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ECONOMIC IMPACT OF THE INCREASED USE OF BIOFUELS AND COAL DERIVED TRANSPORTATION FUELS FOR THE COMMONWEALTH OF PENNSYLVANIA

Prepared for

Citizens for Pennsylvania's Future (PennFuture)

by

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On May 10, 2006 Governor Edward G. Rendell launched the PennSecurity Fuels Initiative ("PFI") designed to replace 900 million gallons of transportation fuel used in the Commonwealth with domestically produced renewable fuels within the next decade. Incentive programs such PFI that stimulate investment in, and production of, biofuels such as ethanol and biodiesel and other alternatives like liquid fuels derived from coal will have a significant positive impact for Pennsylvania.

This study estimates the contribution to the economy of Pennsylvania of replacing transportation fuel produced largely from imported oil with alternative fuels produced in the Commonwealth from feedstocks produced in Pennsylvania and nearby States.

The goal of the PFI is to replace 900 million gallons of transportation fuels over the next decade with ethanol, biodiesel, liquid fuels derived from coal, and methane produced by landfills and coal mines. The allocation of alternative fuels production will be determined by feedstock availability and technology. Table 1 details our assumptions regarding the annual quantities of alternative fuels that are likely to be produced over a ten-year period beginning in 2008. Several considerations went into the development of these assumptions including existing technology, the potential availability of new technology, and the availability of feedstocks to support production. The following sections discuss each of the major alternative fuels.

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Table 1
Projected Annual Production of Alternative Transportation Fuels
2008-2017

	Grain Ethanol (MGY)	Cellulosic Ethanol (MGY)	Biodiesel (MGY)	Coal Derived Transportation Fuel (MGY)	Total Alternative Fuel (MGY)
2008	16	0	4	0	20
2009	32	0	8	0	40
2010	36	0	24	0	60
2011	50	0	50	0	100
2012	90	20	80	10	200
2013	150	45	90	15	300
2014	236	90	90	34	450
2015	315	150	90	45	600
2016	338	225	112	75	750
2017	338	315	135	112	900

I. Ethanol

Ethanol, an alcohol produced by fermentation of sugars found in grains and other biomass, is the most widely produced and used renewable fuel in the United States. Ethanol-blended fuels currently account for more than 35 percent of U.S. motor fuel sales. The most common blend consists of 10 percent ethanol and 90 percent gasoline, although E85 (a blend of 85 percent ethanol and 15 percent gasoline) also is used.

Ethanol can be produced from a diversity of feed stocks, including grains such as corn, wheat, barley, and sorghum; sucrose in the form of cane and beet sugar or molasses. Ethanol also can be produced by converting cellulose into its constituent sugars, which then are fermented and distilled into alcohol. However this technology currently is under development and has not been shown to be commercially feasible. Well over 90 percent of all ethanol produced in the U.S. uses corn as the primary feedstock.

The ethanol industry is one of the most significant success stories in American manufacturing over the past quarter-century. From a cottage industry that produced 175 million gallons in

1980, the American ethanol industry has grown to include 101 manufacturing facilities with an annual capacity of more than 4.7 billion gallons. 2005 was a watershed year for the ethanol industry. In August President Bush signed into law the Energy Policy Act of 2005 (EPACT05). Among the many incentives for renewable fuels, EPACT05 provided the ethanol industry with a Renewable Fuels Standard that requires a minimum of 7.5 billion gallons of renewable fuels to be used in the nation's highway fuel supply by 2012. As a consequence of strong demand from rapidly growing China and India and continued political discord in the Middle East, world oil prices have reached new record levels and show little promise of receding. High gasoline prices combined with low corn prices resulting from the second largest crop on record last season to improve the economics of blending ethanol.

These developments have spurred a surge in ethanol plant investment and development. According to the Renewable Fuels Association 32 new plants and eight major plant expansions representing an additional 2 billion million gallons of capacity currently are under construction and more are planned. Total ethanol production for 2005 was reported by the EIA at more than 3.9 billion gallons on a year-end capacity base of 4.3 billion gallons.[1]

The structure of the ethanol industry has changed dramatically over the past 15 years. In 1991 35 plants produced 865 million gallons of ethanol. Two-thirds of capacity was accounted for by wet mill plants that had an average capacity of 95.5 MGY. The 20 operating dry mill plants had an average capacity of 16.5 MGY. By May 2006, the ethanol industry was comprised of 101 plants with an annual capacity of 4.7 billion gallons. Dry mill plants accounted for 71 percent of capacity with an average size of 42 MGY. Virtually all new ethanol plants being built today are dry mills and average plant sizes are closer to 100 MGY than 50 MGY.

There are no ethanol plants currently operating in Pennsylvania. However, at least four projects with an aggregate capacity of 270 MGY are under various stages of planning and development.

1. <u>Green Renewable Energy</u> is developing a 100 MGY dry mill ethanol plant in Tremont, Schuylkill County that will use corn as the feedstock and energy from an operating co-located waste-coal fired power plant.

