.6	6.3
Appalachia	5.84	5.0%	8.8	11.7
Corn Belt	5.98	3.0%	7.8	9.6
Lakes States	4.8	1.5%	5.5	6.2
Southeast	5.49	5.0%	8.2	11.0
Southern Plains	4.3	5.0%	6.5	8.6
North Plains	3.47	1.5%	4.0	4.5

Source: Role of Biomass in America's Future (RBAEF), ALMANAC Simulation.

3.5.2. Adoption of No-till Practices

Residues from the production of corn (corn stover) and the production of wheat (wheat straw) are likely to be important sources of cellulosic material. These residues are already part of the production system and an increase in the use of reduced and no till practices could increase availability without affecting the amount of residues that need to be left in the ground for erosion control and soil sustainability. Burning wheat stubble is a common practice in certain regions of the country. This practice improves yield by reducing disease potential. Tillage use is changed from baseline to increase reduced and no-till for corn and wheat following the path listed in Table 4.

Table 4. Change in Percentage Tillage Mix for Corn and Wheat.

Year	Conventional Tillage	Reduced Tillage	No Tillage
		Maximum Percent Allowed	
2005-2010	60	20	20
2011-2015	55	20	25
2016-2020	40	20	40
2021-2025	25	20	55
2025-2030	25	20	55

3.5.3. Augment the Landbase

This study focuses on the use of cropland, and one of the uses of cropland is pasture. This includes land that has been previously used for crop production that has shifted to pasture use. According to the last Census of Agriculture, 56.2 million acres of cropland are currently being used for pasture. An increase in the intensity of the management of this cropland could free a significant portion of the acreage for crop production, especially for dedicated energy crops.

In a 2005 study on the willingness to grow switchgrass among Tennessee farmers, about 29.3 percent would be willing to produce switchgrass if profitable, while another 46.7 were not certain (Jensen, et al, 2005). If the ratio of yes to no (54.8 percent of those with an opinion) was assumed for those not certain, potentially as high as 55.9 percent would consider growing switchgrass with additional information. Producers were also asked the amount of acreage they might convert and their net farm income. These numbers and cost of production estimates were used to arrive at estimates of how much switchgrass might be produced at various price levels of switchgrass. Among those who said they would grow switchgrass, projections were that at just over $55 per ton for switchgrass, about 61.8 percent of the producers who said yes would be willing to convert acreage to switchgrass. Multiplying 61.8 percent by the 55.9 percent above suggests that 34.5 percent would convert some acreage at $55 per ton. At $55 per ton or less, the average acreage converted per farm was about 70 acres. Using the Census of Agriculture estimate of 19,684 producers with at least $10,000 in sales, the number of producers who might convert acreage at $55 per ton would be around 6,800. Multiplying this by 70 acres gives about 475,708 acres to be converted. The total acreage of pasture from cropland in the state according to the 2002 Census of Agriculture was 2,066,097. Hence, the projected acreage converted based on the above study estimates is about 23 percent of the state's pasture from cropland.

Following these findings, cropland in pasture in the areas in which energy dedicated crops can be produced is allowed to shift back into production. The increase in intensity is reflected through a requirement that if pasture is converted rather than hay, then additional hay production must occur to produce an equivalent of feed.

3.5.4. Yields of Traditional Commodities

Yields of traditional crops are assumed to increase beyond the baseline yields assumed under the USDAExt scenario. The rationality of this assumption is that as energy use becomes an important demand for agricultural sector, the prices for traditional uses would increase and generate additional incentives for the introduction of new technology and improved production practices, resulting in additional yield gains.

This implies that the efforts for yield improvement should not only be dedicated to the cellulosic sources, but should also include traditional crops as they are also potential energy feedstocks – corn, soybeans, and crop residues. To simulate yield improvements over time, this outlook scenario increases the rate of growth in yields by 50 percent compared with the yield growth rate in the USDAExt scenario.

Table 5 lists the annual rate of growth in yields under the USDAExt and the bioenergy outlook. The change in the annual rate of growth in yields under the bioenergy outlook takes effect in the year 2016 and beyond.

Table 5. Crop Yields under Bioenergy Outlook.

	Projected Percent Growth in Yields		National Average Projected Yields Under Bioenergy Outlook	
Crop (unit)	USDAExt	Outlook*	2015	2030
	Percent Change		Units	
Corn (bushels)	1.13%	1.69%	163.90	193.76
Sorghum (bushels)	0.76%	1.13%	69.00	77.24
Oats (bushels)	0.61%	0.91%	69.00	75.58
Barley (bushels)	0.88%	1.31%	69.80	79.53
Wheat (bushels)	0.88%	1.32%	46.30	52.78
Soybeans (bushels)	0.93%	1.39%	44.30	50.85
Cotton (pounds)	0.43%	0.64%	805.0	858.0
Rice (pounds)	0.79%	1.19%	7477	8417

* The growth in yields over time under the USDAExt scenario is multiplied by 1.5 to obtain a 50 percent increase in the rate of growth of yields over time for the bioenergy outlook.

3.6. Scenarios

The focus of the analysis is on comparing three scenarios which all have the same energy goal. Since the objective of the study is to assess agriculture's ability to produce sufficient ethanol to meet a 60 billion gallon goal by 2030, no specific assumptions are made about the mechanisms to achieve this ethanol demand. The basic purpose is to estimate the impacts to the agricultural sector and each states economy if the target is achieved.

To adequately interpret the results coming from POLYSYS, it is important to refer the simulation values to the baseline scenario (USDAExt). The baseline represents the best estimate of what would be occur without meeting the expanded energy goals. The results from the extension of the 2006 USDA baseline, USDAExt, are provided in Appendix B. The simulation results from the three alternative scenarios indicate what the impacts would be of meeting the specific changes described by the scenario, leaving all other macroeconomic assumptions constant. Comparing a variable value projected by the scenario against the baseline provides an accurate measure of the impact. In this way even if the baseline does not completely reflect what is occurring in a particular time, like a corn price in December of 2006 above 3.00 dollars per bushel, the value simulated stills provides an accurate measure of the change with respect to the baseline situation.

3.6.1. Scenario 1: Ethanol 60 Billion gallons (ETH60)

The main scenario of the analysis is given by pursuing the biofuels targets defined earlier in this document using the technology assumptions in the previous section. This scenario also implies that the cellulose-to-ethanol technology would be commercially available by the year 2012. Another important assumption is that the corn grain-to-ethanol industry would be protected. This means that the use of corn grain would be kept at levels to maintain a high use level of utilization of the production capacity of these plants, even in the face of the introduction of new technology. This would be a risk reducing mechanism to accelerate the level of investment.

3.6.2. Scenario 2: Corn Grain for Ethanol Adjustment (ETH60CA)

The second scenario would relax one of two assumptions defined in the ETH60 scenario. The corn grain-to-ethanol will be allowed to shrink as the new technology of cellulose-to-ethanol becomes commercially available. This means that the corn grain based ethanol industry will either reconvert or will have to reduce its production capacity. This analysis would provide an estimate of the degree of production capacity that could develop if the industry overbuilds.

3.6.3. Scenario 3: Delay in the Cellulose-to-Ethanol Technology to 2015 (ETH60CADC)

The third scenario is based on relaxing the two specific assumptions presented in the ETH60 scenario. In other words, it is based on scenario two plus it considers that the cellulose-to-ethanol technology would be commercially available not in 2012 but in the year 2015. The objective is to identify the degree of viability of long term goals on the availability of this new technology.

IV. Results

The analysis of the results under the ETH60 Scenario indicate that achieving an annual biofuels goal of 60 billion gallons of ethanol, including over a billion gallons of biodiesel by the year 2030, can generate an estimated $110 billion of direct economic activity through purchasing inputs, and the value added of supplying those levels of biofuels to the nation. Moreover, direct activity creates additional demands from the input and machinery producing sectors, so the total impacts to the nation's economy are estimated at $368 billion and the creation of 2.4 million jobs.

For the agricultural sector, this new demand for agricultural cropland and crops implies an additional $11 billion of annual net farm income by 2030, and savings of more than $5 billion dollars in government payments in that year. Overall, for the period 2007 to 2030, the estimated accumulated gains in net farm income are over $210 billion, and the accumulated potential savings in government payments are estimated to be $150 billion.

In addition, by the year 2030 ethanol would have displaced more than 20 percent of the domestic consumption of gasoline, potentially reducing oil imports by $52 billion dollars. For the entire period through 2030, the displacement would be 10.48 billion barrels of oil and a potential import reduction of $629 billion dollars.

The analysis in this section details how these impacts are generated in the agricultural and livestock sectors, and the mechanisms that tied the biofuels goals with the national economic impacts. Most of the discussion is based on output reflecting impacts for the years 2007, 2010, 2015, 2020, 2025 and 2030.

4.1. Agricultural Sector Impacts

The estimates obtained from POLYSYS indicate that the goals targeted in this analysis can be achieved at a reasonable cost by the proposed target year of 2030. The production of feedstock to meet the biofuels demand can be done by re-allocating the current cropland in production and shifting land use towards bioenergy dedicated energy crops, like switchgrass. While the current ethanol industry is based on the transformation of corn grain into ethanol, reaching the proposed ethanol production and utilization level of 60 billion gallons will require a major contribution of cellulosic feedstock: dedicated energy crops (switchgrass), residues from

traditional crops (corn stover, wheat straw), and residues from forest activities (forest thinning, and residues from wood processing facilities). Reaching the goals at a reasonable cost also requires the availability to covert cellulose to ethanol. A delay in the availability of this technology would have significant consequences on the cost and path to reach the goals.

To reach the desired goal of 1 billion gallons of biodiesel by 2012 plus increasing this quantity beyond 2012, it is necessary to utilize both soybeans and other feedstocks such as yellow grease and tallow.

Regional results indicate that the Northern Plains and the Southeast will be the primary areas in which dedicated energy crops will be produced, while the Midwest contribution will be in the form of corn residues. However, most regions of the country have the potential to contribute to biofuels production, and therefore will also likely benefit in terms of net farm income gains and gains for rural communities. The following discussion provides a detailed description and analysis of these impacts.

4.2. Bioenergy Production and Fuels Imports Reduction

As show in Table 6, the production of ethanol reaches the targets provided for the years 2010, 2020, and 2030. In relative terms, the production increases at a faster pace between 2010 and 2020 than between 2020 and 2030. Between 2010 and 2020, production increases by threefold. Between 2020 and 2030, the production doubles. Thus, in absolute terms, the increase between 2020 and 2030 is one and a half times the increase compared with the 2010 to 2020 period. These two issues will be of special interest in some of the sensitivity analysis that will be described later in this section.

Table 6. Projected Bioenergy Production Under the ETH60 Scenario.

		Projected for the Year of:					
Fuel Type	Units	**2007**	**2010**	**2015**	**2020**	**2025**	**2030**
Ethanol	Bil. Gallons	7.0	10.0	20.25	30.11	45.20	60.30
Biodiesel	Bil. Gallons	0.37	0.72	1.10	1.25	1.41	1.60
Total Energy	Quads	**0.64**	**0.94**	**1.85**	**2.71**	**4.00**	**5.31**

The original target for biodiesel was to reach a billion gallons by the year 2012, which is accomplished (although the data presented in the referenced table does not include that particular year). It is important to mention that by the year 2030 the production of biodiesel continues to increase to 1.6 billion gallons.

In terms of savings in the consumption of gasoline, the targets of the ETH60 scenario are extraordinary. As indicated in Table 7, the 60 billion gallons of ethanol in 2030 generate a savings of 40.9 billion gallons of gross gasoline equivalent or a displacement of 21.7 percent of the estimated gasoline consumed in the country in 2030. That gasoline would be the equivalent to 0.88 billion barrels of oil, which if imported at $60 a barrel, would amount to $52.51 billion for the year. The same indicators for the entire period through 2030 indicate that 490.4 billion gallons of gasoline would be displaced or the equivalent of 10.48 billion barrels of oil. This implies a potential savings of $629 billion dollars in imports— a positive contribution to the U.S. balance of trade and domestic economy.

Table 7. Estimated Savings in Gasoline Consumption / Imports Under the ETH60 Scenario.

	2030		Accumulated	
	Gallons	Barrels	Gallons	Barrels
		Billions		
Ethanol[1]	60.0	na[4]	718.72	na
Gross Gasoline equivalent[2]	40.9	0.88	490.4	10.48
Annual Gasoline Displaced[3]	21.7%	na	na	na
Value of imports at $60 a barrel		$52.51		$629.00

[1] Ethanol conversion rate is assumed to be 90.2 gallons/dt
[2] Ethanol has 2/3 of the energy content of gasoline
[3] Energy Information Administration, Department of Energy
[4] Not applicable

4.3. Feedstock Utilization

The production of biofuels, ethanol and biodiesel presented above is derived from several feedstock sources. In the case of ethanol, there is not only a differentiation between corn grain and cellulosic, but there are also several sources of cellulosic feedstock.

It would be helpful to consider the path to achieve the ethanol goal, as it actually becomes the demand that needs to be satisfied by the agricultural sector. This path is presented in Figure 9. The path includes the milestones of the analysis, which are 10 billion gallons by 2010, 30 billion gallons by 2020, and finally 60 billion gallons of ethanol by 2030.

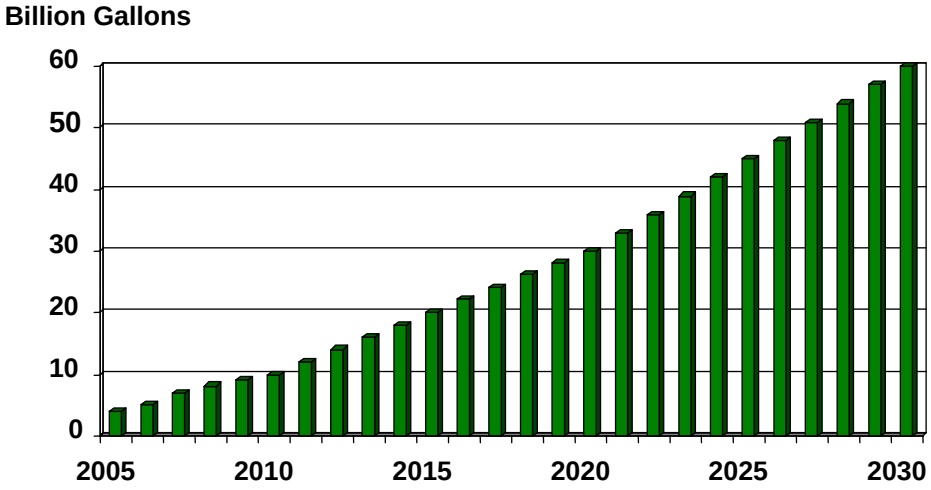


Figure 9. Ethanol Production Path Under the ETH60 Scenario.

Regarding feedstock utilization through the year 2012, corn grain continues to be the base of ethanol production. Given the goals presented in this study and their timing, the first 12

billion gallons of ethanol are produced from corn grain. In later years, the increase of corn grain for ethanol slows down and remains flat after 2020 (Figure 10).

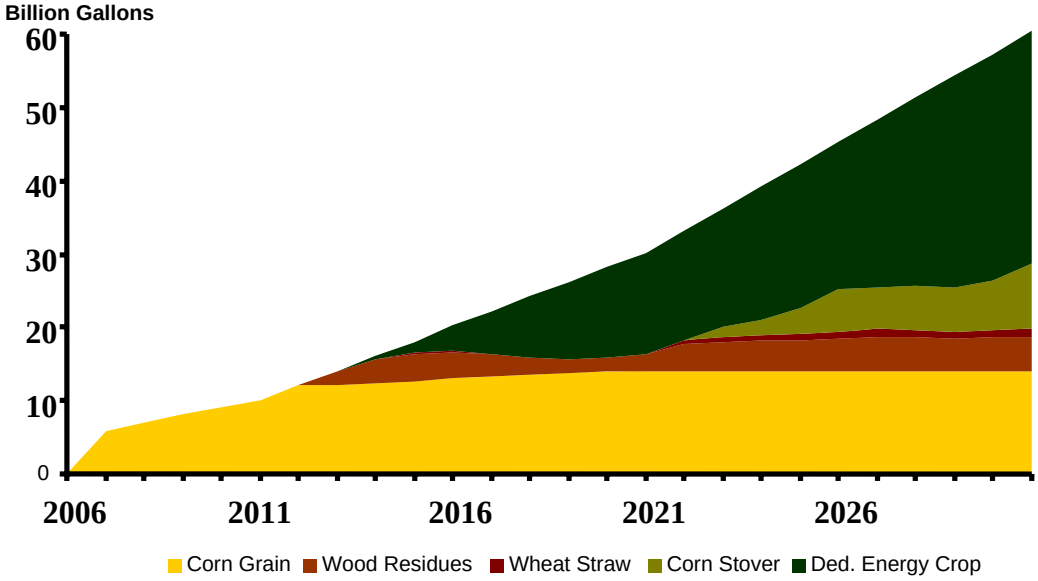


Figure 10. Ethanol Quantities from Selected Feedstock Under the ETH60 Scenario.

The lack of growth in corn grain ethanol after 2012 is due to the assumed introduction of cellulose-to-ethanol conversion technology, which would eventually become the dominant technology due to its lower cost of production. Hence, from 2012 the importance of cellulose at feedstock for ethanol is increasing. Specifically, for the first few years the utilization of wood residues would be the most important cellulose feedstock. As dedicated energy crops come into commercial production, they would become the dominant feedstocks.

