Biofuel Production for Gasoline Displacement and Public Policies in Competitive Energy Market

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Abstract:

The purpose of this study is to look at the cost differences between first generation grain/starch based ethanol production and the second generation cellulosic based ethanol production. This study also tries to determine the least cost combination of imported biofuels and then attempts to see what the necessary means are to make ethanol competitive against gasoline in the energy market. Using the Biofuel Production and Demand Model (BPDM) created at Oak Ridge National Laboratory, the costs needed to produce these two types of ethanol will be analyzed. Also using the model, this paper will look at which types of biofuel sources will be called on to create the least cost combination of ethanol to meet United States fuel demand. The focus is on import supply. The BPDM simulates market outcomes for biofuels production and delivery. Biomass production levels, delivery mode utilization, conversion activity and transportation (marine and ground) are all determined for the least cost activities that satisfy final demand for ethanol in end markets. Supply, conversion and delivery pathways are built up from the following modules:

1. Biomass production
2. Biomass ground transport from field to conversion plant
3. Biomass conversion to biofuels
4. Biofuels ground transport from plant to market or port
5. Biofuels shipping (marine) from origin port to destination port
6. Final demand satisfaction

Each of these submodels and the associated variables, parameters, and cost component will be defined in turn.

Introduction:

This past year the world has seen large rises in the price of gas and oil. This increase in cost coupled with the growing demand for fuel, causes one to begin to look for alternative sources of energy. There are also people who are worried about global climate change and the pollution being created by the current fuels. These new alternatives must meet certain expectations. The new fuels must be "green" meaning emit less greenhouse gases. They also must be sustainable and have a relatively cheap cost to produce while still producing relatively the same amount of energy to gasoline. This study will focus on biofuels as an alternative energy source. Specifically this paper will look at the production and transport cost of biofuels to the United States meaning focusing on import supply. Then using these costs, this paper will see what the proper gas tax should be to make ethanol (specifically E85) competitive in the energy market.

Background:

On January 28, 2008 President George W. Bush introduced the 20-in-10 initiative in his state of the union address. This initiative aims to lower gasoline consumption by twenty percent within the next ten years. After the initiative's introduction, the Bush Administration introduced two more legislative proposals. The first stating "Increasing The Supply Of Renewable And Other Alternative Fuels By Setting A Mandatory Fuels Standard To Require The Equivalent Of 35 Billion Gallons Of Renewable And Other Alternative Fuels In 2017." In the year 2017, this proposal will displace fifteen percent of projected annual gasoline use. The second being "Reforming and Modernizing Corporate Average Fuel Economy (CAFE) Standards for Cars and Extending the Current Light Truck Rule. In 2017, this will reduce projected annual gasoline use by up to eight point five billion gallons, a further five percent reduction that, in combination with increasing the supply of renewable and other alternative fuels, will bring the total reduction in projected annual gasoline use to twenty percent"

The differences between this 20-in-10 initiative and the Energy Independence and Security Act of 2007, signed into law on December 19, 2007, are changes in the timing and targets. The requirement is also now thirty-six billion gallons of alternative fuels by the year 2022. There are also sub targets for advanced renewable fuels, cellulosic biofuels and biodiesel.

These initiatives give birth to the "World biofuels study" sponsored by the Department of Energy. The purpose of the project is to study the world's biofuel market and see how imported biofuels can aid in the new renewable fuel standards. The study is split up among the Biomass Program and the Office of Policy and International Affairs (PI) at the Department of Energy and Oak Ridge National Laboratory (ORNL), National Renewable Energy Laboratory (NREL) and Brookhaven National Laboratory (BNL). At ORNL, their job is to assess the resource potential for biofuel feedstocks such as wheat, corn, sugarcane, soybean, palm oil and lignocellulosic crops as well as develop supply curves for each of these feedstocks. NREL assesses the cost and performance of the technologies used to produce these biofuels.

In the ORNL study, seven countries (Argentina, Brazil, Canada, China, Colombia, India, Mexico) and one region (Caribbean Basin) are selected as the most likely places to grow biofuel feedstocks. The goal is to see what regions have the greatest potential to supply the world's biofuels market. The following chart shows what feedstocks are available in each region.