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[1] McElroy, Anduin Kirkbridge, Holly Jensen, Nicholas Zeman and Jessica Williams. "Proposed Ethanol Plant List: 2006" *Ethanol Producer Magazine*. May 2006

2. The Northwest Pennsylvania Farm Bureau Ethanol Committee is investigating the feasibility of building and operating an 80 MGY dry mill ethanol plant in or around Meadville, Crawford County, which will use corn as the feedstock.

3. Penn-Mar Ethanol LLC is developing a 50 MGY dry mill corn ethanol plant initially targeted for Franklin County. This project has been beset by problems stemming from local resistance that have stopped development pending an appeal of an adverse zoning ruling.

4. Sunnyside Ethanol LLC is planning to develop a 40 MGY corn dry mill plant in Curwensville, Clearfield County.

A. Ethanol Demand

The market for ethanol in Pennsylvania is substantial. A Pennsylvania ethanol industry would sell ethanol into one of the nation's largest gasoline markets. As shown in Table 2, Pennsylvania and surrounding States accounted for 11.2 billion gallons of reformulated gasoline and 17.6 billion gallons of total motor gasoline sales in 2004. This represented nearly one quarter of total RFG gasoline used in the U.S. and 13 percent of total gasoline.

Table 2
Prime Supplier Sales of Gasoline: 2004

	Reformulated (Mil Gal)	**Share (Pct)**	**Total (Mil Gal)**	**Share (Pct)**
NY	3,012	6.7%	5,626	4.1%
PA	**1,283**	**2.8%**	**4,788**	**3.5%**
NJ	4,235	9.4%	4,235	3.1%
MD	2,201	4.9%	2,467	1.8%
DE	449	1.0%	449	0.3%
Subtotal	11,180	24.7%	17,566	12.9%
U.S.	45,267		135,893	

Source: EIA Petroleum Marketing Annual, 2004

Most ethanol consumed in Pennsylvania has been in the form of reformulated gasoline sold in the Southeastern counties surrounding Philadelphia. The Clean Air

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Act Amendments of 1990 (CAAA90) mandated the sale of reformulated gasoline in the nine largest metropolitan areas with highest summer ozone levels beginning on January 1, 1995.[2] The Philadelphia metropolitan area was one of the original nine non-attainment area. Until it was voluntarily removed from the market by the oil industry in May most reformulated gasoline sold in Pennsylvania was oxygenated with MTBE. Because of its favorable handling qualities and the fact that it is a petroleum product, MTBE was the preferred oxygenate for the petroleum industry. However, MTBE has shown significant adverse environmental and health safety characteristics that led several key States to ban its use. Specifically, MTBE is highly persistent (i.e. it has a very long half-life) and has been identified as a potential carcinogen. MTBE has been detected in drinking water supplies in almost all areas where it is used. Reflecting these issues, California, New York, Connecticut, New Jersey, Illinois and 21other states have banned the use of MTBE.

A Federal ban on the use of MTBE was excluded from the EPAC05. However, because of the environmental problems and financial liability issues associated with MTBE use, the major oil marketers have voluntarily removed MTBE from the nation's fuel supply

Ethanol demand for RFG is expected to surge this year as MTBE is removed from the nation's motor fuel supply. However, after this is completed, the demand for RFG and oxyfuel is expected to grow at the same rate as total gasoline consumption. The need for octane in the absence of MTBE also will stimulate ethanol demand. Ethanol and MTBE have been used to increase the octane level of gasoline since lead was banned in the early 1970s. In the absence of MTBE refiners will be forced to increase the use of ethanol or other alternatives such as the aromatic hydrocarbons benzene, toluene, or xylene. These three additives have lower octane ratings than ethanol and are more expensive.[3] In addition, benzene is a known carcinogen while toluene and xylene are suspected carcinogens.

[2] The original nine metropolitan areas were Baltimore, Chicago, Hartford, Houston, Los Angeles, Milwaukee, New York, Philadelphia, and Sacramento. San Diego was added later.

[3] Ethanol has an octane rating of 115; MTBE 110; xylene 106; toluene 103, and benzene 101. Source: *Octane Week*. Vol XXI, Issue 15. April 17, 2006. *MTBE, Oxygenates, and Motor Gasoline*. EIA. March 6, 2000. Available at http://www.eia.doe.goc/emeu/steo/pub/special/mtbe.html

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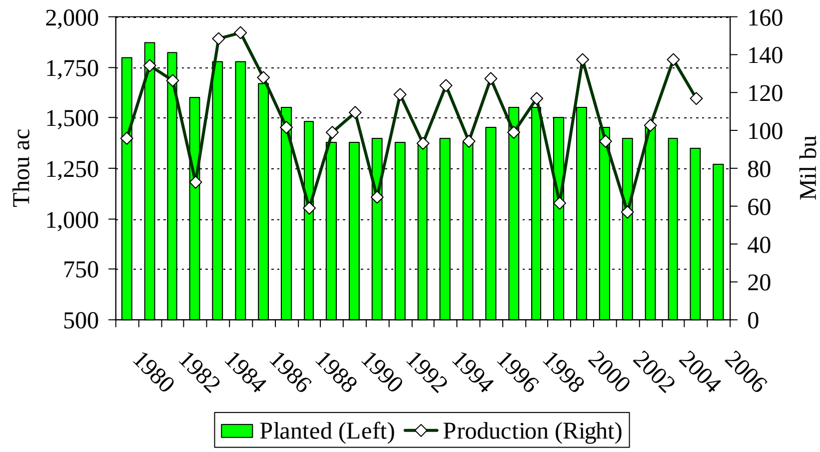
B. Ethanol from grain