Regarding biodiesel, there are two major categories of feedstock, soybeans and residues. The residues include yellow grease and tallow from animal rendering. In this analysis the objective was to reach 1 billion gallons of biodiesel by 2012. Figure 11 depicts the path to achieve the goal and the feedstock utilization between soybeans and residues.

Sensitivity analysis was used to consider an alternative target of 2 billion gallons of biodiesel, but given the current oil crop soybeans, the price impact to reach the target was above $8 per bushel, which is unreasonably high. Additional biofuels crop mix between ethanol and biodiesel could have been considered, but for all practical purposes, the results would have meant pressure on the same cropland, and the results would be similar.

There are two basic assumptions regarding the feedstock use for ethanol. The first keeps corn-to-ethanol conversion infrastructure in production by allowing corn grain for ethanol to increase but not to the decrease. Second, cellulose-to-ethanol technology becomes ready for commercial expansion by 2012. These two assumptions were relaxed to observe their potential impact.

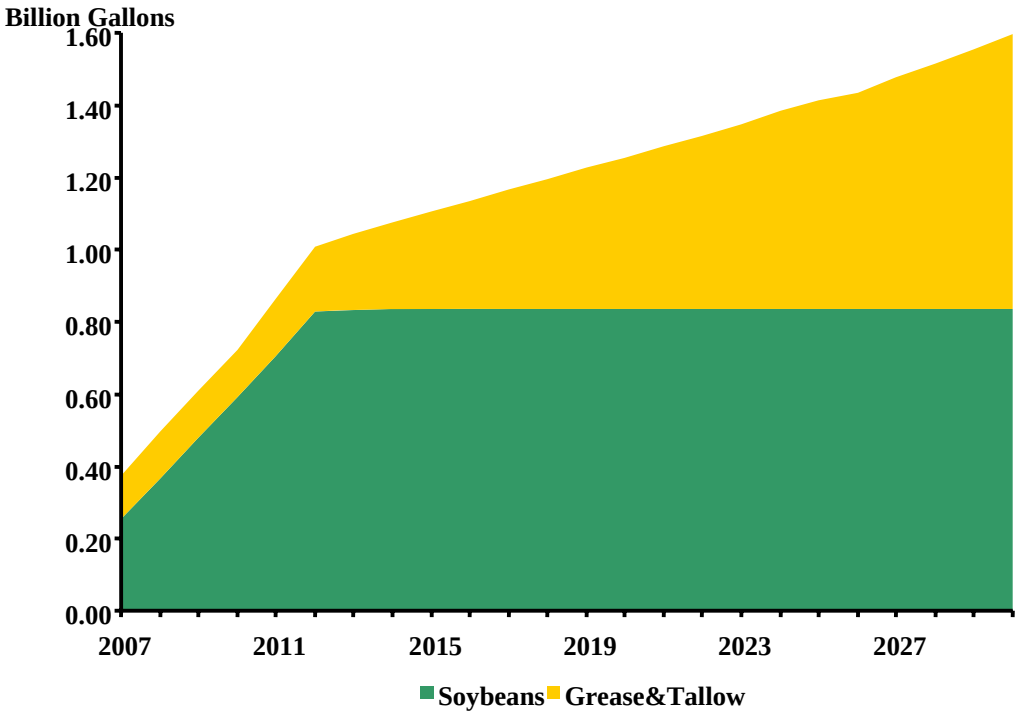


Figure 11. Biodiesel from Selected Feedstock Under the ETH60 Scenario.

There are two basic assumptions regarding the feedstock use for ethanol. The first keeps corn-to-ethanol conversion infrastructure in production by allowing corn grain for ethanol to increase, but not to the decrease. Second, cellulose-to-ethanol technology becomes ready for commercial expansion by 2012. These two assumptions were relaxed to observe their potential impact.

Under the ETH60CA Scenario, the first assumption is relaxed and corn grain to ethanol shrinks as more ethanol from cellulose becomes available. The projected feedstock sources for ethanol under the ETH60CA Scenario are represented by Figure 12. As can be noted from the figure, use of corn reaches a peak in 2012 when the cellulose to ethanol industry is getting started and then declines to less than 8 billion gallons by 2030. This suggests that excess production capacity will appear in 2013, and corn grain ethanol plants will either need to increasingly reconvert to cellulose or shut down. The use of corn grain does not reach zero, because some older plants would remain active as long as they were able to cover less than full costs, since the plants would be totally depreciated. In the nearer term, the cellulose feedstock which replace corn grain are corn stover and wheat straw. In the longer term, dedicated energy crops become the dominant feedstocks.

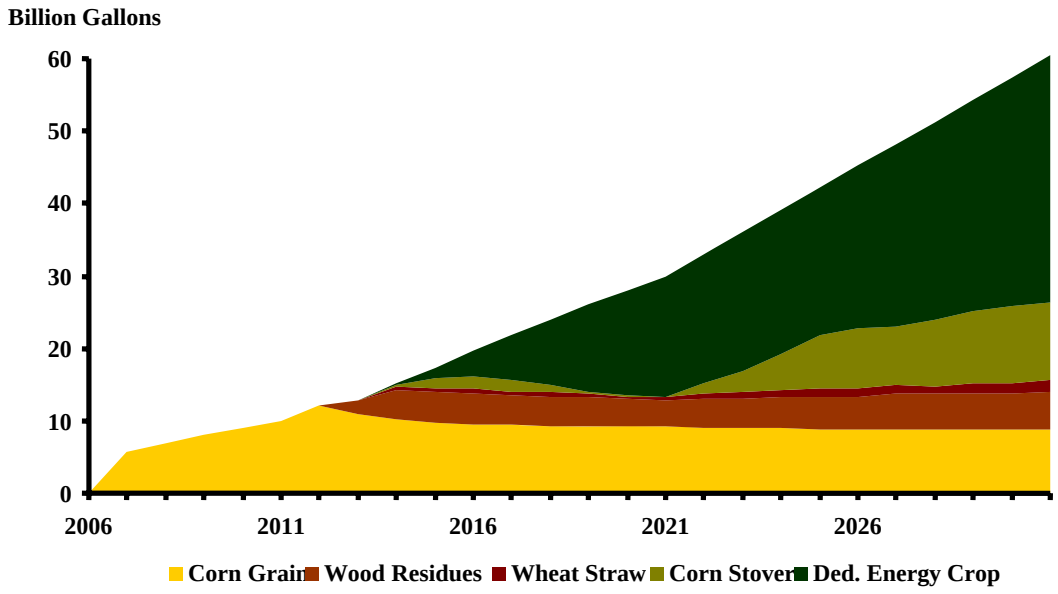


Figure 12. Ethanol from Selected Feedstock Under the ETH60CA Scenario.

Under the ETH60CACD Scenario, the second assumption retained, but the introduction of cellulose-to-ethanol production is delayed until 2015 rather than 2012. The ethanol from the specified feedstock under this scenario is shown in Figure 13. The first observation is that the use of corn for ethanol will not peak until 2015, and it will peak close to 18 billion gallons of ethanol. After the peak year, there will be a significant reduction in the use of grain corn for ethanol in response to the entrance of the cellulose-to-ethanol technology. Notably, the buildup in production capacity that was necessary to take the corn to ethanol industry to 18 billion gallons in 2015 results in excess capacity. Consequently, the cost of transition from corn grain to cellulose ethanol would become costlier in terms of conversion costs creating the potential necessity for a partial corn grain-to-ethanol industry bailout. The price impacts are analyzed later on in this document.

In this situation, corn stover, and to a lesser degree wheat straw, would become the significant feedstocks. Under this scenario, by the year 2030, dedicated energy crops, i.e. switchgrass, are the dominant feedstock. The contribution of corn residues is much more significant than under the other two previous scenarios.

4.4. Changes in Land Use

The additional demand for agricultural feedstock, and, consequently, agricultural cropland is expected to have an important impact in land use. These changes in land use are displayed in Figure 14. There are three major significant changes. First is the emergence of a whole new type of crop – dedicated energy crops, represented by switchgrass. Dedicated energy crops reach about 34.4 million acres by the year 2030 from very low levels in 2007. Rapid conversion of acreage into new crops is not atypical for agriculture. The most significant and recent conversion has been the case of soybeans, which expanded from near non-existence 40 to 50 years ago, to become the second most important crop in terms of acreage after corn.

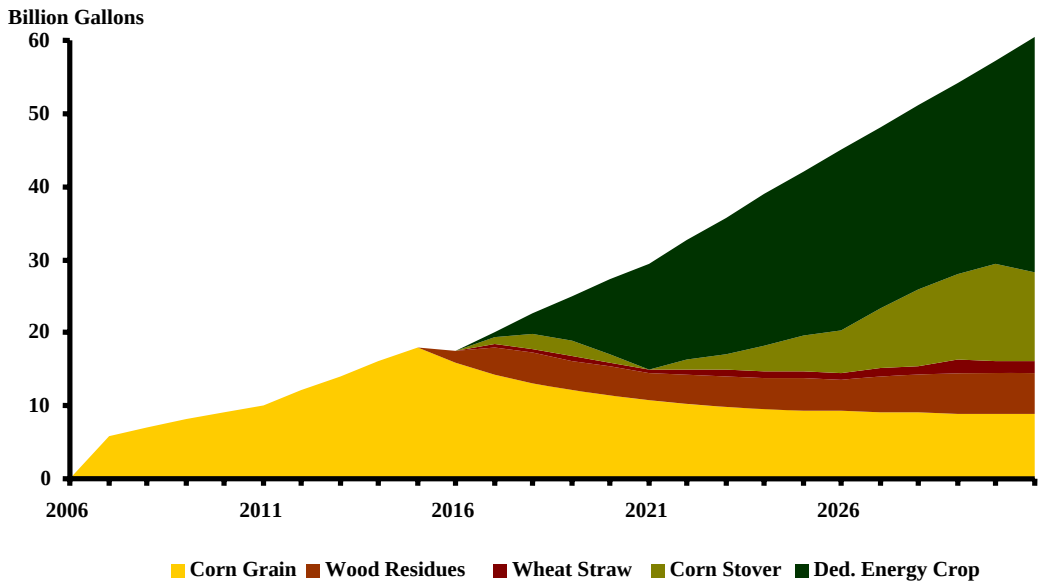


Figure 13. Ethanol from Specified Feedstock under the ETH60CACD Scenario.

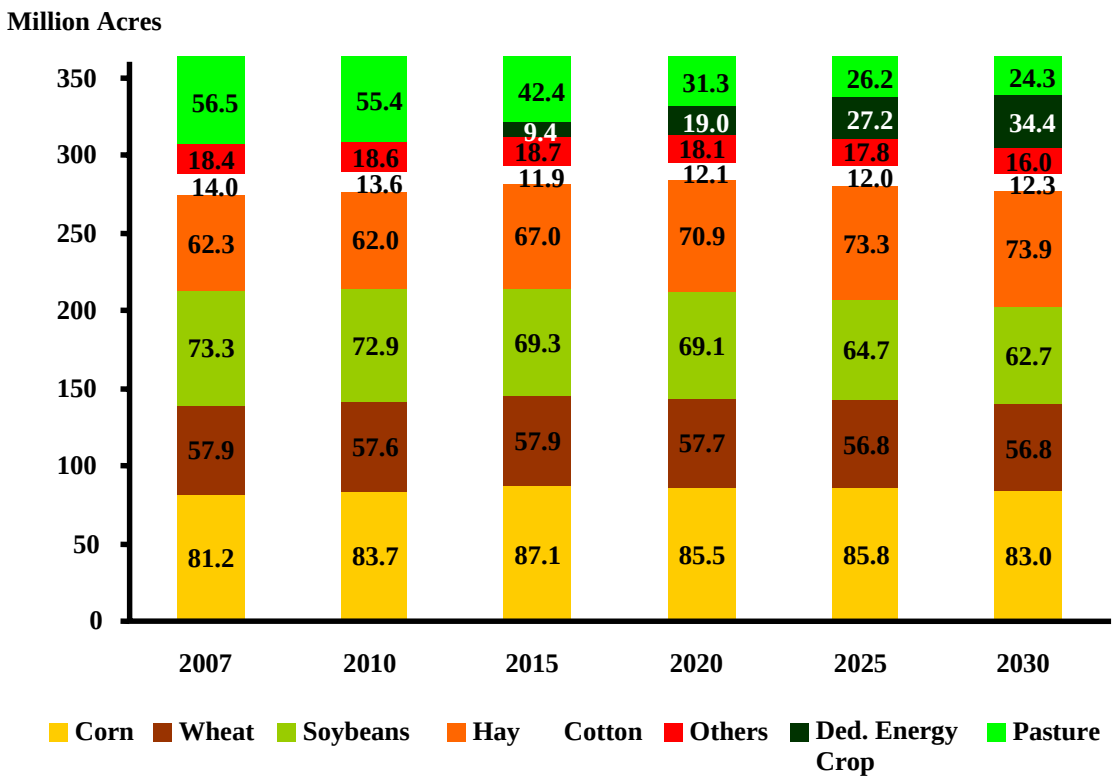


Figure 14. Changes in Land Use for Selected Years Under the ETH60 Scenario.

The second important change is the transformation of cropland in pasture into production of both hay and dedicated energy crops. About 32.2 million acres of cropland in pasture would come back into hay, dedicated energy crops, and other crop production. This pasture

traditionally has been planted in crops, but due to the economic changes and the surging of the livestock industry its use shifted toward pasture. Again because of change in the economic landscape, this pastureland would find its way back into crop production. A small increase in the management intensity of more than 450 million acres of grassland would allow this to happen without a significant impact in the cattle industry.

The third major change is the decrease in the plantings of soybeans. Over the duration of the period, the projected area planted to soybeans goes from 73.3 million acres in 2007 to 62.7 million acres in 2030, a reduction of 10.6 million acres. This reduction occurs in part because unlike corn, soybean produces almost no biomass residues, so it does not receive the additional benefit of the demand from the cellulose-to-ethanol industry and the corresponding potential increase in revenues. Additionally, the increased production of corn ethanol provides for an increase in the availability of distiller's dryed grains. Exports of soybeans also decline as a more stable domestic demand in the form of soybeans for biodiesel and soybeans for meal replaces exports.

The regional changes in soybean acreage are depicted in Figure 15. The areas in orange or darker indicate losses in acreage, while the areas in green indicate gains in acreage from the baseline. In the case of soybeans the major loss of acreage occurs in the plantings of the Southeast and to a lesser extent the Midwest.

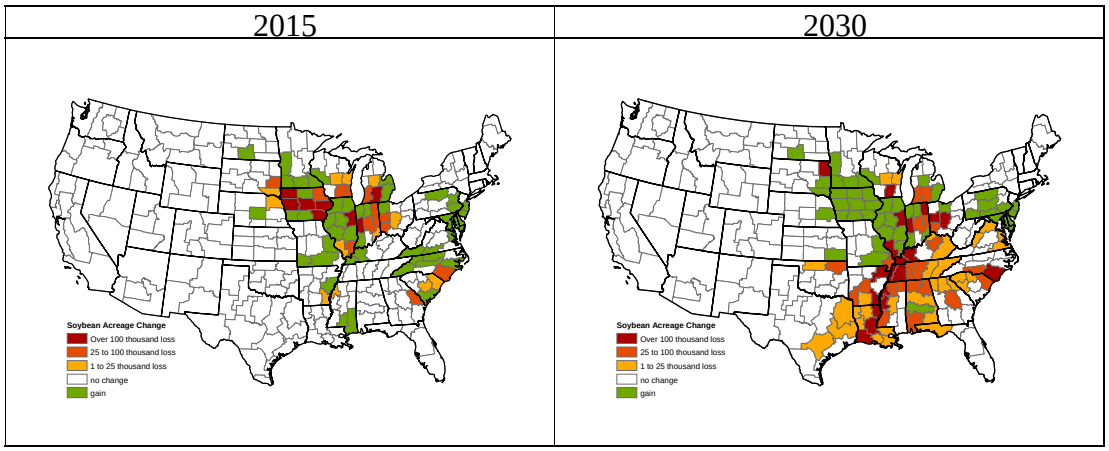


Figure 15. Changes in Soybean Acres from Baseline Under the ETH60 Scenario.

Other major land uses like corn and wheat are not projected to experience a significant change in acreage when comparing the start and ending of the period. However, it is clear that as corn grain for ethanol reaches a peak around 2012, the acreage of corn also experiences a significant increase, which dissipates as cellulose for ethanol comes into the picture.

4.5. Price Impacts

The production of biofuels not only would drive major changes in land use, but would also have significant impacts upon agricultural commodity prices (Table 8). The prices of the major crops are shown by selected years for the baseline (USDAext), the ETH60 scenario, for allowing corn grain ethanol production to decline (ETH60CA), and for the scenario with the additional delay in the commercial availability of cellulose-to-ethanol conversion technology (ETH60CACD).

For the ETH60 scenario, the price estimates indicate that all corn, wheat, and soybeans experience a significant price impact during the period. In the case of corn, by the year 2030 prices are at $3.03 per bushel, more than 60 cents above the baseline. Consistent with the behavior of the feedstock utilization, at the peak of corn grain utilization for ethanol, the price for corn also peaks to levels exceeding $3.00 per bushel. This same pattern follows for the other crops, which also peak about the same time that corn does and then tend to decrease as cellulose-to-ethanol becomes available.