Countries	Feedstocks Corn	Palm Oil	Soybean	Sugarcane	Wheat	Cellulosic Bagasse	Ag Residue	Other
Argentina	Yes	No	Yes	Yes	Yes	No	Yes	Yes
Brazil	Yes	No	Yes	Yes	No	Yes	Yes	Yes
Canada	Yes	No	Yes	No	Yes	No	Yes	Yes
Caribbean Basin	No	Yes	No	Yes	No	Yes	No	Yes
China	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Colombia	No	Yes	No	Yes	No	Yes	No	Yes
India	No	No	No	Yes	No	Yes	No	Yes
Mexico	No	No	No	Yes	Yes	Yes	Yes	Yes

The study analyzes the feedstock's current tendencies of production and cost at the local level in each of the selected countries/regions. The potential future supply is projected based on historical growth rates in yield and area harvested by state over the past seven years. "The methodology assumes that recent growth trends for yield and harvested area at a state level will continue into the future within a set of defined parameters. In addition to reference case projections, which are derived from past growth rates, the ORNL report also includes high and low feedstock availability curves based on historical variance in year-on-year growth. This allowed sensitivity analysis of feedstock availability." (BNL 13)

In the NREL study the cost data is country/region specific. A few assumptions for this study are that technology progress will transfer among regions. This means that technology developed in one region will be available to all the other regions as well. Advanced biofuel technologies are more likely to be developed for industrialized country applications. The technology will be "capital-intensive, labor-minimizing and designed for large scale production facilities to achieve better economics of scale." (BNL 16) Developing countries to make best use of these technologies, they will have to adapt them to local crops and to their competitive advantages. Differences in climate and soil conditions might also require the adaptation of technology to local crops and conditions. One also assumes that all regions can effectively deploy these technologies.

Methodology:

To be able to analyze the costs that go into the production of biofuels, the Biofuel Demand Production Model was developed at Oak Ridge National Lab. This model looks at the cost to produce the biomass, transport the biomass to a refinery, convert the biomass into biofuel, transport the biofuel to a shipping port, and finally shipping the biofuel to the end destination for each type of biofuel for each supply region specified. The model will then use these costs to pick the least cost mixture to be imported into the United States.

I. Biomass production

Supply curves for each of the feedstocks for each individual country/region are created by taking the given data from the ORNL Kline et. al study and putting it in Microsoft Excel. The data used for the curves consisted of the average production cost in 2005 U.S. Dollars and amount of the feedstock produced in million metric tons. This data was collected for each region/state of the country and then compiled together. This is done so for the years 2012, 2017, and 2027. These curves are fitted to the following equation with an optimization algorithm found in Microsoft Solver that is available in Microsoft Excel.

Specifically, this module describes the cost of producing quantity Q_{mrt} of biomass feedstock type *m* in production region *r* at time *t*. Example feedstocks include wheat, corn, sugar cane, bagasse, and corn stover. The typical feedstock supply curve displays a minimum production cost, a range of slowly rising marginal cost, and a rapidly rising marginal cost as supply approaches some upper limit. This behavior is well represented by the following form:

Equation 1 Supply Curve Marginal Cost:

$$C'_{P,rmt} = \alpha_{rmt} + \frac{\beta_{rmt}}{c_{rmt} - Q_{rmt}}$$

With a cutoff point

$$Q_{rmt} \leq Q_{MAX,rm}$$

Minimum marginal production cost is $\alpha_{rmt} + \beta_{rmt} / c_{rmt}$, and the upper bound on production level is c_{mrt}. Marginal cost becomes arbitrarily large as quantity approaches the limit c_{mrt}. The rate of increase is governed by β_{rmt}. Given these marginal cost curves, total production cost of supplying feedstock quantity Q_{mrt} is the integral from Q_R to Q_{mrt}:

Equation 2 Biomass Supply Total Cost

$$C_{P,rmt} = \int_{Q_r}^{Q_{rmt}} \left\{ \alpha_{rmt} + \frac{\beta_{rmt}}{c_{rmt} - q} \right\} dq$$

Producer cost is, i.e.,

$$C_{P,rmt} = \alpha_{rmt} q - \beta_{rmt} \ln(c_{rmt} - q) \Big|_{Q_r}^{Q_{rmt}}$$
$$= \alpha_{rmt} Q_{rmt} - \beta_{rmt} \ln(c_{rmt} - Q_{rmt}) - \delta_{rmt}$$

(Note: log base e, natural log, not Log base 10).