The technology for producing ethanol from grain is well established, readily available, and economically feasible. The current cost to build a new state-of-the-art dry mill ethanol plant using corn as the feedstock is about $1.40 per gallon. As current national average grain and energy prices the operating cost of producing ethanol in a dry mill plant is estimated at about $1.15 per gallon. When compared to the May 2006 average spot market price of ethanol at New York harbor of $3.16 ethanol is a highly profitable business.[4]

The challenge for ethanol in Pennsylvania is the availability and price of corn (feedstock). Pennsylvania is a corn deficit state. That is, Pennsylvania uses more corn than it produces. Last year Pennsylvania farmers planted 1.45 million acres to corn and harvested 117 million bushels. Figure 1 displays area planted and corn production in Pennsylvania over the past 25 years. Pennsylvania has lost nearly 500 thousand acres of corn acreage over the last quarter century, most to development or other crops. Increased yields have helped offset reduced plantings to stabilize production. Increased demand for corn to produce ethanol is expected to provide an incentive for farmers bring additional land back into production.

[4] Oil Price Information Service, Daily Price Report.

Figure 1
Pennsylvania Corn Production



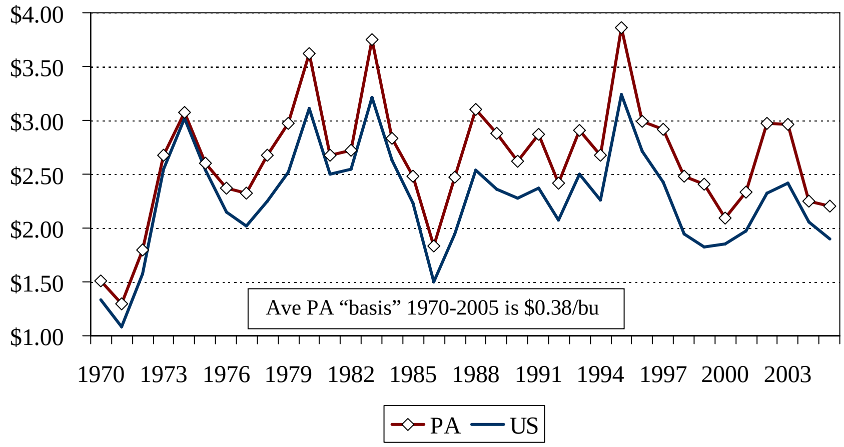
Source: USDA/NASS

If all of this corn were used for ethanol, it would produce 322 million gallons. However, corn is required for Pennsylvania's large livestock, dairy, and poultry industries. Increased supplies of Distiller's dried grains, the medium protein feed ingredient produced as a co-product of corn dry milling, will offset the loss of some of the corn used to produce ethanol.

Another factor to consider is economic: corn prices in Pennsylvania are higher than in Midwest markets where most ethanol production is concentrated. Figure 2 compares the average price received by farmers for corn to the national average.[5] Between 1970 and 2005, the price of corn in Pennsylvania averaged 38 cents per bushel above the national average. This "basis" likely will increase as ethanol production in Pennsylvania expands.

[5] The farm level price for corn mirrors the principal cash market price for No. 2 Yellow Corn, Central Illinois. Between 1970 and 2005 these prices have differed by less than 1.5 cents per bushel.

Figure 2
Corn, Average Price Received by Farmers
Pennsylvania and U.S.



Reflecting these dynamics we believe it is reasonable for Pennsylvania to produce at least 338 million gallons of ethanol from corn by 2017 when the 113 million bushels of corn required would represent about 40 percent of Pennsylvania's corn crop. These assumptions are outlined in Table 3.

Table 3
Pennsylvania Grain Ethanol Assumptions

	Ethanol Production (Mil Gal)	New Capacity (Mil Gal)	Total Capacity (Mil Gal)	Ethanol Yield (Gal/bu)	Total Corn Required (Mil bu)	Share of PA Crop (pct)	PA Corn Required (Mil bu)	DDG Production (Thou tons)
2008	16	16	16	2.79	6	100%	6	49
2009	32	16	32	2.81	11	100%	11	97
2010	36	4	36	2.83	13	100%	13	108
2011	50	14	50	2.85	18	100%	18	149
2012	90	40	90	2.87	31	100%	31	267
2013	150	60	150	2.89	52	75%	39	331
2014	236	86	236	2.91	81	50%	41	345
2015	315	79	315	2.93	108	40%	43	366
2016	338	23	338	2.95	114	40%	46	389

2017	338	0	338	3.00	113	40%	45	383

C. Ethanol from cellulose

Ethanol also can be produced by converting cellulose into its constituent sugars, which then are fermented and distilled into alcohol. Examples of Cellulosic materials include wood and other fibrous plant material such as crop residues and waste materials such as paper and cardboard. Cellulosic resources are widespread and abundant. For example, forests comprise about 80 percent of the world's biomass. Cellulosic materials are a relatively inexpensive feedstock for ethanol production since they are abundant and outside the human food chain. Pennsylvania's vast forest resources provide a significant competitive advantage for Cellulosic ethanol production.