For the next scenario (ETH60CA), which allows the demand for corn grain ethanol to diminish as cellulose comes into the mix in 2012, prices of corn and soybeans show a more significant decrease relative to wheat prices. The reduction in the use of corn for ethanol causes less pressure on corn prices and releases land for the production of soybeans which causes the soybean price to decline.

The third scenario, ETH60CACD, provides sensitivity to what might happen if a delay in the introduction of cellulose-to-ethanol technology occurs. The price increase, by 2015, represents the impact of the surge in biofuels demand on the current conversion technology. The price deflation following the 2015 peak is an indication of the size of the downward adjustment that may come into place as cellulose-to-ethanol becomes available.

It is important to mention than under the three scenarios considered, except for the baseline, the variable costs at the farm gate for dedicated energy crops remain between $21.60 and $30.00. The sensitivity of the changes analyzed is much more disruptive for the traditional crops prices than energy dedicated crops prices.

4.6. Biofuels Cost

The costs of production for ethanol and for biodiesel given the different feedstocks are presented in Table 9. The costs reported correspond to the ETH60 scenario. Although not listed, the costs of the other scenarios follow this general trend, but with even higher corn grain ethanol and soybean biodiesel costs in the years in which corn and soybean prices rise.

The cost of ethanol from corn grain and ethanol includes all production costs except finance charges. It is possible that financing a first of kind cellulose plant might be more expensive than financing plants using existing technologies. Therefore, there may be a reduction in the cost gap between the ethanol feedstock

It should be noted that the biodiesel from yellow grease and tallow costs do include a $1.30 cost for the feedstock (Ash and Dohlman, 2006). Yellow grease costs are about 12-13 cents per pound and inedible tallow prices are about 16-17 cents per pound. These prices imply feedstock costs of about $.90 to $1.00 per gallon for biodiesel from yellow grease and $1.20 to $1.30 per gallon for biodiesel from tallow. The collection costs for yellow grease could be relatively high, while in the case of tallow, locating the conversion facility next to rendering facilities would result in a relatively low collection cost of the feedstock.

Table 8. Impact on the Average Crop Price by Scenario for Selected Simulated Years.

Crop and Scenario	Projected for the Year: 2007	2010	2015	2020	2025	2030
			$/Bushel			
Corn:						
ETH60CACD	2.44	3.46	4.65	2.70	2.31	3.00
ETH60CA	*2.44*	*3.46*	*2.98*	*2.45*	*2.32*	*2.93*
ETH60	**2.44**	**3.49**	**3.29**	**2.87**	**2.42**	**3.03**
USDAExt	*2.20*	*2.60*	*2.60*	*2.51*	*2.46*	*2.41*
Wheat:						
ETH60CACD	3.12	3.36	4.01	3.50	3.40	3.79
ETH60CA	*3.12*	*3.36*	*3.74*	*3.5*	*3.41*	*3.79*
ETH60	**3.12**	**3.36**	**3.87**	**3.57**	**3.48**	**3.96**
USDAExt	*3.10*	*3.25*	*3.55*	*3.5*	*3.47*	*3.43*
Soybeans:						
ETH60CACD	5.83	6.70	7.52	6.60	6.23	6.42
ETH60CA	*5.83*	*6.7*	*6.75*	*6.66*	*6.24*	*6.44*
ETH60	**5.83**	**6.77**	**7.59**	**6.82**	**6.67**	**6.76**
USDAExt	*5.40*	*5.95*	*6.10*	*5.85*	*5.69*	*5.53*
Cotton			$/Pound			
ETH60CACD	0.51	0.51	0.59	0.60	0.61	0.61
ETH60CA	*0.51*	*0.51*	*0.61*	*0.60*	*0.60*	*0.61*
ETH60	**0.51**	**0.51**	**0.61**	**0.60**	**0.61**	**0.61**
USDAExt	*0.51*	*0.51*	*0.57*	*0.57*	*0.58*	*0.59*
Dedicated Energy Crops:			$/Dry Ton			
ETH60CACD	0.0	0.0	21.6	26.0	27.1	30.0
ETH60CA	*0.0*	*0.0*	*27.9*	*26.0*	*28.0*	*30.0*
ETH60	**0.0**	**0.0**	**26.2**	**22.8**	**27.1**	**27.6**
USDAExt	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*

Table 9. Estimated Cost of Biofuels for ETH60 Scenario.

	Projected for the Year: 2007	2010	2015	2020	2025	2030
			$/Gallon			
Ethanol:						
Cellulose	0.00	0.00	1.16	1.10	1.13	1.14
Corn Grain	1.45	1.83	1.74	1.51	1.36	1.56
Average	1.45	1.83	1.53	1.29	1.20	1.23
Biodiesel:						
Soybeans	4.22	4.82	5.37	4.89	4.78	4.91
Yellow grease / Tallow	1.74	1.77	1.77	1.77	1.77	1.77

4.7. Exports

While exports have traditionally served as an important market for agricultural commodities, newly expanding demands for these commodities from bioenergy development would likely impact exports. With a significant increase in commodity demands for energy purposes, exports are expected to decline. This is because more production finds a market locally and also because of higher commodity prices. Tables 10 and 11 contain the estimates of the volume and value of exports respectively.

From Table 10 it can be seen that there is an overall reduction in export volume for the agricultural commodities reported. The most dramatic reduction occurs in soybeans for which the quantity exported decreases almost in half. This is because the crop has experienced a large reduction in the acres planted. Additionally most of the volume that was not exported is being used domestically as either food, feed, or an energy source.

Table 10. Projected Volume of Exports for ETH60 Scenario and Baseline.

	Projected for the Year:					
Crop and Scenario	2007	2010	2015	2020	2025	2030
Corn:			Million Bushels			
ETH60	1,943	1,766	1,692	2,131	2,559	2,268
USDAExt	*2,025*	*2,125*	*2,375*	*2,575*	*2,789*	*3,018*
Wheat:						
ETH60	954	1,008	1,097	1,172	1,271	1,188
USDAExt	*950*	*1,000*	*1,125*	*1,193*	*1,273*	*1,358*
Soybeans:						
ETH60	1,013	756	489	649	748	637
USDAExt	*1,080*	*1,030*	*975*	*1,034*	*1,099*	*1,170*
Cotton:			Million Bales			
ETH60	15	16	14	15	16	16
USDAExt	*15*	*16*	*16*	*17*	*18*	*19*

For the value of exports, Table 11 indicates that the total reduction in annual export value is nearly $3.5 billion by the year 2030. This represents a reduction of a little more than 10 percent of the value of exports for these agricultural commodities. The accumulated export decline through 2030 amounts to $43.5 billion dollars.

This overall reduction in the value of agricultural exports is more than offset in the balance of trade by replacing imported gasoline and diesel. Earlier, it was reported that over $52 billion would be saved in 2030 by displacing gasoline with domestic ethanol. This, by far, outweighs the loss of export value from agricultural grain commodities.

Table. 11. Projected Value of Agricultural Exports for Corn, Wheat, Soybeans, and Cotton by Selected Year and Scenario.

Crop and Scenario	Projected for the year: 2007	2010	2015	2020	2025	2030
	Million Dollars					
Corn:						
ETH60	4,733	6,158	5,565	6,112	6,204	6,864
USDAExt	4,455	5,525	6,175	6,474	6,854	7,259
Wheat:						
ETH60	2,982	3,391	4,240	4,183	4,418	4,699
USDAExt	2,945	3,250	3,994	4,174	4,410	4,657
Soybeans:						
ETH60	5,903	5,122	3,714	4,420	4,991	4,300
USDAExt	5,832	6,128	5,947	6,055	6,253	6,468
Cotton:						
ETH60	3,731	3,835	4,115	4,380	4,510	4,659
USDAExt	3,731	3,868	4,460	4,798	5,067	5,358
Total:						
ETH60	18,656	19,948	19,386	20,767	22,002	22,202
USDAExt	18,271	20,162	22,179	23,220	24,420	25,681

4.8. Regional Impacts: Feedstock and Net Returns

Thus far the discussion has focused on national changes and trends. Also useful is examination of changes in land use and net returns at a regional level. The following section discusses the regional changes that might occur with increased demand for biofuels.

The geographic distribution of the production of cellulosic feedstock for the ETH60 is presented in Figure 16. The temporal and geographic changes in production presented indicate that a significant concentration of the cellulosic feedstock production occurs in the Southeast and Southern regions of the country first, and then moves towards the Midwest and Northern Plains. While what is shown is the total cellulosic feedstock, closer analysis indicates that the Southeast, Southern and Northern Plains have a concentration of dedicated energy crops production, while the Midwest has a concentration of corn stover. For wheat straw, the Northern Plains and Mountain states are the concentrated production regions.

The largest availability of wood and forest residues would be located west of the Rocky Mountains, in the Southeast, and in New England. The estimates of cellulose from forest do not include any trees from commercial plantations specifically harvested for energy.

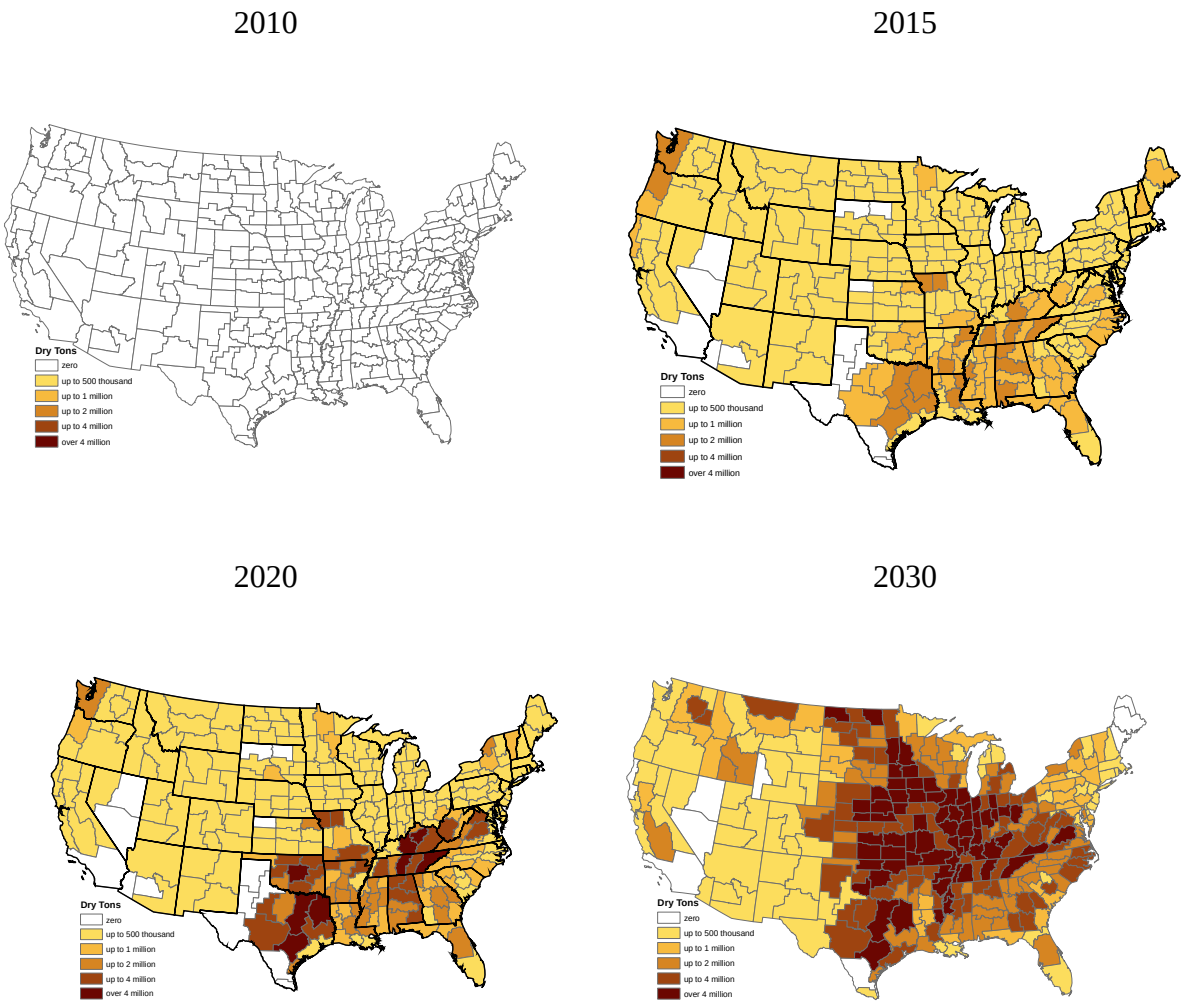


Figure 16. Distribution of All Cellulosic Feedstock (Crop Residues, Dedicated Energy Crops, Forest Residues, Mill Wastes, and Wood from Fuel Reduction) Under the ETH60 Scenario.

Figure 17 contains the regional estimates for changes in agricultural net returns, including the agricultural production for feed, food, and energy purposes. From the set of maps presented in the figure, gains in agricultural income are occurring in the whole nation. At the beginning of the projected timeframe, corn is the primary feedstock for the ethanol industry, and the major impacts are concentrated in the major corn producing areas of the Midwest. As the shift towards cellulose-to-ethanol occurs, the gains in net returns begin to expand rapidly outward beyond the Midwest. By the end of the projected time period, dramatic gains in farm income occur in the Midwest, Southeast, the Plains, and even the East Coast. It should be noted that the western regions would reflect more impacts if POLSYS captured returns from forest activity; however, these gains will be incorporated in the next section when accounting for national economic impacts.

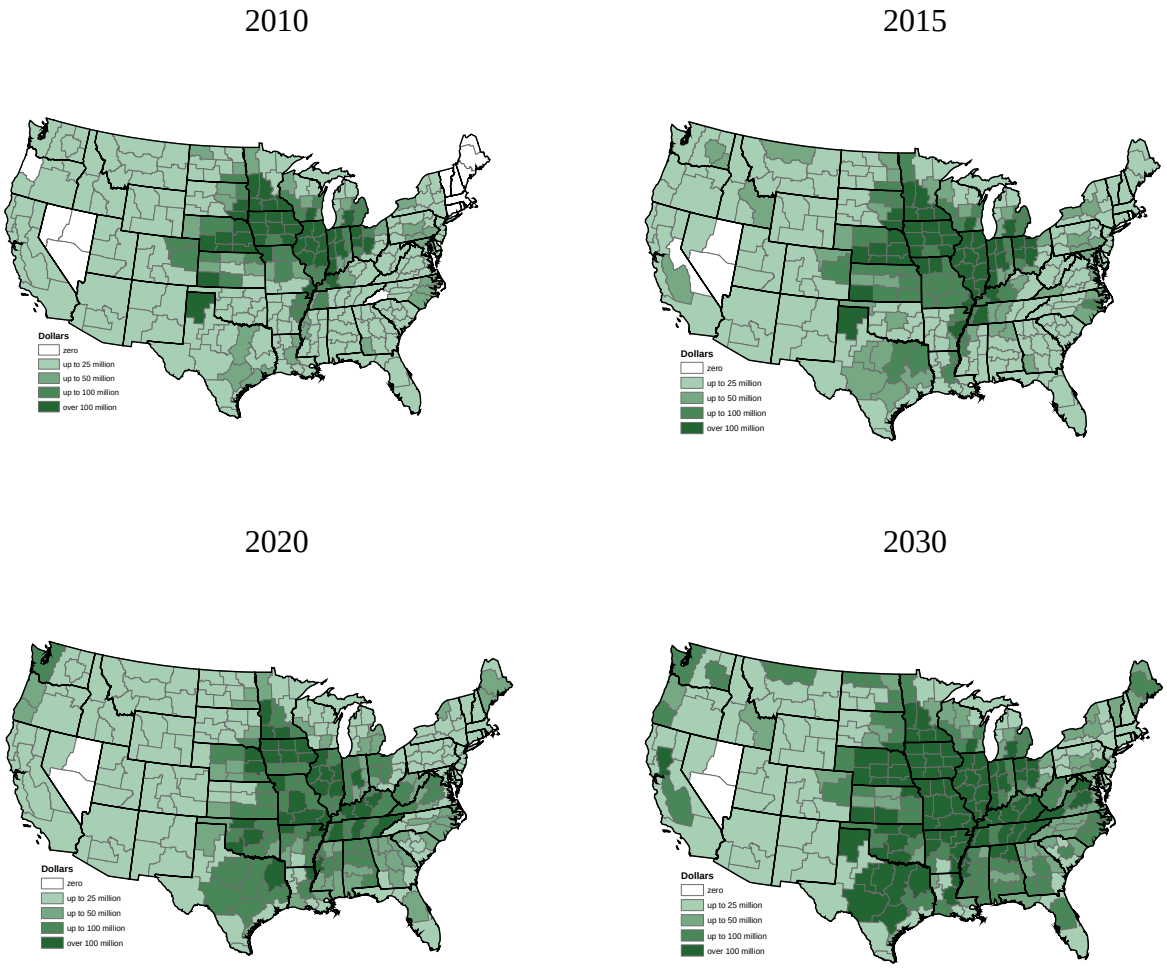


Figure 17. Distribution of Changes in Farm Net Returns Under the ETH60 Scenario.