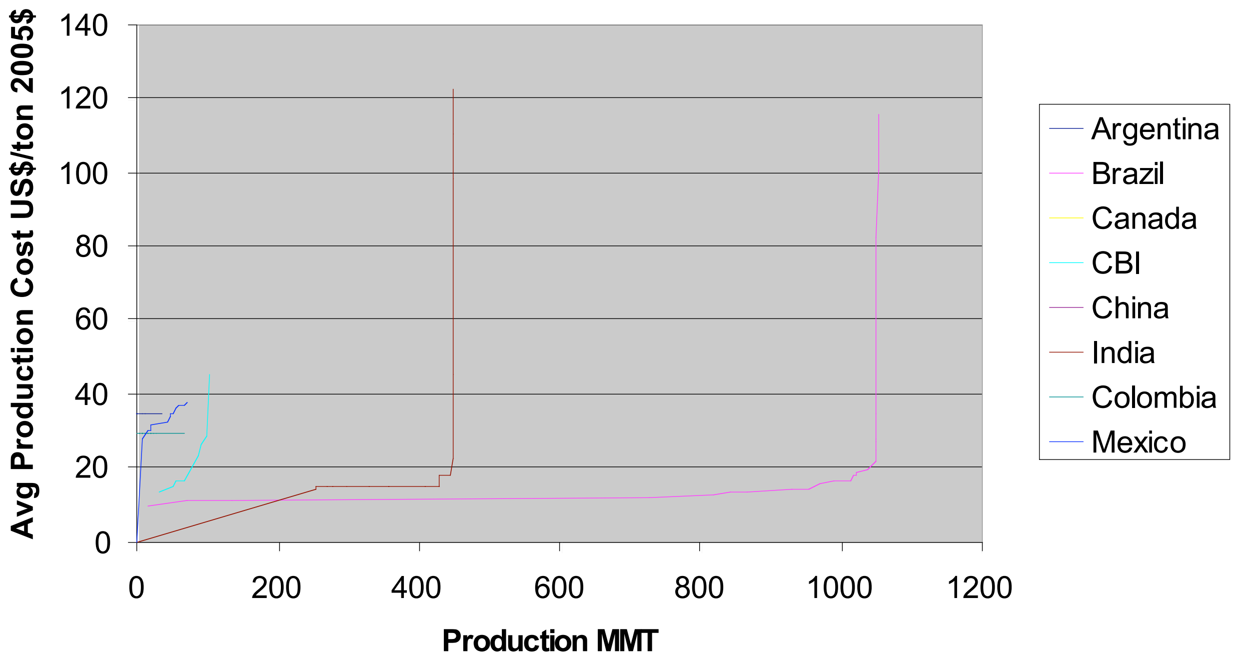
The constant is determined from the arbitrary reference level Q_R

$$\delta_{rmt} = \alpha_{rmt} Q_R - \beta_{rmt} \ln(c_{rmt} - Q_R)$$
$$for Q_R = 0$$
$$\delta_{rmt} = -\beta_{rmt} \ln(c_{rmt})$$