The limiting factors for Cellulosic ethanol production principally involve technology and economics. Accessing the glucose in cellulose under existing technology has high capital and operating costs. Cellulosic materials are comprised of lignin, hemicellulose, and cellulose. One of the primary functions of lignin is to provide structural support for the plant. Thus, in general, trees have higher lignin contents then grasses. Unfortunately, lignin which contains no sugars encloses the cellulose and hemicellulose molecules, making them difficult to reach.

Cellulose molecules consist of long chains of glucose molecules as do starch molecules, but have a different structural configuration. These structural characteristics plus the encapsulation by lignin makes Cellulosic materials more difficult to hydrolyze than starchy materials.

Hemicellulose is also made up of long chains of sugar molecules; but also contains a different sugar structure known as pentose, or a 5-carbon sugar. These make up a high percentage of the available sugars in hemicellulose. Several firms have developed genetically engineered microorganisms that can ferment 5-carbon sugars into ethanol with relatively high efficiency. The complicating factor is that the exact sugar composition of

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hemicellulose can vary depending on the type of plant, thereby requiring specialized enzymes or microorganisms for each type of plant. [6]

There are three basic processes for Cellulosic ethanol production: acid hydrolysis, enzymatic hydrolysis, and thermo chemical. The most common is acid hydrolysis. In this process, an acid solution is combined with high temperature and pressure to recover the sugar in the Cellulosic material which are then fermented and distilled into alcohol. Sulfuric acid is most commonly used since it is usually the least expensive.

Another basic method of Cellulosic ethanol production is enzymatic hydrolysis. Enzymes are naturally occurring proteins that cause certain chemical reactions to occur. However, for enzymes to work, they have to be able to access the molecules to be hydrolyzed. This requires a pretreatment process to break the crystalline structure of the lignocellulose and remove the lignin to expose the cellulose and hemicellulose molecules. Depending on the biomass material, either physical or chemical pretreatment methods may be used. Physical methods employ high temperature and pressure, milling, radiation, or freezing—all of which require expensive high-energy consumption.

In the thermo chemical process the biomass materials is gasified under heat and pressure and the synthesis gas is bubbled through specially designed fermenters. A microorganism capable of converting the synthesis gas is introduced into the fermenters under specific process conditions to cause fermentation to ethanol. An alternative approach doesn't use microorganisms. The biomass materials are gasified and the synthesis gas passed through a reactor containing catalysts, which cause the gas to be converted into ethanol.

Currently there are no commercial scale Cellulosic ethanol plants operating in North America, but there are plans to construct one facility in Louisiana. Iogen operates a pilot/demonstration scale wheat straw fermentation plant in Ontario.

The production of ethanol from biomass is expensive. A recent survey of biomass processing indicates that the capital costs for producing ethanol under a thermo chemical

[6] Badger, P.C. 2002. Ethanol from cellulose: A general review. p. 17–21. In: J. Janick and A. Whipkey (eds.), Trends in new crops and new uses. ASHS Press, Alexandria, VA.

gasification process approach $2.40 per gallon while the acid hydrolysis process has a capital cost of $4.70 per gallon. Operating costs for acid hydrolysis are estimated at $1.80 per gallon (compared to $1.15 for corn dry milling). [7]

The ultimate profitability of Cellulosic ethanol depends in large part on improvements in technology. A major emphasis of research is devoted to reducing the high cost of pretreatment enzymes and fermentation bacteria. Current enzyme costs are about $.50 per gallon. Significant work is underway to reduce these to about $.10 per gallon. Additionally, access to licenses for enzymes and genetically engineered bacteria need considerable work as well.

According to Gallagher, a number of technical advances will need to occur before biomass-fermentation adoption becomes economical. The first of these is yield improvements that provide a biomass yield that approaches the 98 gallons per ton level of corn. Second, enzyme costs for biomass-ethanol must fall to the low levels of the corn-ethanol industry. “With these advances, biomass ethanol might approach the breakeven point with the corn-ethanol process. But biomass-ethanol's high capital costs relative to corn processing would still remain. It could take very cheap biomass, like corn residues, or high corn prices to offset the capital costs.”[8]

Significant research is being devoted to addressing these issues and the Federal government has stepped up with funding. The Energy Bill calls for 200 million gallons of ethanol to be produced from cellulose by 2012.