4.9. Livestock Sector

The results of the analysis indicate that the livestock sector would likely face higher feed expenses. However, of the primary feed sources for livestock (hay, soybean meal and corn), only corn is expected to experience a significant increase in price. Hay price is determined at the regional level and is not determined in the POLYSYS model, but in order for cropland in pasture to come into crop production a portion of pasture must be converted to hay production to make up for the regional loss in pasture forage productivity. By 2030, national hay acreage is expected to rise from 62.3 to 73.9 million acres, an increase in 11.6 million acres. While there could be a one time cost of shifting cropland in pasture to hay, it is not expected to be of any long term significance. As cropland in pasture is replaced with hay acreage, hay price is not expected to rise. A key finding is that the beef cattle sector responds to increased corn prices by reducing inventories leading to increased revenues.

Although there is a large decline in soybean acreage, the soybean meal supply does not change significantly. This is because of decreased exports of soybeans and a large influx of soybean meal byproduct from biodiesel production.

The various sectors within the livestock industry react differently to the higher feed prices. The reactions are driven by the relative importance of corn in the feed ration, by the importance of the feed expenses in the overall cost of production, and by the ability to transfer the cost of the additional feed expenses through the market channel.

The cattle sector reacts to the cost increase by adjusting cattle inventories. The reduction in inventories leads to higher prices that offset the sector's increased production costs and reduces the total expenditures in feed. Table 12 indicates that by 2030 cash receipts from cattle increase $387 million over baseline. Feed costs increase $440 million over baseline and net returns increase by $800 million, which is about an 8 percent gain in total net returns to cattle.

The hog and poultry sectors experience significant decreases in net returns through the first years of the projected time period up to 2015. In both industries, corn is a major component of feed ration and, consequently, the cost of feed increases result in a small but noticeable drop in net returns. Later in the period the impact of DDGs and the reduction of inventories of live animals contribute to offsetting earlier declines in net returns. However, the results by the end of the period reflect a net loss of returns. The increase in feed expenses by 2030 in both industries is above $1.5 billion. The increase in feed costs is experienced mostly in the poultry sector. The model results indicate that the production adjustment and increase in prices are not large enough to compensate for that increase in feed expenditures. A caveat is that the high degree of vertical integration in the poultry and hog sectors and associated production contracts make predicting market adjustments difficult.

Other factors need to be mentioned which have not been accounted for in the quantitative analysis. First, as the production of forage increases as a result of added management, there would be a long term change in the feed ration of cattle, in which corn and soybean meal would be partially replaced by increased pasture and forages. In turn this would contribute to reduce the price pressure for the feed in the poultry and hog industries. Second, the process of converting cellulosic material to ethanol through fermentation opens up the opportunity to produce byproducts with a high content of protein and energy suitable to replace corn and soybean meal in the livestock industry (Dale, 2006). This integration of the energy feedstock conversion and livestock production would result in gains for the livestock industry not quantified in this report.

Table 12. Change in Livestock Sector Costs and Returns Under the ETH60 Scenario.

	2008	2010	2015	2020	2025	2030
Cattle			Million Dollars			
Expenses	51	53	-306	-378	-453	-440
Cash Receipts	358	638	1095	475	67	387
Net Returns	306	585	1401	853	520	827
Percent Change Net Returns	3.4%	7.1%	16.7%	8.0%	4.9%	7.9%
Hogs						
Expenses	285	608	608	90	-190	365
Cash Receipts	9	87	362	74	-21	93
Net Returns	-276	-522	-246	-17	170	-272
Percent Change Net Returns	-13.6%	-32.3%	-13.7%	-0.8%	7.7%	-11.6%
Chickens						
Expenses	599	1192	1549	769	407	1259
Cash Receipts	22	113	318	100	-33	55
Net Returns	-577	-1079	-1232	-669	-440	-1204
Percent Change Net Returns	-8.3%	`-15.5%	-15.2%	-8.1%	-5.3%	-14.2%

The second scenario (ETH60CA) has a significantly different result on livestock sector costs and returns. By 2015 and thereafter, with the introduction of cellulose-to-ethanol technology, the price impact on corn and soybeans is significantly reduced, so in comparison with the previous scenario, the increase in feed expenses is much lower for the hog and poultry industries (Table 13). The reduction in expected net returns is much smaller than the level of net returns in ETH60. When returns increase as a result of the reduction in animal inventories and price increases, the changes are more favorable as a consequence of allowing the use of corn grain for ethanol to adjust downwards. For the case of the cattle industry, the impacts do not change in a significant way. The inventory adjustment would be smaller than under ETH60 scenario.

Table 13. Change in Livestock Sector Costs and Returns Under the ETH60CA Scenario.

	2008	2010	2015	2020	2025	2030
Cattle		Million Dollars				
Expenses	51	53	-397	-417	-481	-413
Cash Receipts	358	638	599	-69	-406	-24
Net Returns	306	585	995	348	75	390
Percent Change Net Returns	3.4%	7.1%	11.9%	3.3%	0.7%	3.7%
Hogs						
Expenses	285	608	141	-359	-561	58
Cash Receipts	9	87	306	-84	-149	-77
Net Returns	-276	-522	165	275	413	-135
Percent Change Net Returns	-13.6%	-32.3%	8.8%	13.7%	18.9%	-5.6%
Chickens						
Expenses	599	1192	638	46	-294	509
Cash Receipts	22	113	224	-35	-130	-103
Net Returns	-577	-1079	-414	-81	164	-612
Percent Change Net Returns	-8.3%	-15.5%	-5.1%	-1.0%	2.0%	-7.2%

The third scenario, which includes the delay of the introduction of the cellulose-to-ethanol technology to the year 2015, ETH60CACD, results in a much higher projected burden for the hog and poultry industries through the year 2015. In the case of hogs the loss of net returns is above 80 percent, while in the case of poultry the loss is almost a 50 percent compared with the baseline estimates (Table 14).

4.10. Corn Utilization

The changes in the utilization of corn grain are show in Table 15. In the ETH60 scenario the participation of energy in the utilization of corn reaches is the highest level in 2015 at 36 percent. This is almost 50 percent above the baseline utilization. From that point forward, as cellulose-to-ethanol becomes available in 2012, the relative participation of energy demand in the use of corn decreases to 31.8 percent by 2030. Compared with the ETH60CACD scenario, where the introduction of cellulose-to-ethanol is delayed to 2015, and the use of corn is adjusted as cellulose ethanol becomes available, the use of corn for energy reaches its maximum in 2015 at 44.2 percent of total use. Similar to the ETH60 scenario, the relative participation diminishes as cellulose becomes more available, and by 2030 the relative use of corn for energy is 21.1 percent.

Table 14. Change in Livestock Sector Costs and Returns Under the ETH60 CACD Scenario.

	2008	2010	2015	2020	2025	2030
			Million Dollars			
Cattle:						
Expenses	51	53	-14	-303	-359	-281
Cash Receipts	358	638	3167	859	213	432
Net Returns	306	585	3181	1161	571	713
Percent Change Net Returns	3.4%	7.1%	38.0%	10.9%	5.4%	6.8%
Hogs:						
Expenses	285	608	2381	-257	-521	117
Cash Receipts	9	87	848	112	-81	-30
Net Returns	-276	-522	-1532	369	439	-146
Percent Change Net Returns	-13.6%	-32.3%	-84.9%	18.4%	20.1%	-6.0%
Chickens:						
Expenses	599	1192	4917	227	-248	612
Cash Receipts	22	113	1067	393	204	198
Net Returns	-577	-1079	-3850	166	452	-414
Percent Change Net Returns	-8.3%	-15.5%	-47.7%	2.0%	5.4%	-4.9%

Table 15. Corn Utilization for Selected Scenarios and Years.

	USDAExt			ETH60			ETH60CACD		
	2007	2015	2030	2007	2015	2030	2007	2015	2030
					Million Bushels				
Feed	5,850	5,875	5,932	5,654	5,107	5,191	5,654	4,172	5,804
	51.2%	***46.4%***	***41.0%***	***48.8%***	***39.3%***	***35.2%***	***48.8%***	***31.9%***	***41.4%***
Food, Seed, & Industrial Use	1,405	1,490	2,590	1,405	1,490	2,591	1,405	2,443	2,590
	12.3%	***11.8%***	***17.9%***	***12.1%***	***11.5%***	***17.6%***	***12.1%***	***18.7%***	***18.5%***
Energy	2,150	2,915	2,915	2,591	4,696	4,696	2,591	5,773	2,966
	18.8%	***23.0%***	***20.2%***	***22.3%***	***36.2%***	***31.8%***	***22.3%***	***44.2%***	***21.1%***
Exports	2,025	2,375	3,018	1,943	1,692	2,269	1,943	672	2,670
	17.7%	***18.8%***	***20.9%***	***16.8%***	***13.0%***	***15.4%***	***16.8%***	***5.1%***	***19.0%***
Total Use	11,430	12,655	14,455	11,593	12,985	14,747	11,593	13,060	14,030

An important element of the use of corn grain for ethanol is the co-production of dry distillers grains, which have a high feed value for the livestock sector. In Table 16, the estimates for the production of DDG's and the corresponding corn equivalent are presented. These data show that about 30 percent of the corn use for energy returns to the livestock industry, contributing in this way to reduce the pressure on corn prices and overall increase in feed costs.

Table 16. Dry Distillers Grains for Selected Scenarios and Years.

	USDAExt			ETH60			ETH60CACD		
	2007	2015	2030	2007	2015	2030	2007	2015	2030
				Million Pounds					
Production	39,367	53,374	53,374	47,441	85,984	85,984	47,441	105,704	54,307
				Million Bushels					
Corn Feed Equivalent	702	951	951	846	1,533	1,533	846	1,884	968

4.11. Government Payments and Net Farm Income

The new demand by biofuels for agricultural resources resulted in changes in land use and a general increase in commodity prices. These two elements have significant consequences for government payments for agricultural programs and for net farm income.

Among government payments, there are four broad categories: loan deficiency payments, contract payments, counter cyclical payments, other payments that include mostly conservation programs and minor programs. Both loan deficiency payments (LDPs) and Counter Cyclical payments depend on the average market prices. Contract payments, also known Direct Payments, are based on historical plantings fixed in 2002, and remain fixed for the duration of the farm legislation. Conservation programs are also independent of prices and land use, and are kept fixed for the duration of this analysis.

Table 17 indicates the impacts in government payments as a result of considering the ETH60 scenario. It contains the impacts on each of these payments categories. The changes in government payments are extremely sensitive to the baseline levels of prices and payments. The changes follow the USDA outlook for Loan Deficiency Payments and Counter Cyclical Payments. While payments are at very low levels in the baseline, the current year crop has shown a significant deviation from USDA projections. Even given these low baseline levels of payments, the increase prices induced by the new biofuels demand resulted in savings in government payments of about a $1 billion for Loan Deficiency Payments, and an additional $7 billion in Counter Cyclical payments for a total savings over the period of about $8 billion.

If a small deviation in the estimates of USDA (between $1 to $2 billion) is considered, the potential total savings in the categories of LDPs and CCP would jump from $8 billion to beyond $50 billion. Moreover, if the possibility of reducing the Contract or Direct payments is considered as a result of increasing Net Farm Income, the potential savings in government payments would jump to above $150 billion. Havsing said that, it is likely that the accumulated government savings would amount to at least $100 billion over the 25 year period. The relationship between changes in net farm income and in government savings is displayed in Figure 18. There is cumulative increase in net farm income over the 2007-2030 of $210 billion projected.

Table 17. Estimated Level of Government Payments by Government Program Under the ETH60 Scenario and the Extended USDA Baseline.

Government Program and Scenario	Projected for the Year: 2007	2010	2015	2020	2025	2030	Total
	Million Dollars						
Loan Deficiency :							
ETH60	780	0	0	0	0	3	4,098
USDAExt	816	360	0	0	0	0	5,069
Contract:							
ETH60	4,249	5,168	5,168	5,168	5,168	5,168	127,833
USDAExt	4,249	5,168	5,168	5,168	5,168	5,168	127,833
Counter Cyclical:							
ETH60	2,126	1,450	470	571	574	682	24,833
USDAExt	3,458	1,714	868	832	819	757	32,616
Other:							
ETH60	3,950	4,490	3,610	3,610	3,610	3,610	98,470
USDAExt	3,950	4,490	3,610	3,610	3,610	3,610	98,470
Total Payments:							
ETH60	11,105	11,108	9,248	9,349	9,352	9,463	255,234
USDAExt	12,473	11,732	9,646	9,610	9,597	9,535	263,988

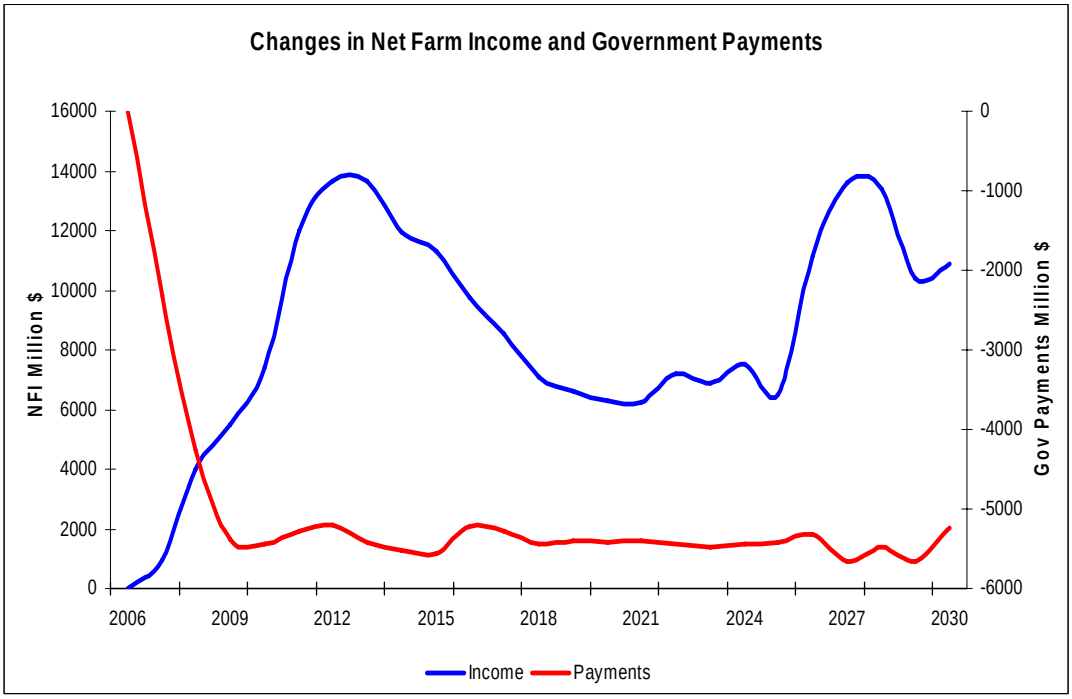


Figure 18. Changes in Net Farm Income and Government Payments Under the ETH60 Scenario.

4.12. Impacts on the Nation's Economy

As shown in Table 18, in the USDA baseline, 7.02 billion gallons is produced in the year 2010 and expands to 8.75 billion gallons in the years 2020 and 2030. The baseline assumes no growth in feedstock quantities past 2015. The growth in baseline biofuels quantities is a result of improved conversion of these feedstocks.

By 2030, a total of $110 billion annually is directly generated in the economy via purchasing inputs, adding value to those inputs, and supplying biofuels to the nation. In addition, these expenditures create additional impacts. The total impact to the nation's economy is estimated at $368 billion per year creating an estimated 2.4 million jobs (Table 19). These impacts do not account for the potential of reduced economic activity that might occur in the current energy industry. However, if biofuels are used to meet new energy demands, the gasoline refining industry might experience minimal or no downsizing.

The impacts projected in this study are divided into two areas: 1) those caused by changes in the agricultural sector, and 2) those caused by the development of a renewable energy industrial sector. The agricultural sector impacts include the additional impacts that result from changes from the baseline in agricultural commodity prices, government payments, and acres planted in both traditional crops and dedicated energy crops. The impacts in the renewable energy and interstate commerce sectors incorporate the entire production of the ethanol and biodiesel industries.

An estimated $25 billion per year in the year 2030 is added to the nation's economy as a result of changes that occur in the agricultural sector (acres planted, commodity prices, and reduced government payments) in producing the feedstock required for an additional 51 billion gallons of ethanol and 1.54 billon gallons of biodiesel. In addition, an estimated 360,000 additional jobs will be created in 2030. In 2010, an estimated $12 billion is added to the economy primarily through increased proprietary income as a result of increased agricultural prices. The multiplier is estimated at 1.46 and measures the impact to the economy that occurs primarily through increased proprietor incomes. This increases to $24.9 billion in 2020 and $37.5 billion in 2030.

Table 18. Amount of Ethanol and Biodiesel Production Assumed in the POLYSYS Baseline and the Amount of Additional Gallons Required to Meet the Estimated Goal.

	Projected in the Year:		
Fuel and Scenario:	2010	2020	2030
	Billion Gallons		
Ethanol:			
Baseline	7.02	8.75	8.75
Additional	2.98	21.17	51.6
Goal	10	29.92	60.35
Biodiesel:			
Baseline	0.0385	0.05	0.05
Additional	0.68	1.2	1.54
Goal	0.72	1.25	1.59

Table 19. Estimated Annual Economic Impacts from Meeting 10, 30, and 60 Million Gallon Ethanol Goals in 2010, 2020, and 2030, Respectively.