The timing of investment and the type of technology for Cellulosic ethanol that would be adopted in Pennsylvania is unclear. However the ready availability of cellulose feedstocks, largely in the form of wood, and access to markets make Pennsylvania an excellent candidate for Cellulosic ethanol production.

[7] Gallagher, Paul W. “Energy Production with Biomass: What Are the Prospects? *Choices*. 1st Quarter 2006. 21(1)
[8] Op. cit.

Reflecting this, we have assumed that cellulose ethanol production begins at a relatively low level of 20 million gallons in 2012 and expands rapidly to 315 million gallons by 2017. If the technology and economic stars line up for Cellulosic ethanol these estimates may be significantly underestimated.

II. Biodiesel

Biodiesel is a non-toxic, biodegradable diesel fuel made from soybean and other vegetable oils, animal fats, and used or recycled oils and fats. The biodiesel industry is in its infancy but is poised for significant growth. An estimated 75 million gallons of biodiesel were used in the U.S. last year, up from about 500 thousand gallons in 1999. According to the National Biodiesel Board the U.S. biodiesel industry is comprised of 65 manufacturing plants with annual capacity of 395 million gallons per year. Eight of these plants are in the process of expanding capacity and an additional 50 plants are currently under construction. If all of these projects are completed and come on line, they will add an estimated 714 million gallons of capacity.

There are four operating biodiesel plants in Pennsylvania with a reported capacity of 6.5 million gallons per year.

- AGRA Biofuels LLC in Middletown has the capacity to produce 2 MGY of biodiesel from soybean oil
- Keystone BioFuels Inc. in Shiremanstown has the capacity to produce 2 MGY of biodiesel from soybean oil
- United Biofuels, Inc. in York produces 500 thousand gallons of biodiesel from soybean oil
- United Oil Company in Pittsburg has the capacity to produce 2 million gallons of biodiesel from multiple feedstocks

According to the Pennsylvania Department of Environmental Protection an additional 13 biodiesel plants have been proposed or are under development. Taken together these plants would have the capacity to produce 210 million gallons of biodiesel.

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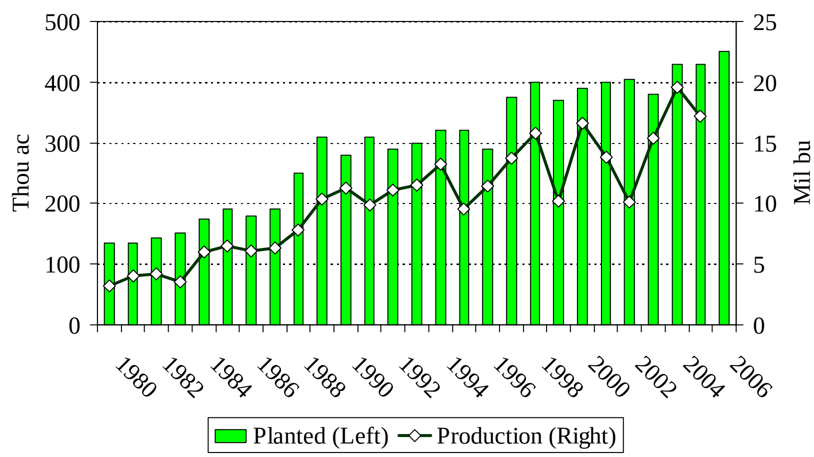
As with ethanol the primary limiting factor for the expansion of biodiesel production in Pennsylvania is the availability of feedstock inputs. Most biodiesel in the U.S. is made from soybean oil although recycled cooking oil and waste grease (yellow grease) and animal fats (white grease) can also be used to produce biodiesel.

As shown in Figure 3, Pennsylvania farmers produced 17.2 million bushels of soybeans on 430 thousand acres in 2005. Since there are relatively few soybean processors in Pennsylvania most of the soybeans are shipped out of State for crushing. Further, the existing Pennsylvania soybean crushing operations utilize mechanical extraction rather than solvent extraction to produce soybean oil. This method is less efficient and yields a lower quantity of soybean oil (7.8 pounds per bushel compared to 10.5 to 11.0 pounds from the solvent extraction process used in larger plants). The 17.2 million bushels of soybeans would produce about 201 million pounds of soybean oil, or the equivalent of 27 million gallons of biodiesel.

Figure 3
Pennsylvania Soybean Production



Source: USDA/NASS

Biodiesel also can be made from used and recycled cooking oil and other fats. Spent cooking oil can be vegetable oil or animal fat that was heated and used for cooking.[9] Renderers "manufacture" yellow grease from spent cooking oil by filtering out the solids and heating the spent cooking oil to drive out moisture until the oil meets industry specifications for yellow grease.[10] There are no published statistics on the production and consumption of yellow grease. Nor has the volume of used cooking oils and restaurant greases generated by the foodservice industry been well documented either. A very influential factor in establishing accurate volumes is the actual yield from the material obtained from the food service site. The raw material is diluted with water and contains solid material such as French fry and breading particles. These fractions must be removed by processing. The most commonly experienced yield is 65 percent, though this is highly variable and considered to be proprietary by most renderers. Another factor in accurately determining yellow grease supply is identifying non-renderer grease collectors of which resale or disposal is often not recorded. Pilfering of grease containers is also a problem in certain locations, especially when market prices for yellow grease are up.