Year and Sector		Change in Industry Output		Impact in Employment	
		Direct Impact	Total Impact	Direct Impact	Total Impact
		Million Dollars (in 2006 $)		Number Of Jobs	
2010:					
Agricultural Production Sector		$12,078	$17,657	63,776	122,161
Renewable Energy Sector		$7,287	$15,423	3,198	76,796
Interstate Commerce [a]		$0	$13,357	0	103,210
	Total	$19,365	$46,437	66,975	302,166
2020:					
Agricultural Production Sector		$13,906	$21,903	161,146	242,487
Renewable Energy Sector		$37,466	$76,378	23,296	398,864
Interstate Commerce [a]		$0	$73,282	0	558,986
	Total	$51,373	$171,564	184,442	1,200,337
2030:					
Agricultural Production Sector		$24,869	$37,527	235,709	359,674
Renewable Energy Sector		$85,093	$171,096	57,597	898,192
Interstate Commerce [a]		$0	$159,730	0	1,229,325
	Total	$109,962	$368,353	293,306	2,487,191

[a] Since ethanol is a relatively new industry in many of the states, the estimated state level impacts did not capture the impacts of interstate commerce.

In 2030, the impact to the sectors supplying cellulosic material is estimated at over $7.8 billion. In both 2020 and 2030, the impacts to agricultural input sectors increases $1 billion and $2 billion, respectively, reflecting the decrease in inputs used in the production of traditional crops, as well as the increase in the production of dedicated crops and the harvesting of stover and wheat straw.

Although the estimated impacts are distributed throughout the nation, the central part of the nation receives the largest benefits. All states, except Maine, show a gain in economic activity and jobs as a result of the agricultural sector impacts on each state's economy as a result of meeting the Governors Ethanol Coalition Goal (Figure 19). However, Maine is expected to have a positive impact in forestry rather than agriculture. These impacts are incorporated in the conversion impact analysis.

Impact to Total Industry Output **Impact to Employment**

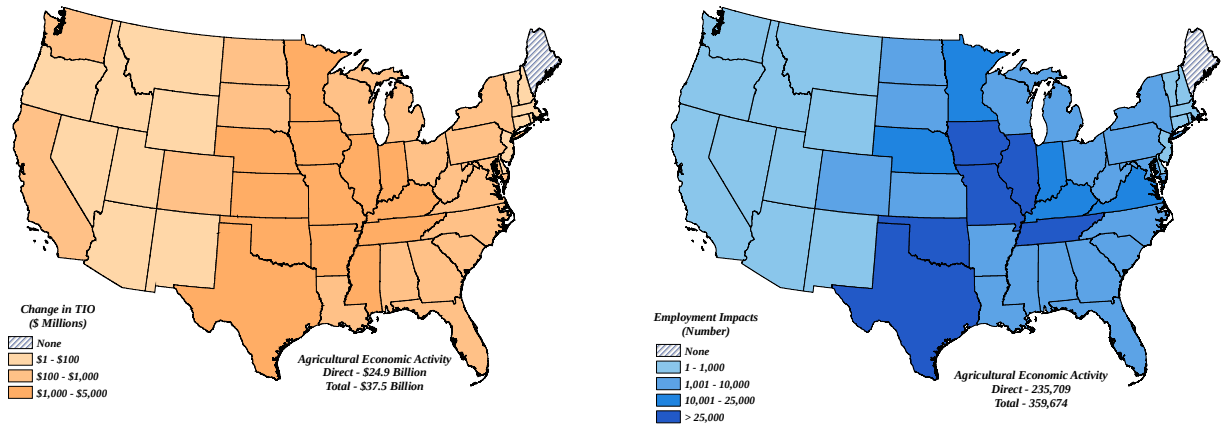


Figure 19. Estimated Impacts to the National Economy as a Result of Changes in Agricultural Production, Prices, and Government Payments to Meet the 60 billion Gallon Ethanol Demand in 2030.

4.13. Impacts in the Ethanol Energy Conversion Sector

By 2030, an estimated $330.8 billion is generated annually in the conversion of renewables to energy based on expenditures of $85 billion in the ethanol conversion industry, excluding expenditures in the agricultural sectors that supply feedstocks. Assuming the renewable energy sector is developed in close proximity to the feedstocks, the states that receive the greatest benefit include Arkansas, Illinois, Iowa, Oklahoma, and Texas (Figure 20). Other states receive an estimated $5 billion to $10 in economic activity associated with conversion. Interstate commerce associated with conversion that cannot be assigned to any individual state is nearly equal to impacts that are allocated. Including both allocated and unallocated economic activity, nearly 2.1 million jobs are estimated to be created from the development of a renewable energy sector beyond what exists today.

Impact to Total Industry Output **Impact to Employment**

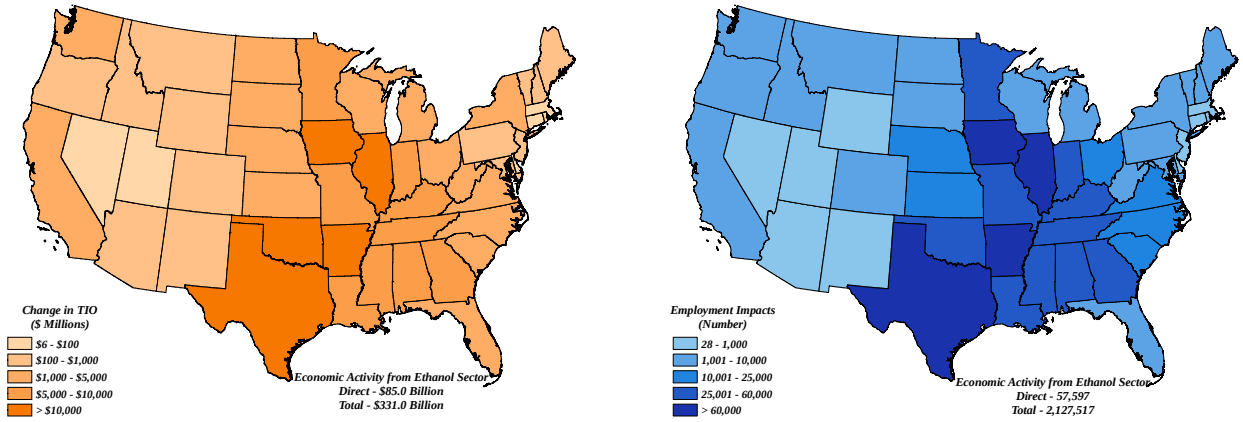


Figure 20. Estimated Impacts to the National Economy as a Result of Establishing a Larger Renewable Energy Sector to Meet the 60 billion Gallon Ethanol Demand in 2030.

4.14 Tax Implications of producing 60 Billion Ethanol Gallons

Using information from the IMPLAN tax report and based on 2001 tax code, an estimated $45 billion in tax revenue is generated through indirect business taxes (27%), employee compensation (20%), corporate taxes (6%), household expenditure (41%), and proprietary income (6%) (Figure 21). Slightly over $30 billion is estimated to go to the federal government with Social Insurance taxes accounting for $9 billion and income tax $14.2 billion. On the state side, indirect business taxes on property is projected to increase by $4.1 billion in 2030 and sales tax could increase by $5.2 billion as a result of producing 60 billion gallons of ethanol. Appendix C includes a description of the taxes included in the IMPLAN analysis along with detailed tables for the 2030 solution.

Breaking the impacts apart into those generated by the renewable energy sector and those generated by the agricultural sector, a projected $43 billion will be generated from economic activity generated from the renewable energy sector and an estimated $2 billion from economic activity generated from the agricultural sector.

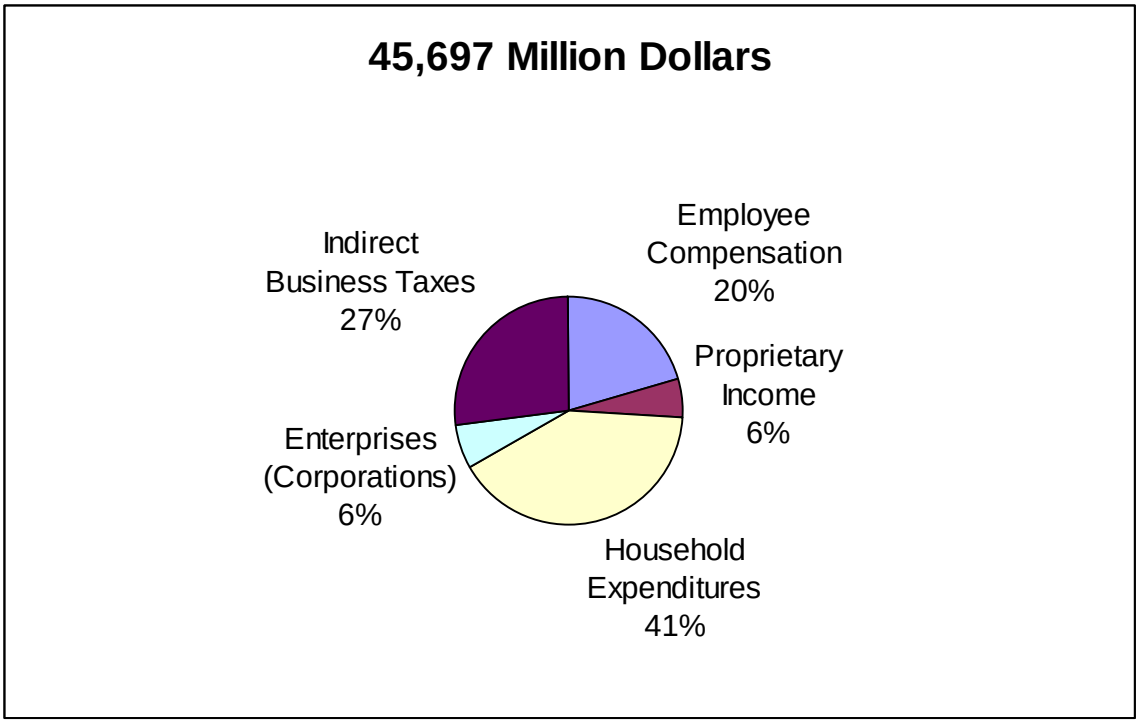


Figure 21. Estimated annual increase in tax collections as a result of producing 60 billion gallons of ethanol

4.15. Summary of Key Findings

Some of the key findings revolving around attaining a 60 billion gallon ethanol goal and a 1.6 billion gallon biodiesel goal by the are presented in Table 20.

Table 20. Summary of Key Results

Key Variables	Summary of Results
Bioenergy Production and Fuels Imports Reduction	The 60 billion gallon goal is attainable by 2030. Reaching the goal by 2030 would result in a cumulative displacement of 490.4 billion gallons of gasoline (the equivalent of 10.48 billion barrels of oil). A biodiesel goal of 1.6 billion gallons by 2030 is also attainable.
Feedstock Utilization	Prior to 2012, corn grain will be the primary feedstock for ethanol. As cellulosic to ethanol is commercialized, dedicated energy crops will become the dominant feedstock. Soybeans serve as the primary feedstock for biodiesel (1 billion gallons) along with tallow and yellow grease (.6 billion gallons)
Changes in Land Use	Dedicated energy crops use 34.4 million acres by 2030. Acreage is converted from soybean production and pastureland.
Price Impacts	Corn price increases by $.60 per bushel above the baseline to $3.03 per bushel in 2030. Delaying cellulosic to ethanol to 2015 from 2012 would result in a sharp increase in corn price ($1.95 per bushel above the baseline). Soybean prices increase to $6.76 in 2030 ($1.23 per bushel above baseline).

Table 20. Continued	
Key Variables	Summary of Results
Biofuels Cost	Average ethanol costs decline over the period from $1.45 per gallon in 2007 to $1.23 in 2030. Biodiesel from soybeans is $4.22 per gallon in 2007 and increases to $4.91 per gallon in 2030, reflecting the increase in feedstock prices. Yellow grease costs are considerably lower (about $1.77 per gallon).
Exports	Soybean exports decline significantly compared with the baseline (1.1 billion bushels in the baseline compared with .6 billion bushels) in the year 2030. The value of exports declines by $3.4 billion in the year 2030. The accumulated declined in exports for the period 2006-2030 amounts to $ 43.5 billion dollars.
Regional Impacts: Feedstock and Net Returns	A significant concentration of the cellulosic feedstock production occurs in the Southeast and Southern regions of the country first, and then moves towards the Midwest and Northern Plains. The largest availability of wood and forest residues would be located west of the Rocky Mountains, in the Southeast, and in New England. Gains in agricultural income are projected to occur across the whole nation.
Livestock Sector	An 8 percent gain in total net returns accrues to the cattle industry in the year 2030. Other livestock impacts are difficult to assess due to the level of vertical integration.
Corn Utilization	By 2030, corn used in feed decreases 13.6 percent from current levels reflecting increased production of DDG's. Corn utilized in energy production increases from 2.6 billion bushels in 2007 to 4.7 billion bushels in 2015.
Government Payments and Net Farm Income	A cumulative increase in net farm income over the 2007-2030 period of $210 billion is projected. Cumulative savings in government payments of $8.6 billion are projected through the year 2030.
Impacts on the Nation's Economy	By 2030, a total of $110 billion annually is directly generated and the total impact to the nation's economy is estimated at $368 billion per year. An estimated 2.4 million jobs are created. This includes the impacts from feedstock production ($37.5 billion annually in 2030) and conversion ($330.8 billion annually in 2030).

V. Conclusions

The analyses performed indicate that U.S. agriculture is in a position to play a significant role as a source of energy. Not only can the U.S. meet food and feed demands, but it can also produce 60 billion gallons of ethanol per year by 2030. This would replace over 20 percent of the gasoline needs in the US market and would be produced from U.S. crop and forest lands. In addition to the ethanol, by 2030, 1.6 billion gallons of biodiesel per year could also be produced.

By 2030, the production of biofuels from renewable feedstocks will generate an estimated $368 billion of additional economic activity per year and potentially create 2.4 million jobs. This annual amount includes $110 billion in economic activity directly linked to the production and conversion of biofeedstocks to ethanol and biodiesel. An estimated $45 billion in tax revenue is generate for local, states and federal governments.

For agriculture, this new demand for cropland and crops implies an additional $11 billion of net farm income annually by 2030, and a yearly savings of more than $5 billion dollars in government payments. Overall, for the period 2007 to 2030, the estimated accumulated gains in net farm income are over $210 billion; and the accumulated potential savings in government payments are estimated to be $150 billion.

In addition, in the year 2030, ethanol would have displaced more than 20 percent of the domestic consumption of gasoline, potentially reducing oil imports by $52 billion each year assuming oil price remains at $60 per barrel. For the entire period through 2030, the cumulative displacement could be as high as 10.48 billion barrels of oil, causing a potential reduction in imports of $629 billion dollars.

Due to the geographic decentralization of the production of feedstock, the economic gains reach the vast majority of the country. This regional distribution of the benefits is reinforced by the fact that due to its low density transportation of feedstock is expensive, so pre-treatment and/or conversion facilities would also tend to be located across the country.

Regionally, the Midwest would have the comparative advantage to produce cellulosic ethanol from corn and wheat residues, while the Southeast and the South would have the comparative advantage in dedicated crops production. In addition, cellulosic material from wood and forest residues would come primarily from the West, Southeast, and Northeast. The gains would primarily be concentrated in the areas in which agricultural production occurs, but the use of wood and forest residues expands the gains beyond the agricultural areas.

The growth of the bioenergy industry is closely tied to the availability of the cellulose-to-ethanol technological path. A delay in the commercial introduction and wide spread adoption of this new technology would impose significant costs for the users of agricultural commodities and limit the contribution of agriculture to the energy needs of the country. To expedite commercial introduction of cellulosic ethanol technologies, adequate support of research and development activities and policies toward commercialization are merited.

The development of a sustainable bioenergy industry should rely on an environmentally sound use of resources within the framework of a coherent and sustainable energy policy. In order to foster development of the bioenergy industry, policies will likely need to be in place providing buffers from short- to medium-term drops in the price of fossil fuels that could jeopardize the long term viability of the new industry.

It is important to note that the 60 million gallon per year target does not represent an upper limit of the potential energy production of the agricultural sector. Significant expansion beyond the 60 billion gallon per year target could occur with one or more of the following:

- Expansion of the region suitable for the production of bioenergy crops beyond the western edge of the Rocky Mountains;
- Incorporation of the ability to convert pastureland (different than cropland in pasture) into energy dedicated crops;
- Allowing the use acreage in the Conservation Reserve Program for the production of bioenergy;
- Increasing short-rotation wood crops in the Northeast and Northwest regions;
- Increased yields above those assumed in the analysis; and/or
- Increasing the efficiency of cellulosic conversion.

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APPENDIX A: Renewable Conversion Technologies — Expenditures In IMPLAN

Table A.1. IMPLAN Expenditures for Ethanol from Shelled Corn (Dry Mill).