The supply and availability of waste grease is more difficult to quantify than for vegetable oils. Most yellow grease is produced by restaurant and food operations as they recycle cooking oils. Consequently, yellow grease output is directly tied to the number and type of restaurants in a locale (consider that the typical McDonald's changes their cooking oils about once every two weeks), and output is generally expressed in terms of pounds per capita. Per capita and per restaurant estimates of yellow grease production vary widely ranging from a low of 5.78 pounds per person to a high of 11.3 pounds per person.[11] The mid-point of this range suggests that Pennsylvania produces somewhere in the area of 118

[9] LECG LLC. "Statewide Feasibility Study for a Potential New York State Biodiesel Industry". Final Report 04-02. June 2003. Prepared for the New York State Energy Research and Development Authority.
[10] Groschen, Ralph, Minnesota Department of Agriculture, "Overview of: The Feasibility of Biodiesel from Waste/Recycled Greases and Animal Fats," October 2002, p. 2.
[11] In 2003, the Census Bureau started separating out estimates of production and consumption of yellow grease in their M311K Current Industrial Reports, "Fats and Oils: Production, Consumption and Stocks," available at http://www.census.gov/cir/www/311/m311k.html

million pounds of yellow grease annually. If all of this were directed to biodiesel production, this would provide for 15 million gallons of biodiesel production.

Assuming that the supply of fats and oils produced in Pennsylvania available for biodiesel remains stable over time, increased use and production of biodiesel Pennsylvania will increasingly require feedstocks imported from other States. This is illustrated in Table 4.

Table 4
Pennsylvania Biodiesel Assumptions

	Biodiesel Production (Mil Gal)	Fat and Oil Required (Mil lb)	PA Fats & Oil Production (Mil bu)	PA Fats & Oil Share (Mil lb)
2008	4	30	318	100%
2009	8	60	318	100%
2010	24	180	318	100%
2011	50	375	318	85%
2012	80	600	318	53%
2013	90	675	318	47%
2014	90	675	318	47%
2015	90	675	318	47%
2016	113	844	318	38%
2017	135	1,013	318	31%

III. Coal derived transportation fuels

Synthetic transportation fuels can be made from coal [12][13] While the production costs, estimated at $0.71 per gallon, appear to be lower than corn dry mill ethanol due in large part to the favorable economics of the coal feedstock, capital costs are in the range of Cellulosic ethanol ($4.32 per gallon). In general, coal liquefaction technology can be divided into two generic types: direct and indirect. Direct liquefaction is the reaction of coal with hydrogen (usually in the presence of some liquid solvent) to produce a synthetic crude oil, or syncrude. No intermediate gasification step is

[12] Fuat Celik, Eric H. Larson and Robert H. Williams. "Transportation Fuel from Coal with Low CO_2 Emissions". Proceedings of the 7th International Conference on Greenhouse Gas Control Technologies. Vancouver, B.C. September 2004.
[13] John E. Saymansky and Thomas F. Torries. "Critical Economics of Coal Derived Alcohol Transportation Fuels." College of Agriculture and Forestry. West Virginia University.

needed. Direct liquefaction, however, is a very difficult process to carry out, involving very high temperatures and pressures, and an appropriate catalyst. The syncrude can be refined to produce gasoline, as well as diesel fuel and fuel oils. Indirect liquefaction involves the gasification of coal to produce a mixture of carbon monoxide and hydrogen, called synthesis gas. The synthesis gas can then be converted into liquid hydrocarbons using one of several conversion technologies. According to EIA the only commercial-scale coal liquefaction process in operation in the world is Sasol's indirect-Fischer-Tropsch-based process used to produce coal-based liquid transportation fuels in South Africa.

DOE studies place the estimated cost of producing coal liquids at approximately $30 per barrel ($0.71 per gallon). Major hurdles facing the start-up of a U.S. coal-to-liquids industry are the high capital costs associated with the construction of a commercial-sized plant. DOE estimates the capital costs of a coal-to-liquids facility with generating capacity of 1,000 megawatts and daily liquids production capacity of 33,200 barrels (500 MGY) at approximately $2.2 billion ($4.32 per gallon).[14]

The obvious attractiveness of this alternative transportation fuel relates to Pennsylvania's abundant coal resources and established coal infrastructure. Pennsylvania is the nation's fourth largest coal producer. According to the EIA Pennsylvania produced 76.4 million short tons of coal on recoverable coal reserves of 657.4 million short tons in 1999.[15]

It is difficult to estimate the timing of commercialization and expansion of coal derives transportation fuels in Pennsylvania; however the expectation of continued high oil and gasoline prices will intensify research and development and attract investment. In the absence of independent projections we have assumed that coal derived transportation fuel production will increase from 10 million gallons in 2012 to 113 million by 2013.