Conversion Technology: Ethanol from Shelled Corn (Dry Mill)
Facility Size: 48 MM Gal/year
Total Industry Output: $101,280,000
Employees: 36
Source: McAloon, A., F. Taylor, W. Yee, K. Ibsen, and R. Wooley. 2000. "Determining the Cost of Producing Ethanol from Corn Starch and Lignocellulosic Feedstocks". National Renewable Energy Laboratory (NREL/TP-580-28893). Joint study sponsored by USDA and DOE; e-mail correspondence from Dr. Vernon R. Eidman

Type	IMPLAN Sector	IMPLAN Sector Description	Expenditures
Investment	239	Metal Tank, Heavy Gauge, Manufacturing (Saccharification, Storage/Load Out))	$5,527,361
Investment	269	All Other Industrial Machinery Manufacturing (Fermentation, Distillation, Solid/Syrup Separation/Drying)	$30,910,641
Investment	289	Air & Gas Compressor Manufacturing (Air Compressor)	$152,294
Investment	292	Feedstock Handling	$3,932,322
Investment	460	Waste Management & Remediation Services (Wastewater Treatment)	$1,522,182
Operating	2	Grain Farming (Feedstock)	$33,427,796
Operating	30	Power Generation & Supply (Electricity)	$1,739,332
Operating	31	Natural Gas Distribution (Natural Gas)	$16,923,254
Operating	32	Water, Sewage, & Other Systems (Makeup Water, Steam, CT Water, Cool Water)	$268,729
Operating	84	All Other Food Manufacturing (Yeast)	$1,023,390
Operating	150	Other Basic Inorganic Chemical Manufacturing (Caustic)	$1,138,713
Operating	151	Other Basic Organic Chemical Manufacturing (Gluco-Anylase)	$2,186,330
Operating	390	Wholesale Trade (Denaturant (Gasoline))	$1,125,885
Operating	411	Miscellaneous Store Retailers (Operating Supplies)	$624,329
Operating	425	Banking (Interest Expense)	$2,316,760
Operating	427	Insurance Carriers (Insurance & Local Taxes)	$266,321
Operating	451	Management of Companies & Enterprises (Consulting Services)	$623,246
Operating	485	Commercial Machinery Repair & Maintenance (Maintenance Supplies)	$550,941
Depreciation	239	Metal Tank, Heavy Gauge, Manufacturing (Saccharification, Storage/Load Out))	$552,736
Depreciation	269	All Other Industrial Machinery Manufacturing (Fermentation, Distillation, Solid/Syrup Separation/Drying)	$3,091,064
Depreciation	289	Air & Gas Compressor Manufacturing (Air Compressor)	$15,229
Depreciation	292	Feedstock Handling	$393,232
Byproduct	47	Other Animal Food Manufacturing (DDGS)	$12,315,927

Expenditure Summary for Ethanol from Shelled Corn

Expenditure Type	Total $	$/Gallon
Investment	$42,044,801	$0.88
Operating	$62,215,026	$1.30
Operating w/out Feedstock Expenditure	$28,787,230	$0.60
Depreciation	$4,052,262	$0.08
Byproduct	$12,315,927	$0.26

Table A.2. IMPLAN Expenditures for Ethanol from Cellulosic Residues (Stover, Switchgrass, Rice Straw, and Wheat Straw).

Conversion Technology: Ethanol from Cellulosic Residues (Stover, Switchgrass, Rice Straw, and Wheat Straw)
Facility Size: 69.3 MM Gal/year
Total Industry Output: $146,223,000
Employees: 77
Source: Aden, A., M. Ruth, K. Ibsen, J. Jechura, K. Neeves, J. Sheehan, B. Wallance, L. Montague, A. Slayton, and J. Lukas. 2002. "Lignocellulosic Biomass to Ethanol Design and Economics Utilizing Co-Current Dilute Acid Prehydrolysis and Enzymatic Hydrolysis for Corn Stover". National Renewable Energy Laboratory & Harris Group (NREL/TP-510-32438).

Type	IMPLAN Sector	IMPLAN Sector Description	Expenditures
Investment	37	Manufacturing & Industrial Buildings (Concrete Feedstock-Storage Slab)	$1,014,619
Investment	150	Other Basic Inorganic Chemical Manufacturing (Hydrazine Addition, Ammonia Addition, & Phosphatic Addition Packages)	$56,097
Investment	171	Other Miscellaneous Chemical Product Manufacturing (Biogas Emergency Flare)	$15,449
Investment	238	Power Boiler & Heat Exchanger Manufacturing (Condensors, Feed Economizers & Interchangers, Evaporators)	$10,592,600
Investment	239	Metal Tank, Heavy Gauge, Manufacturing (Mixing Tanks, Water Tanks, Filtrate Tanks, Storage Tanks)	$9,014,827
Investment	240	Metal Can, Box, & Other Container Manufacturing (Storage Bins & Drums)	$584,479
Investment	255	Miscellaneous Fabricated Metal Product Manufacturing (Corn Stover Wash Table)	$506,357
Investment	257	Farm Machinery & Equipment Manufacturing (Shredder)	$1,698,900
Investment	269	Other Industrial Machinery Manufacturing (Mixers, Agitators, & Fermentors)	$8,881,329
Investment	273	Other Commercial & Service Industry Machinery Manufacturing (Hot Process Water Softener System)	$1,486,715
Investment	275	Air Purification Equipment Manufacturing (Filters & Scrubbers)	$14,123,771
Investment	276	Industrial & Commercial Fan & Blower Manufacturing (Blowers & Instrument Air Dryer)	$246,726
Investment	277	Heating Equipment except Warm Air Furnaces (Heaters & Reboilers)	$1,016,025
Investment	278	AC Refrigeration & Forced Air Heating (Coolers & Cooling Tower System)	$3,053,855
Investment	285	Turbine & Turbine Generator Set Units Manufacturing (Turbine/Generator)	$11,497,789
Investment	288	Pump & Pumping Equipment Manufacturing (Pumps)	$6,794,254

Type	IMPLAN Sector	IMPLAN Sector Description	Expenditures
Investment	289	Air & Gas Compressor Manufacturing (Plant Air Compressor)	$1,111,595
Investment	292	Conveyor & Conveying Equipment Manufacturing (Conveyors, Feed Systems, & Screws)	$20,540,498
Investment	294	Industrial Truck, Trailer, & Stacker Manufacturing (Bale Moving Forklift)	$165,413
Investment	301	Scales, Balances, & Miscellaneous General Purpose Machinery (Truck Scales & Bar Screen)	$298,873
Investment	316	Industrial Process Variable Instruments (Magnetic Separator, Thickener, & Clarifiers)	$593,929
Investment	460	Waste Management & Remediation Services (Digesters & Waste Basins)	$22,853,455
Operating	2	Grain Farming (Feedstock)	$23,444,607
Operating	32	Water, Sewage, & Other Systems (Makeup Water)	$414,876
Operating	150	Other Basic Inorganic Chemical Manufacturing (Clarifier Polymer, Sulfuric Acid, Boiler Chemicals, Cooling Tower Chemicals, Waste Water Chemicals/Polymers)	$1,716,182
Operating	151	Other Basic Organic Chemical Manufacturing (Corn Steep Liquor & Purchased Cellulase)	$9,176,952
Operating	157	Phosphatic Fertilizer Manufacturing (Ammonium Phosphate)	$214,630
Operating	196	Lime Manufacturing (Hydrated Lime)	$1,570,267
Operating	427	Insurance Carriers (Insurance)	$672,365
Operating	438	Accounting Bookkeeping Services (Taxes, etc.)	$671,514
Operating	460	Waste Management & Remediation Services (Steam, etc.)	$2,079,300
Operating	485	Commercial Machinery Repair & Maintenance	$2,375,777
Depreciation	37	Manufacturing & Industrial Buildings (Concrete Feedstock-Storage Slab)	$50,731
Depreciation	150	Other Basic Inorganic Chemical Manufacturing (Hydrazine Addition, Ammonia Addition, & Phosphatic Addition Packages)	$5,610
Depreciation	171	Other Miscellaneous Chemical Product Manufacturing (Biogas Emergency Flare)	$1,545
Depreciation	238	Power Boiler & Heat Exchanger Manufacturing (Condensors, Feed Economizers & Interchangers, Evaporators)	$1,059,260
Depreciation	239	Metal Tank, Heavy Gauge, Manufacturing (Mixing Tanks, Water tanks, Filtrate Tanks, Storage Tanks)	$901,483
Depreciation	240	Metal Can, Box, & Other Container Manufacturing (Storage Bins & Drums)	$58,448
Depreciation	255	Miscellaneous Fabricated Metal Product Manufacturing (Corn Stover Wash Table)	$50,636
Depreciation	257	Farm Machinery & Equipment Manufacturing (Shredder)	$169,890
Depreciation	269	Other Industrial Machinery Manufacturing (Mixers, Agitators, & Fermentors)	$888,133
Depreciation	273	Other Commercial & Service Industry Machinery	$148,672

Type	IMPLAN Sector	IMPLAN Sector Description	Expenditures
		Manufacturing (Hot Process Water Softener System)	
Depreciation	275	Air Purification Equipment Manufacturing (Filters & Scrubbers)	$1,412,377
Depreciation	276	Industrial & Commercial Fan & Blower Manufacturing (Blowers & Instrument Air Dryer)	$24,673
Depreciation	277	Heating Equipment except Warm Air Furnaces (Heaters & Reboilers)	$101,603
Depreciation	278	AC Refrigeration & Forced Air Heating (Coolers & Cooling Tower System)	$305,386
Depreciation	285	Turbine & Turbine Generator Set Units Manufacturing (Turbine/Generator)	$1,149,779
Depreciation	288	Pump & Pumping Equipment Manufacturing (Pumps)	$679,425
Depreciation	289	Air & Gas Compressor Manufacturing (Plant Air Compressor)	$111,160
Depreciation	292	Conveyor & Conveying Equipment Manufacturing (Conveyors, Feed Systems, & Screws)	$2,054,050
Depreciation	294	Industrial Truck, Trailer, & Stacker Manufacturing (Bale Moving Forklift)	$16,541
Depreciation	301	Scales, Balances, & Miscellaneous General Purpose Machinery (Truck Scales & Bar Screen)	$29,887
Depreciation	316	Industrial Process Variable Instruments (Magnetic Separator, Thickener, & Clarifiers)	$59,393
Byproduct	30	Power Generation & Supply (Electricity Credit)	$6,544,130

Expenditure Summary for Ethanol from Cellulosic Residues

Expenditure Type	Total $	$/Gallon
Investment	$116,147,555	$1.68
Operating	$42,336,470	$0.61
Operating w/out Feedstock Expenditure	$18,891,864	$0.27
Depreciation	$9,278,682	$0.13
Byproduct	$6,544,130	$0.09

Table A.3. IMPLAN Expenditures for Ethanol from Food Residues.

Conversion Technology: Ethanol from Food Residues
Facility Size: 69.3 MM Gal/year
Total Industry Output: $146,223,000
Employees: 77
Source: Aden, A., M. Ruth, K. Ibsen, J. Jechura, K. Neeves, J. Sheehan, B. Wallance, L. Montague, A. Slayton, and J. Lukas. 2002. "Lignocellulosic Biomass to Ethanol Design and Economics Utilizing Co-Current Dilute Acid Prehydrolysis and Enzymatic Hydrolysis for Corn Stover". National Renewable Energy Laboratory & Harris Group (NREL/TP-510-32438).

Type	IMPLAN Sector	IMPLAN Sector Description	Expenditures
Investment	37	Manufacturing & Industrial Buildings (Concrete Feedstock-Storage Slab)	$1,014,619
Investment	150	Other Basic Inorganic Chemical Manufacturing (Hydrazine Addition, Ammonia Addition, & Phosphatic Addition Packages)	$56,097
Investment	171	Other Miscellaneous Chemical Product Manufacturing (Biogas Emergency Flare)	$15,449
Investment	238	Power Boiler & Heat Exchanger Manufacturing (Condensors, Feed Economizers & Interchangers, Evaporators)	$10,592,600
Investment	239	Metal Tank, Heavy Gauge, Manufacturing (Mixing Tanks, Water Tanks, Filtrate Tanks, Storage Tanks)	$9,014,827
Investment	240	Metal Can, Box, & Other Container Manufacturing (Storage Bins & Drums)	$584,479
Investment	255	Miscellaneous Fabricated Metal Product Manufacturing (Wash Table)	$506,357
Investment	257	Farm Machinery & Equipment Manufacturing (Shredder)	$1,698,900
Investment	269	Other Industrial Machinery Manufacturing (Mixers, Agitators, & Fermentors)	$8,881,329
Investment	273	Other Commercial & Service Industry Machinery Manufacturing (Hot Process Water Softener System)	$1,486,715
Investment	275	Air Purification Equipment Manufacturing (Filters & Scrubbers)	$14,123,771
Investment	276	Industrial & Commercial Fan & Blower Manufacturing (Blowers & Instrument Air Dryer)	$246,726
Investment	277	Heating Equipment except Warm Air Furnaces (Heaters & Reboilers)	$1,016,025
Investment	278	AC Refrigeration & Forced Air Heating (Coolers & Cooling Tower System)	$3,053,855
Investment	285	Turbine & Turbine Generator Set Units Manufacturing (Turbine/Generator)	$11,497,789
Investment	288	Pump & Pumping Equipment Manufacturing (Pumps)	$6,794,254
Investment	289	Air & Gas Compressor Manufacturing (Plant Air Compressor)	$1,111,595

Type	IMPLAN Sector	IMPLAN Sector Description	Expenditures
Investment	292	Conveyor & Conveying Equipment Manufacturing (Conveyors, Feed Systems, & Screws)	$20,540,498
Investment	294	Industrial Truck, Trailer, & Stacker Manufacturing (Forklift)	$165,413
Investment	301	Scales, Balances, & Miscellaneous General Purpose Machinery (Truck Scales & Bar Screen)	$298,873
Investment	316	Industrial Process Variable Instruments (Magnetic Separator, Thickener, & Clarifiers)	$593,929
Investment	460	Waste Management & Remediation Services (Digesters & Waste Basins)	$22,853,455
Operating	32	Water, Sewage, & Other Systems (Makeup Water)	$414,876
Operating	150	Other Basic Inorganic Chemical Manufacturing (Clarifier Polymer, Sulfuric Acid, Boiler Chemicals, Cooling Tower Chemicals, Waste Water Chemicals/Polymers)	$1,716,182
Operating	151	Other Basic Organic Chemical Manufacturing (Corn Steep Liquor & Purchased Cellulase)	$9,176,952
Operating	157	Phosphatic Fertilizer Manufacturing (Ammonium Phosphate)	$214,630
Operating	196	Lime Manufacturing (Hydrated Lime)	$1,570,267
Operating	427	Insurance Carriers (Insurance)	$672,365
Operating	438	Accounting Bookkeeping Services (Taxes, etc.)	$671,514
Operating	460	Waste Management & Remediation Services (Steam, etc.)	$2,079,300
Operating	485	Commercial Machinery Repair & Maintenance	$2,375,777
Depreciation	37	Manufacturing & Industrial Buildings (Concrete Feedstock-Storage Slab)	$50,731
Depreciation	150	Other Basic Inorganic Chemical Manufacturing (Hydrazine Addition, Ammonia Addition, & Phosphatic Addition Packages)	$5,610
Depreciation	171	Other Miscellaneous Chemical Product Manufacturing (Biogas Emergency Flare)	$1,545
Depreciation	238	Power Boiler & Heat Exchanger Manufacturing (Condensors, Feed Economizers & Interchangers, Evaporators)	$1,059,260
Depreciation	239	Metal Tank, Heavy Gauge, Manufacturing (Mixing Tanks, Water tanks, Filtrate Tanks, Storage Tanks)	$901,483
Depreciation	240	Metal Can, Box, & Other Container Manufacturing (Storage Bins & Drums)	$58,448
Depreciation	255	Miscellaneous Fabricated Metal Product Manufacturing (Wash Table)	$50,636
Depreciation	257	Farm Machinery & Equipment Manufacturing (Shredder)	$169,890
Depreciation	269	Other Industrial Machinery Manufacturing (Mixers, Agitators, & Fermentors)	$888,133
Depreciation	273	Other Commercial & Service Industry Machinery Manufacturing (Hot Process Water Softener System)	$148,672
Depreciation	275	Air Purification Equipment Manufacturing (Filters & Scrubbers)	$1,412,377

Type	IMPLAN Sector	IMPLAN Sector Description	Expenditures
Depreciation	276	Industrial & Commercial Fan & Blower Manufacturing (Blowers & Instrument Air Dryer)	$24,673
Depreciation	277	Heating Equipment except Warm Air Furnaces (Heaters & Reboilers)	$101,603
Depreciation	278	AC Refrigeration & Forced Air Heating (Coolers & Cooling Tower System)	$305,386
Depreciation	285	Turbine & Turbine Generator Set Units Manufacturing (Turbine/Generator)	$1,149,779
Depreciation	288	Pump & Pumping Equipment Manufacturing (Pumps)	$679,425
Depreciation	289	Air & Gas Compressor Manufacturing (Plant Air Compressor)	$111,160
Depreciation	292	Conveyor & Conveying Equipment Manufacturing (Conveyors, Feed Systems, & Screws)	$2,054,050
Depreciation	294	Industrial Truck, Trailer, & Stacker Manufacturing (Forklift)	$16,541
Depreciation	301	Scales, Balances, & Miscellaneous General Purpose Machinery (Truck Scales & Bar Screen)	$29,887
Depreciation	316	Industrial Process Variable Instruments (Magnetic Separator, Thickener, & Clarifiers)	$59,393
Byproduct	30	Power Generation & Supply (Electricity Credit)	$6,544,130

Expenditure Summary for Ethanol from Food Residues

Expenditure Type	Total $	$/Gallon
Investment	$116,147,555	$1.68
Operating	$18,891,863	$0.27
Depreciation	$9,278,682	$0.13
Byproduct	$6,544,130	$0.09

Table A.4. IMPLAN Expenditures for Ethanol from Wood Residues.