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[14] EIA. "Impacts of Energy Research and Development (S.1766 Sections 1211-1245, and Corresponding Sections of H.R.4) With Analysis of Price-Anderson Act and Hydroelectric Relicensing." *Fossil Energy (Subtitle C, Sections 1231 and 1232). http://www.eia.doe.gov/oiaf/servicerpt/erd/fossil.html*

[15] EIA. Pennsylvania Coal Statistics. http://www.eia.doe.gov/cneaf/coal/statepro/imagemap/pa1p1.html

IV. Economic Impact of Renewable fuels

Production of biofuels and coal derived transportation fuels will provide a significant contribution to the Pennsylvania economy. This contribution comes from two sources: construction and annual operations.

- Construction

  Expenditures for plant construction have a short-term impact that is replaced by the contribution from ongoing production. The size of the impact is directly linked to plant size and depends on the relationship between the plant and the local economy. Specifically this relates to the amount of inputs that are sourced locally. The construction of new production facilities results in spending for a wide range of goods and services. At an estimated construction cost of $1.40 per gallon for a new dry mill ethanol plant, $1.13 per gallon for biodiesel, and about $4.50 per gallon for cellulose and coal-derived transportation fuels capacity, nearly $2.6 billion (2006 dollars) will be invested in plant and equipment over the next decade.

- Annual/ongoing operations

  In order to produce alternative fuels as outlined above the biofuels industry will spend $3.5 billion (2006 dollars) on raw materials, other inputs, goods and services over the next decade.[16] The largest share of this spending will be for corn, soybean oil, recycled fats and oils, and cellulose feedstocks required to make ethanol and biodiesel. Between 2008 and 2017 we expect the Pennsylvania alternative fuels industry to use 546 million bushels of corn and 5.1 billion pounds of fats and oils to make ethanol and biodiesel. Half of the corn and nearly two-thirds of the fats and oils are expected to be produced by Pennsylvania farmers. The remainder of the spending by the alternative fuels industry will be for a wide range of inputs such as yeast, enzymes, other chemicals; electricity, natural gas, and water; labor; and services such as maintenance, insurance, and general overhead.

[16] All dollar values are expressed in constant 2006 prices.

Spending for these goods and services represents the purchase of output of other industries. The spending associated with alternative fuels production and investment spending on new plant capacity will circulate throughout the entire Pennsylvania economy several fold. This will stimulate aggregate demand, support the creation of new jobs, generate additional household income, and provide new tax revenue.

The impact increased production and use of biofuels and coal derived transportation fuel on the Pennsylvania economy was estimated by applying the appropriate final demand multipliers for output, earnings, and employment for the relevant supplying industry calculated by the U.S. Bureau of Economic Analysis ("BEA") to the estimates of spending described above.[17] These multipliers are shown in Table 5.

Table 5
BEA RIMS II Final Demand Multipliers, Pennsylvania

	Output	Earnings	Employment
Construction	2.5949	0.7835	21.5
Annual Operations			
Grain farming	1.8165	0.2867	14.9
Oilseed farming	1.8071	0.2894	11.8
Wet corn milling	2.1038	0.3635	9.6
Soybean processing	1.8185	0.2872	11.6
Fats and oils refining and blending	1.8036	0.2940	7.5
Basic organic chemical mfg	2.4144	0.4457	9.8
Power generation and Supply	1.8989	0.4223	8.7
Natural gas distribution	1.8338	0.3378	7.3
Water, sewer and other systems	1.8492	0.5297	13.1
Office administrative services	2.1671	0.7690	19.5
Facilities support services	2.0443	0.7316	21.3
Households	1.5551	0.4203	13.7

Source: Regional Input-Output Modeling System (RIMS II). Regional Economic Analysis Division, BEA.
Multipliers based on 1997 Benchmark I-O Table; 2003 regional accounts data.

[17] The multipliers used in this analysis are the detailed industry RIMS II multipliers for Pennsylvania estimated by the Bureau of Economic Analysis, U.S. Department of Commerce.

Assumptions for capital and production costs for corn-based ethanol and biodiesel were based on empirical data from currently operating facilities and confirmed by analyses published by the U.S. Department of Agriculture Agricultural Research Service.[18] [19] Assumptions for cellulose ethanol and coal derived transportation fuel were taken from the published literature.

The estimates summarized below result from a static analysis of the impact of increasing biodiesel fuels demand and production on the Pennsylvania economy. That is, they reflect the combination of a series of snapshots of the economy rather than a dynamic flow analysis.

The combination of spending for annual operations and capital spending for new plants to replace 900 million gallons of petroleum-based transportation fuel with domestically produced alternatives will generate direct output in the form of the value of ethanol, biodiesel, coal derived fuels and co-products (DDG and glycerin). These first round (or initial) values are added to the indirect impacts, or additional gross output generated by the purchase of goods and services needed to build and operate plants. Gross output represents the market value of production. This measure differs from the commonly recognized Gross Domestic Product ("GDP") since it includes the value of intermediate goods and services, which are "netted out" of GDP.[20]

As outlined above, the biofuels industry will produce the following quantities and values over the next ten years.

- 1.6 billion gallons of ethanol from corn and 845 million gallons of Cellulosic ethanol over the next ten years valued at $6.7 billion (2006 dollars);
- 2.5 million tons of Distiller's dried grains valued at $268.5 million (2006 dollars)
- 683 million gallons of biodiesel valued at $2.2 billion (2006 dollars);

[18] Jason R. Kwiatkowski, Andrew J. McAloon, Frank Taylor, and David B. Johnson. "Modeling the process and costs of fuel ethanol, production by the corn dry mill process". September 2005. USDA/ARS/Eastern Regional Research Center.
[19] Haas, Michael J., Andrew J. McAloon, Winnie C. Yee, and Thomas A. Foglia. "A process model to estimate biodiesel production costs". *Bioresource Technology.* 2005.
[20] BEA description of Gross Output taken from http://www.bea.gov/bea/pn/GDPbyInd_GO_NAICS.xls. According to BEA accounts, GDP was 55% of the value total gross output in 2004. The state equivalent to GDP is Gross State Product (GSP).

- 263 million pounds of glycerin valued at $52.6 million (2006 dollars), and
- 291 million gallons of coal derived transportation fuels valued at $801 million (2006 dollars)

The economic impacts of replacing 900 million gallons of petroleum fuels with biofuels and coal derived transportation fuels between 2008 and 2017 are summarized in Table 6.

Table 6
Economic Contribution of Biofuels and Coal Derived Transportation Fuels
To the Pennsylvania Economy
2008-2017

		Impact		
	Spending (Mil 2006$)	Gross Output (Mil 2006$)	Earnings (Mil 2006$)	Employment (Jobs)
Construction				
Corn ethanol	$473	$1,226	$370	2,596
Biodiesel	$153	$396	$3,280	729
Cellulosic ethanol	$1,481	$3,842	$1,160	9,095
Coal Derived Fuel	$486	$1,262	$381	3,485
Subtotal	**$2,592**	**$6,726**	**$5,191**	**15,905**
Annual Operations				
Corn ethanol	$1,242	$2,298	$431	2,812
Biodiesel	$631	$1,131	$216	719
Cellulosic ethanol	$1,521	$3,672	$678	5,557
Coal Derived Fuel	$207	$499	$92	783
Subtotal	**$3,601**	**$7,600**	**$1,417**	**9,870**
Plus initial changes:				
Construction		$2,592		
Corn ethanol		$4,401		
Biodiesel		$2,324		
Cellulosic ethanol		$817		
Coal Derived Fuel		$2,208		
DDG		$268		
Glycerin		$53		
Subtotal		**$12,662**		
Total		**$26,988**	**$6,608**	**25,775**
Gross State Product		**$14,843.2**		

When the value of these products are added to the additional gross output generated by construction and operation of the biofuels industry, the total impact on gross output for the Pennsylvania economy is nearly $27 billion (2006 dollars).

- The replacement of 900 million gallons of petroleum-based transportation fuel by 2017 with domestically produced biofuels will add nearly $1.5 billion (2006 dollars) to the Pennsylvania economy annually over the next decade. The Pennsylvania economy, measured by Gross State Product, will be $14.8 billion (2006 dollars) larger by 2017 than would be the case without increased production and use of biofuels and coal derived fuels.

- New jobs are created as a consequence of increased economic activity caused by biofuels and coal derived liquid fuels. The increase in gross output (final demand) resulting from production and construction of new capacity will support the creation of as many as 25,775 new jobs in all sectors of the Pennsylvania economy by 2017.

- Increased economic activity and new jobs will generate additional income for Pennsylvania households. The production of biofuels and coal derived liquid fuels will put an additional $6.6 billion (2006 dollars) into the pockets of Pennsylvanians over the next decade.

- The combination of increased higher personal and corporate income will generate additional revenue from personal and corporate income and sales and use taxes. The full impact of the annual operations to produce biofuels and coal-derived transportation fuels and spending for new construction will add more than $900 million (2006 dollars) of new tax revenue for Pennsylvania over the next decade.

- Pennsylvania farmers will benefit from expanded markets for their corn and soybeans that will be used as feedstocks for ethanol and biodiesel. Increased demand can be expected to raise the State-wide average price received by farmers by 10 to 20 cents per bushel thereby increasing income from marketing. This will provide an incentive for farmers to bring additional land back into production in counties where planted area has declined due to poor profitability.

Livestock, dairy, and poultry producers will benefit from increased supplies of medium-protein distiller's grains, a co-product of corn dry mill ethanol production, and soybean meal that will be produced as more soybeans are crushed for oil to produce biodiesel.

- Ethanol, biodiesel and coal-derived transportation fuels will displace imported oil and keep more money in the Commonwealth. The production and use of 900 million gallons of biofuels and other alternatives by 2017 will mean that the U.S. will need to import 122 million fewer barrels of crude oil over the next decade. At current prices, this means that the $6.8 billion that would be sent abroad to finance these imports will stay in the U.S. and Pennsylvania.