Conversion Technology: Ethanol from Wood Residues
Facility Size: 32.4 MM Gal/year
Total Industry Output: $68,364,000
Employees: 38
Source: BBI International. 2002. "State of Maine Ethanol Pre-Feasibility Study". Prepared for Finance Authority of Maine.

Type	IMPLAN Sector	IMPLAN Sector Description	Expenditures
Investment	37	Manufacturing & Industrial Buildings (Plant Engineering & Construction)	$137,568,289
Investment	150	Other Basic Inorganic Chemical Manufacturing (Inventory - Chemicals & Denaturant)	$265,846
Investment	151	Other Basic Organic Chemical Manufacturing (Inventory - Ethanol & Lignin Residue)	$1,111,099
Investment	292	Conveyor & Conveying Equipment Manufacturing (Spare Parts)	$293,934
Investment	356	Railroad Rolling Stock Manufacturing (Rolling Stock & Shop Equipment)	$147,356
Investment	425	Banking (Startup Costs, Working Capital, capitalized Fees & Interest)	$10,154,237
Investment	431	Real Estate (Land)	$194,991
Investment	437	Legal Services (Permits, Legal & Miscellaneous)	$290,676
Investment	451	Management of Companies & Enterprises (Organizational Costs)	$293,052
Operating	14	Logging (Feedstock)	$14,580,764
Operating	30	Power Generation & Supply (Electricity)	$884,912
Operating	32	Water, Sewage & Other Systems (Steam & Fresh Water)	$11,623,994
Operating	150	Other Basic Inorganic Chemical Manufacturing	$5,642,213
Operating	390	Wholesale Trade (Denaturants)	$1,060,416
Operating	411	Miscellaneous Store Retailers (Office/Lab Supplies & Expenses)	$72,074
Operating	425	Banking (Interest - Senior Debt)	$6,881,729
Operating	437	Legal Services (Legal & Accounting/Community Affairs)	$35,579
Operating	451	Management of Companies & Enterprises (Consulting Services)	$23,913
Operating	456	Travel Arrangement & Reservation Services (Travel, Training & Miscellaneous)	$29,902
Operating	458	Services to Buildings & Dwellings (Maintenance Materials & Services)	$2,008,746
Operating	460	Waste Management & Remediation Services (Wastewater Effluent Treatment & Solid Waste Disposal)	$892,591
Operating	499	Other State & Local Govt. Enterprises (Property Taxes & Insurance)	$1,986,679

Type	IMPLAN Sector	IMPLAN Sector Description	Expenditures
Depreciation	37	Manufacturing & Industrial Buildings (Plant Engineering & Construction)	$6,878,414
Depreciation	150	Other Basic Inorganic Chemical Manufacturing (Inventory - Chemicals & Denaturant)	$26,585
Depreciation	151	Other Basic Organic Chemical Manufacturing (Inventory - Ethanol & Lignin Residue)	$111,110
Depreciation	292	Conveyor & Conveying Equipment Manufacturing (Spare Parts)	$29,393
Depreciation	356	Railroad Rolling Stock Manufacturing (Rolling Stock & Shop Equipment)	$14,736
Depreciation	431	Real Estate (Land)	$9,750
Byproduct	148	Industrial Gas Manufacturing (Carbon Dioxide)	$955,767
Byproduct	151	Other Basic Organic Chemical Manufacturing (Lignin Residue)	$7,497,280

Expenditure Summary for Ethanol from Wood Residues

Expenditure Type	Total $	$/Gallon
Investment	$150,319,480	$4.64
Operating	$45,723,512	$1.41
Operating w/out Feedstock Expenditure	$31,142,748	$0.96
Depreciation	$7,069,988	$0.22
Byproduct	$8,453,047	$0.26

Table A.5. IMPLAN Expenditures for Biodiesel from Soybeans.

Conversion Technology: Biodiesel from Soybeans
Facility Size: 13.0 MM Gal/year
Total Industry Output: $32,749,600
Employees: 18
Source: English, B., K. Jensen, and J. Menard in cooperation with Frazier, Barnes & Associates, Llc. 2002. "Economic Feasibility of Producing Biodiesel in Tennessee".

Type	IMPLAN Sector	IMPLAN Sector Description	Expenditures
Investment	30	Power Generation & Supply (Utilities)	$1,241,521
Investment	37	Manufacturing & Industrial Bldgs. (Buildings, Civil/Mechanical/Electrical, Land/Prep/Trans Access)	$7,157,477
Investment	150	Other Basic Inorganic Chemical Manufacturing (Solvent Extraction)	$6,868,171
Investment	239	Metal Tank, Heavy Gauge, Manufacturing (Preparation and Mill Feed/Meal Sizing)	$5,079,026
Investment	269	All Other Industrial Machinery Manufacturing (Peripherals)	$2,985,735
Investment	292	Conveyor & Conveying Equipment Manufacturing (Feedstock & Product Storage and Handling)	$11,742,001
Investment	425	Banking (Contingency (10%))	$1,701,107
Investment	431	Real Estate (Land)	$194,991
Investment	439	Architectural & Engineering Services (Engineering/Permitting)	$334,672
Investment	451	Management of Companies & Enterprises (Set-up Consulting)	$5,206
Operating	1	Oilseed Farming (Feedstock)	$41,988,192
Operating	30	Power Generation & Supply	$338,482
Operating	32	Water, Sewage & Other Systems	$891,995
Operating	148	Industrial Gas Manufacturing	$35,677
Operating	150	Other Basic Inorganic Chemical Manufacturing	$261,496
Operating	151	Other Basic Organic Chemical Manufacturing	$921,664
Operating	425	Banking	$1,543,306
Operating	427	Insurance Carriers	$276,737
Operating	438	Accounting	$1,627,729
Operating	485	Commercial Machinery Repair & Maintenance	$353,271
Depreciation	30	Power Generation & Supply (Utilities)	$121,987
Depreciation	37	Manufacturing & Industrial Bldgs. (Buildings, Civil/Mechanical/Electrical, Land/Prep/Trans Access)	$349,696
Depreciation	150	Other Basic Inorganic Chemical Manufacturing (Solvent Extraction)	$705,300
Depreciation	239	Metal Tank, Heavy Gauge, Manufacturing (Preparation and Mill Feed/Meal Sizing)	$508,700
Depreciation	269	All Other Industrial Machinery Manufacturing (Peripherals)	$305,000
Depreciation	292	Conveyor & Conveying Equipment Manufacturing (Feedstock & Product Storage and Handling)	$1,198,434
Depreciation	431	Real Estate (Land)	$10,000

Type	IMPLAN Sector	IMPLAN Sector Description	Expenditures
Byproduct	151	Glycerine Credit	$6,972,756
Byproduct	163	Soapstock Credit	$129,604

Expenditure Summary for Biodiesel from Soybeans

Expenditure Type	Total $	$/Gallon
Investment	$37,309,907	$2.87
Operating	$48,238,549	$3.71
Operating w/out Feedstock Expenditure	$6,250,356	$0.48
Depreciation	$3,199,117	$0.25
Byproduct	$7,102,361	$0.55

Table A.6. IMPLAN Expenditures for Biodiesel from Yellow Grease.

Conversion Technology: Biodiesel from Yellow Grease
Facility Size: 10.0 MM Gal/year
Total Industry Output: $25,192,000
Employees: 10
Source: Fortenberry, T. 2005. "Biodiesel Feasibility Study: An Evaluation of Biodiesel Feasibility in Wisconsin". University of Wisconsin-Madison, Department of Agricultural & Applied Economics. Staff Paper No. 481.

Type	IMPLAN Sector	IMPLAN Sector Description	Expenditures
Investment	37	Manufacturing & Industrial Buildings (Building)	$287,772
Investment	41	Other New Construction (Civil and site work)	$570,715
Investment	239	Metal Tank, Heavy Gauge, Manufacturing (Storage Tanks)	$676,812
Investment	292	Conveyor & Conveying Equipment Manufacturing (Transesterfication Machinery)	$5,179,308
Investment	425	Banking (Working Capital)	$1,328,593
Investment	431	Real Estate (Land)	$64,991
Investment	439	Architectural & Engineering Services (Permits/misc.)	$138,373
Operating	30	Power Generation & Supply (Electricity)	$1,711
Operating	31	Natural Gas Distribution (Natural Gas/diesel)	$530,040
Operating	32	Water, Sewage, & Other Systems (Water)	$10,352
Operating	37	Manufacturing & Industrial Buildings (Building)	$15,441
Operating	54	Fats & Oils Refining & Blending (Yellow Grease)	$12,912,929
Operating	150	Other Basic Inorganic Chemical Manufacturing (Catalyst)	$296,096
Operating	151	Other Basic Organic Chemical Manufacturing (Methanol)	$1,088,151
Operating	239	Metal Tank, Heavy Gauge, Manufacturing (Storage Tanks)	$45,514
Operating	292	Conveyor & Conveying Equipment Manufacturing (Equipment)	$538,271
Operating	392	Rail Transportation (Rail Transportation)	$466,382
Operating	425	Banking (Interest Expense)	$139,026
Operating	427	Insurance Carriers (Insurance)	$222,796
Operating	439	Architectural & Engineering Services (Permits)	$27,675
Operating	451	Management of Companies & Enterprises (Marketing)	$93,359
Operating	460	Waste Management & Remediation Services (Waste Disposal & Waste Water Treatment)	$40,145
Operating	485	Commercial Machinery Repair & Maintenance (Maintenance)	$88,217
Depreciation	37	Manufacturing & Industrial Buildings (Building)	$14,389
Depreciation	41	Other New Construction (Civil and site work)	$28,536
Depreciation	239	Metal Tank, Heavy Gauge, Manufacturing (Storage Tanks)	$67,681
Depreciation	292	Conveyor & Conveying Equipment Manufacturing (Transesterfication Machinery)	$517,931
Depreciation	431	Real Estate (Land)	$3,250

Type	IMPLAN Sector	IMPLAN Sector Description	Expenditures
Byproduct	151	Glycerine	$2,405,777
Byproduct	163	Soap Stock	$38,246

Expenditure Summary for Biodiesel from Yellow Grease

Expenditure Type	Total $	$/Gallon
Investment	$8,246,564	$0.82
Operating	$16,516,104	$1.65
Operating w/out Feedstock Expenditure	$3,603,176	$0.36
Depreciation	$631,787	$0.06
Byproduct	$2,444,023	$0.24

APPENDIX B: 2006 USDA Baseline Extended to 2030 (USDAExt)

POLYSYS is initially anchored to the 2006 USDA baseline, which contains projections values for agricultural variables from 2006 through the year 2015. Because the time horizon of the study goes to 2030, the 2006 USDA baseline is extended to 2030 by exogenously estimating three variables. These variables are export changes, yield changes, and population changes. All other variables are solved endogenously from these changes.

Exports

Exports beyond 2015 (the final year of USDA baseline) are determined by extending the trend in the final three years of USDA baseline outward. Corn and wheat export trends are reduced 50%. The resulting export projections are used to 'shock' the model in the first iteration and thereafter solving to an endogenous equilibrium. The baseline exports are listed in Table B.1 along with the annual rate of change.

Yields

The last three years of USDA baseline trend in yields are extended beyond 2015 to 2030. The resulting baseline yields are listed in Table B.2 along with the annual rates of change for the individual crops.

Population

Population of the U.S. is extended out using U.S. Census Bureau 2006 estimates. (http://www.census.gov/ipc/www/usinterimproj/). Population estimates affect food demand and therefore crops prices and production. Table B.3 gives the Census Bureau estimates for population in the US.

In addition, commodity programs were kept under the same legislation and instrument levels prevailing in 2006 and the Conservation Reserve Program contracts were extended to the year 2030.

Table B.1. Export Projections for Estimated Baseline, USDAExt.

	2006	2010	2015	2020	2025	2030
Corn (mil bu)	2100	2125	2375	2576	2791	3018
Grain Sorghum	175	155	165	170	172	172
Oats	3	3	3	3	3	3
Barley	20	20	20	21	23	26
Wheat	1000	1000	1125	1192	1272	1358
Soybeans	1095	1030	975	1036	1100	1170
Cotton (mil bales)	15	16	16	17	18	19
Rice (mil cwt)	116	117	123	134	145	156

*Shocked model with USDA baseline trend to all except corn and wheat, where shock factor =50% of USDA baseline trend.

Table B.2. Yield Projections for Estimated Baseline, USDAExt.

	2006	2010	2015	2020	2025	2030
Corn(bu/ac)	147.7	154.9	163.9	173.3	183.3	193.8
Sorghum	65.0	66.8	69.0	71.6	74.2	77.0
Oats	62.8	64.4	66.4	68.4	70.6	72.7
Barley	64.4	66.8	69.8	72.9	76.2	79.5
Wheat	42.7	44.3	46.3	48.4	50.5	52.8
Soybeans	40.7	42.3	44.3	46.4	48.5	50.8
Cotton(lbs/ac)	760.0	780.0	805.0	830.6	857.1	884.4
Rice(lbs/ac)	6917.0	7184.0	7477.0	7771.0	8076.5	8394.0

*USDA baseline trends extended beyond 2014 to 2025

Table B.3. Population Projections for Estimated Baseline, USDAExt.

	Projected to the Year:					
Item	2005	2010	2015	2020	2025	2030
Population (000)	295,530.5	308936.0	322,302.0	335,846.0	349,758.0	363,584.0

U.S. Bureau of Census, 2006

APPENDIX C: Definitions, Data Sources for numbers generated in IMPLAN's Tax Impact Report, and Results

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(Source: Information below from Douglas C. Olson, Minnesota IMPLAN Group, "Using Social Accounts to Estimate Tax Impacts",available at http://www.implan.com/library/pdf_files/tax_impact_report.pdf.)

Data Sources: the tax impact report values are based on the existing relationships of the data found in the IMPLAN database. The general sources for that data are described immediately below:

NIPA: As with all items in the IMPLAN data sets all data is ultimately controlled, at the US level, by the BEA's (Bureau of Economic Analysis) NIPA (National income and product accounts) values. For 1996 IMPLAN data, the National values were controlled to the revised NIPA accounts released in the August, 1997 issue of the Survey of Current Business (volume 77, number 8). Tables 3.4 – Personal Tax and Nontax Receipts, 3.5 – Indirect Business Tax and Nontax Accruals, and 3.6 – Contributions for Social Insurance (all on page 67) and Tables 3.2 – Federal Government Receipts and Current Expenditures (page 65) and 3.3 – State and Local Government Receipts and Current Expenditures (page 66) contain controls for all the IMPLAN data elements found in the Tax Impact report.

Consumer Expenditure Survey (CES): The Bureau of the Census annually conducts surveys and diary samplings of household expenditure patterns. It is from these surveys that the BEA benchmarks the personal consumption expenditures portion of NIPA. The survey data is reported for nine different categories of household income. We can establish the tax to income level relationships for the nine different household categories. It is based on these relationships that we can distribute many of the State and Federal tax values to a county and state level, using the number of local households in each of the nine household categories.

Annual Survey of State and Local Government Finances (SLGF): The Bureau of the Census also collects annual state and local government receipts and expenditures data. This data acts as preliminary controls for state level values (subject to controlling to the National NIPA values).

Regional Economic Information System (REIS): The BEA collects and reports income, wealth, tax, and employment data on a regional (state and county) basis also. Much of the data used to distribute the US NIPA values to states and counties come from REIS tables:

Table CA05 -- Personal Income by major source and Earnings by industry
Table SA50 -- Personal Tax and Nontax Payments

Definitions and data interpretation (letters correspond to the value positions in figure A-1)

a) The employee paid portion for Federal social insurance – this includes social security, unemployment insurance, medical and retirement plans. Source: US NIPA value ("Personal contributions: Federal social insurance funds" minus "Old-age, survivors,

disability and hospital insurance: Self-employed" – table 3.6) is distributed to states and counties based on the "Personal Contribution for Social Insurance" from BEA REIS CA05 (Personal Income) table.
b) The employer paid portion for Federal social insurance – this includes social security, medical and retirement plans. Source: US NIPA value ("Employer contributions: Federal social insurance funds" – table 3.6) is distributed to states and counties based on the "Personal Contribution for Social Insurance" from BEA REIS CA05 (Personal Income) table. The employer paid portion is assumed to be a constant proportion of the personal paid proportion. This assumption will be affected by, a greater or lesser than average, proprietor income.
c) The employee paid portion for State social insurance – this represents retirement plans and temporary disability insurance. Source: US NIPA value ("Personal contributions: State and local social insurance funds – table 3.6) is distributed to states and based on each state's share of employee paid state social insurance specified in the SLGF. The SLGF categories comprising employee paid state social insurance are: "X01 Employee Retirement – Local Employee Contribution"; "X02 Employee Retirement – State Employee Contribution"; and "Y11 Workers Compensation – Other Contributions". County distribution is based on county portion of state and local government non-education employee compensation from IMPLAN.
d) The employer paid portion for State social insurance – this represents retirement plans, worker's comp and temporary disability insurance. Source: US NIPA value ("Employer contributions: State and local social insurance funds – table 3.6) is distributed to states and based on each state's share of employer paid state social insurance specified in the SLGF. The SLGF categories comprising employer paid state social insurance are: "X04 Employee Retirement – From Local Government"; "X05 Employee Retirement – From State Government"; "Y01 Unemployment Compensation – Contribution"; and "Y10 Workers Compensation – Own Contributions". County distribution is based on county portion of state and local government non-education employee compensation from IMPLAN.
e) Federal social insurance paid by self-employed – this includes social security, unemployment insurance, medical and retirement plans. Source: US NIPA value ("Personal contributions: Federal social insurance funds: Old-age, survivors, disability and hospital insurance: Self-employed" – table 3.6) is distributed to states and counties based on the "Proprietors' Income" from BEA REIS CA05 (Personal Income) table.
f) Estate and gift taxes are net of refunds (including interest). Source: State "Federal government: Estate and gift taxes" from REIS table SA50 (tax tables) is controlled to the US NIPA value ("Federal: Estate and gift taxes"– table 3.4). State values are distributed to counties based on total "Personal Income" from the BEA REIS CA05 (Personal Income) table.
g) Income tax is taxes paid to the Federal Government through withholding, declarations and final settlement less refunds. Source: State "Federal government: Individual Income taxes (net of refunds)" from REIS table SA50 (tax tables) is controlled to the US NIPA value ("Federal: Income taxes" – table 3.4). State values are distributed to counties based on total "Personal Income" from the BEA REIS CA05 (Personal Income) table.
h) Personal nontaxes consist of a variety of small payments – e.g., passport and immigration fees, fines and migratory bird-hunting stamps. Source: State "Federal

government: Nontaxes" from REIS table SA50 (tax tables) is controlled to the US NIPA value ("Federal: Nontaxes" – table 3.4). State values are distributed to counties based on total "Personal Income" from the BEA REIS CA05 (Personal Income) table.
i) Household estate tax payments to state and local governments. Source: US NIPA value ("State and local: Estate taxes" – table 3.4) value is distributed to states based on "Tax – Death & Gift" (item T50) from the SLGF. State values are distributed to counties based on total "Personal Income" from the BEA REIS CA05 (Personal Income) table.
j) Household personal income tax payments to state and local governments. Source: US NIPA value ("State and local: Income taxes" – table 3.4) value is distributed to states based on "Tax – Individual Income" (item T40) from the SLGF. State values are distributed to counties based on total "Personal Income" from the BEA REIS CA05 (Personal Income) table.
k) Household personal motor vehicle fee payments to state and local governments. Source: US NIPA value ("State and local: Motor Vehicle Licenses" – table 3.4) value is distributed to states based on "Miscellaneous – Fines & Forfeits" (item U30) from the SLGF. State values are distributed to counties based on total "Personal Income" from the BEA REIS CA05 (Personal Income) table.
l) Household personal nontax payments to state and local governments include payments for fines and donations. Source: US NIPA value ("State and local: Nontaxes" – table 3.4) value is distributed to states based on "Tax – Motor Vehicle License" (item T25) from the SLGF. State values are distributed to counties based on total "Personal Income" from the BEA REIS CA05 (Personal Income) table.
m) Household personal other tax payments to state and local governments include hunting, fishing and other personal licenses. Source: US NIPA value ("State and local: Other taxes" – table 3.4) value is distributed to states based on "Tax – Hunting and Fishing License" (item T23) from the SLGF. State values are distributed to counties based on total "Personal Income" from the BEA REIS CA05 (Personal Income) table.
n) Household personal property tax payments to state and local governments. Source: US NIPA value ("State and local: Property taxes" – table 3.4) value is distributed to states based on "Tax – Property" (item T01) from the SLGF. State values are distributed to counties based on total "Personal Income" from the BEA REIS CA05 (Personal Income) table.
o) Federal Corporate profits tax. Source: US NIPA value ("Corporate profits tax accruals" – table 3.2) is distributed to states and counties based on the proportion of US Other Property Income (from IMPLAN database).
p) State & Local government Corporate profits tax. Source: US NIPA value ("Corporate profits tax accruals" – table 3.3) is distributed to states based on "Tax – Corporate Net Income" (item T41) from the SLGF. The state distribution to counties is based on counties based on the proportion of state Other Property Income (from IMPLAN database).
q) State & Local government dividends represent dividend payments to government by corporations from investments. Source: US NIPA value ("Dividends received by government" – table 3.3) is distributed to states based on: "Employee Retirement – Securities – Mortgages" (X42); "Employee Retirement – Securities – Corporate Stocks" (X41); "Employee Retirement – Securities – Corporate Bonds" (X40); and "Employee Retirement – Total Other Securities" (X44) from the SLGF. The state distribution to

counties is based on the proportion of state Other Property Income (from IMPLAN database).
r) Custom duties are gross collections net refunds. Source: US NIPA value ("Federal: Customs duties" – table 3.5) is distributed to states and counties based on IMPLAN estimates of total IBT for all industries in relationship to US total IBT.
s) Includes federally levied excise taxes on alcohol, tobacco, telephones, coal, fuels, air transportation, vehicles, etc. Source: US NIPA value ("Federal: Excise taxes" – table 3.5) is distributed to states and counties based on IMPLAN estimates of total IBT for all industries in relationship to US total IBT.X
t) IBT federal non-tax payments include petroleum royalties, fines, regulatory fees, forfeitures and donated funds. Source: US NIPA value ("Federal: Nontaxes" – table 3.5) is distributed to states and counties based on IMPLAN estimates of total IBT for all industries in relationship to US total IBT.
u) Motor vehicle license taxes paid to state and local governments. Source: US NIPA value ("State and Local: Motor Vehicle Licenses" -table 3.5) is distributed to states based on each state's proportion of "Tax – Motor Vehicle Operator's License" (item T25) plus "Tax – Motor Vehicle License" (item T24) from the SLGF. State values are distributed to counties based on total "Personal Income" from the BEA REIS CA05 (Personal Income) table.
v) Other taxes paid to state and local governments include business licenses, documentary and stamp taxes. Source: US NIPA value ("State and Local: Other taxes" - table 3.5) is distributed to states based on each state's proportion of: "T99 Tax – Corporation License"; "T21 Tax – Amusement License"; "T29 – Other License"; "T51 Tax – Documentary & Stock Transfer"; "T27 Tax – Public Utility License"; "T20 Tax – Alcoholic Beverage License"; "T28 Tax – Occupation & Business License, NEC"; and "T99 Tax – NEC" from the SLGF. State values are distributed to counties based on total "Personal Income" from the BEA REIS CA05 (Personal Income) table.
w) Property taxes paid to state and local governments. Source: US NIPA value ("Indirect business tax and nontax accruals: Property Taxes" -table 3.3) is distributed to states based on each state's proportion of "Tax – Property" (item T01) from the SLGF. State values are distributed to counties based on total "Personal Income" from the BEA REIS CA05 (Personal Income) table.
x) Non taxes paid to state and local governments include rents and royalties, special assessments, fines, settlements and donations. Source: US NIPA value ("State and Local: Nontaxes" - table 3.5) is distributed to states based on each state's proportion "U 40 Miscellaneous – Rents"; "U01 Miscellaneous – Special Assessments"; "U41 Miscellaneous – Royalties"; and "U50 Miscellaneous – Donations From Private Sources" from the SLGF. State values are distributed to counties based on total "Personal Income" from the BEA REIS CA05 (Personal Income) table.
y) Sales taxes paid to state and local government. Source: US NIPA value ("Indirect business tax and nontax accruals: Property taxes" -table 3.3) is distributed to states based on each state's proportion of "Tax – Total General Sales" (item T09) from the SLGF. State values are distributed to counties based on total "Personal Income" from the BEA REIS CA05 (Personal Income) table.
z) Severance taxes paid to state and local governments. Source: US NIPA value ("State and Local: Severance taxes" -table 3.5) is distributed to states based on each state's

proportion of “Tax - Severance” (item T53) plus “Tax – Motor Vehicle License” (item T24) from the SLGF. State values are distributed to counties based on total “Personal Income” from the BEA REIS CA05 (Personal Income) table.

Table C.1. Estimated annual impact on taxes in the year 2030 as a result of producing 60 billion gallons of ethanol

IMPLAN Sector	Description	Employee Compensation	Proprietary Income	Household Expenditures	Enterprises (Corporations)	Indirect Business Taxes	Total
Enterprises (Corporations)	Transfers	62,862					*62,862*
	Total	*62,862*	*0*	*0*	*0*	*0*	*62,862*
Federal Government Non-Defense	Corporate Profits Tax				2,485,275,438		*2,485,275,438*
	Indirect Bus Tax: Custom Duty					332,230,694	*332,230,694*
	Indirect Bus Tax: Excise Taxes					1,069,266,763	*1,069,266,763*
	Indirect Bus Tax: Fed NonTaxes					377,388,267	*377,388,267*
	Personal Tax: Estate & Gift Tax						
	Personal Tax: Income Tax			14,226,230,552			*14,226,230,552*
	Personal Tax: NonTaxes (Fines-Fees)			152,097,683			*152,097,683*
	Social Ins Tax-Employee Contr	4,525,948,473	2,604,888,558				*7,130,837,031*
	Social Ins Tax-Employer Contr	4,686,865,071					*4,686,865,071*
	Total	*9,212,813,544*	*2,604,888,558*	*14,378,328,235*	*2,485,275,438*	*1,778,885,724*	*30,460,191,499*
State/Local Government Non-Education	Corporate Profits Tax				418,727,261		*418,727,261*
	Dividends				5,803,429		*5,803,429*
	Indirect Bus Tax: Motor Vehicle Lic					91,288,723	*91,288,723*
	Indirect But Tax: Other Taxes					540,154,979	*540,154,979*
	Indirect Bus Tax: Property Tax					4,140,459,276	*4,140,459,276*
	Indirect Bus Tax: S/L NonTaxes					651,220,070	*651,220,070*
	Indirect Bus Tax: Sales Taxes					5,168,297,005	*5,168,297,005*
	Indirect Bus Tax: Severance Tax					100,180,687	*100,180,687*
	Personal Tax: Estate & Gift Tax						
	Personal Tax: Income Tax			3,108,706,671			*3,108,706,671*
	Personal Tax: Motor Vehicle Lic			181,843,844			*181,843,844*
	Personal Tax: NonTaxes (Fines-Fees)			591,649,937			*591,649,937*
	Personal Tax: Other Tax (Fish/Hunt)			45,184,082			*45,184,082*
	Personal Tax: Property Taxes			68,075,097			*68,075,097*
	Social Ins Tax-Employee Contr	27,144,427					*27,144,427*
	Social Ins Tax-Employer Contr	97,719,949					*97,719,949*
	Total	*124,864,376*	*0*	*3,995,527,631*	*424,530,690*	*10,691,600,740*	*15,236,523,437*
	Grand Total	*9,337,740,782*	*2,604,888,558*	*18,373,855,865*	*2,909,806,128*	*12,470,486,464*	*45,696,777,797*

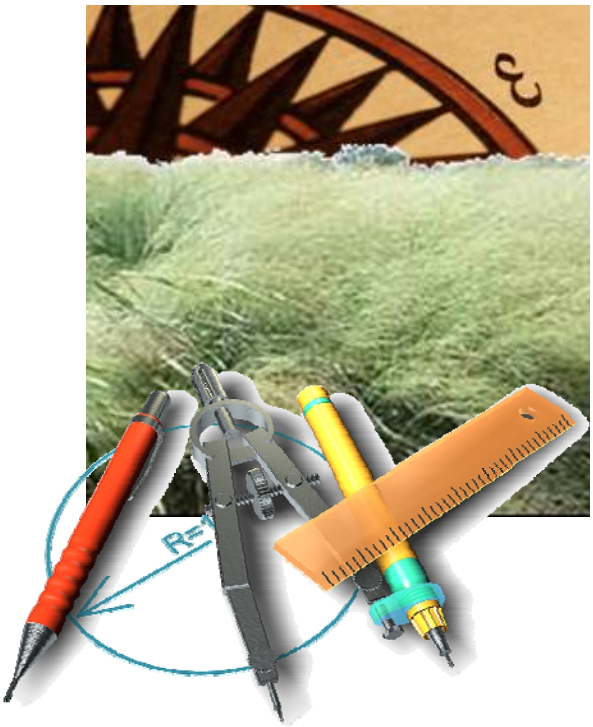
Table C.2. Estimated annual impact on taxes from the economic activity from the agricultural sector in the year 2030 as a result of producing 60 billion gallons of ethanol

		Employee Compensation	Proprietary Income	Household Expenditures	Enterprises (Corporations)	Indirect Business Taxes	Total
Federal Government Non-Defense	Corporate Profits Tax				167,436,249		*167,436,249*
	Indirect Bus Tax: Custom Duty					24,923,032	*24,923,032*
	Indirect Bus Tax: Excise Taxes					80,213,444	*80,213,444*
	Indirect Bus Tax: Fed NonTaxes					28,310,628	*28,310,628*
	Personal Tax: Estate & Gift Tax						
	Personal Tax: Income Tax			565,201,057			*565,201,057*
	Personal Tax: NonTaxes (Fines-Fees)			7,334,232			*7,334,232*
	Social Ins Tax-Employee Contr	317,943,421	35,023,784				*352,967,205*
	Social Ins Tax-Employer Contr	329,247,649					*329,247,649*
	Total	*647,191,070*	*35,023,784*	*572,535,289*	*167,436,249*	*133,447,104*	*1,555,633,496*
State/Local Government Non-Education	Corporate Profits Tax				22,433,957		*22,433,957*
	Dividends				356,098		*356,098*
	Indirect Bus Tax: Motor Vehicle Lic					9,240,557	*9,240,557*
	Indirect But Tax: Other Taxes					34,439,906	*34,439,906*
	Indirect Bus Tax: Property Tax					300,605,077	*300,605,077*
	Indirect Bus Tax: S/L NonTaxes					50,030,807	*50,030,807*
	Indirect Bus Tax: Sales Taxes					376,684,081	*376,684,081*
	Indirect Bus Tax: Severance Tax					9,181,814	*9,181,814*
	Personal Tax: Estate & Gift Tax						
	Personal Tax: Income Tax			121,935,514			*121,935,514*
	Personal Tax: Motor Vehicle Lic			11,132,158			*11,132,158*
	Personal Tax: NonTaxes (Fines-Fees)			19,424,494			*19,424,494*
	Personal Tax: Other Tax (Fish/Hunt)			2,847,462			*2,847,462*
	Personal Tax: Property Taxes			3,066,852			*3,066,852*
	Social Ins Tax-Employee Contr	1,999,491					*1,999,491*
	Social Ins Tax-Employer Contr	7,198,179					*7,198,179*
	Total	*9,197,670*	*0*	*158,474,480*	*22,790,055*	*780,182,242*	*970,644,447*
	Grand Total	*656,388,740*	*35,023,784*	*731,009,769*	*190,226,304*	*913,629,346*	*2,526,277,943*

Table C.3. Estimated annual impact on taxes from the economic activity of the renewable energy sector in the year 2030 as a result of producing 60 billion gallons of ethanol

	Employee Compensation	Proprietary Income	Household Expenditures	Enterprises (Corporations)	Indirect Business Taxes	Total
			Dollars			
Transfers						
Enterprises		0	0	0	0	62,862
(Corporations)						
Corporate Profits Tax				2,317,839,189		2,317,839,189
Indirect Bus Tax: Custom Duty					307,307,662	307,307,662
Indirect Bus Tax: Excise Taxes					989,053,319	989,053,319
Indirect Bus Tax: Fed NonTaxes					349,077,639	349,077,639
Personal Tax: Estate and Gift Tax					0	
Personal Tax: Income Tax			13,661,029,495			13,661,029,495
Personal Tax: NonTaxes (Fines- Fees			144,763,451			144,763,451
Social Ins Tax- Employee Contribution	4,208,005,052	2,569,864,774				6,777,869,826
Social Ins Tax- Employer Contribution	4,357,617,422					4,357,617,422
Federal	8,565,622,474	2,569,864,774	13,805,792,945	2,317,839,189	1,645,438,620	28,904,558,002
Government						
NonDefense						
Corporate Profits Tax				396,293,304		396,293,304
Dividends				5,447,331		5,447,331
Indirect Bus Tax: Motor Vehicle Lic					82,048,166	82,048,166
Indirect Bus Tax: Other Taxes					505,715,073	505,715,073
Indirect Bus Tax: Property Tax					3,839,854,199	3,839,854,199
Indirect Bus Tax: S/L NonTaxes					601,189,263	601,189,263
Indirect Bus Tax: Sales Tax					4,791,612,924	4,791,612,924
Indirect Bus Tax: Severance Tax					90,998,873	90,998,873
Personal Tax: Estate and Gift Tax			0			
Personal Tax: Income Tax			2,986,771,157			2,986,771,157
Personal Tax: Motor Vehicle License			170,711,686			170,711,686
Personal Tax: NonTaxes (Fines- Fees			572,225,443			572,225,443
Personal Tax: Other Tax (Fish/Hunt)			42,336,620			42,336,620
Personal Tax: Property Taxes			65,008,245			65,008,245
Social Ins Tax- Employee Contribution	25,144,936					25,144,936
Social Ins Tax- Employer Contribution	90,521,770					90,521,770
State/Local		0	3,837,053,151	401,740,635	9,911,418,498	14,265,878,990
Govt						
NonEducation						
Total	8,681,352,042	2,569,864,774	17,642,846,096	2,719,579,824	11,556,857,118	43,170,499,854

Bio-Based Energy Analysis Group



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