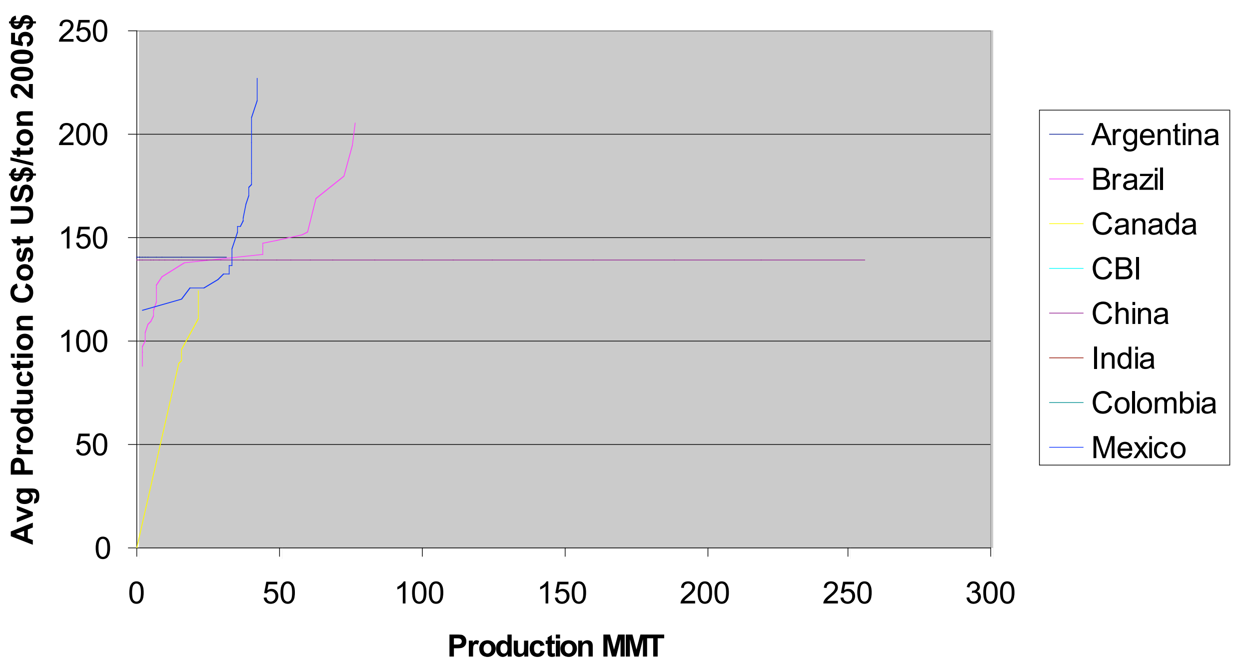
Constraints:

$$0 \le Q_{rmt} < c_{rmt}$$
$$Q_{rmt} \le Q_{rm\max}$$

In the initial version of this model, biomass supply regions *r* are established on a country level. Thus these are county-wide supply curves (for non-U.S. countries).



Corn Baseline Case 2027



II. Biomass ground transport from field to conversion plant

The biomass ground transportation module describes the costs of loading, transporting and unloading biomass at a conversion plant. The data and model references were taken from the paper Cost benefit of biomass supply and pre-processing, A BIOCAP Research Integration Program Synthesis Paper by Shahab Sokhansanj and Jim Fenton March 2006. Unit costs are determined on a dollars per ton-mile basis, and vary with delivery mode but not by feedstock type. A variety of delivery modes *v* (truck, rail and pipeline) are considered. Define the following parameters and variables:

L_{rj} = Distance ([Miles]) from the biomass production site to the conversion plant. This can be an average distance for each country.

X_{mrjvt} = Amount of feedstock *m* shipped from region *r* to refinery *j* via mode *v* at

Equation 3 Unit Transport Costs for Biomass from Field to Conversion Plant

$$c_{TB,vt}(L_{rj}, X_{mrjvt}) = C_{0v} X_{mrjvt}{}^{e_{Q0}} + C_{Lv} \cdot L_{rj} \cdot X_{mrjvt}{}^{e_{Q1}}$$

Unit transport costs are scale-dependent (the exponents e_{Q0} and e_{Q1} are non-zero) for pipeline transport, but are constant over quantity (exponents e_{Q0} and e_{Q1} are zero) for truck and rail transport. For all modes transport costs are a linear (affine) function of distance.

Total ground transport costs for each biomass type are just total shipping quantity times the unit transport costs:

Equation 4 Total Transport Costs for Biomass from Field to Conversion Plant

$$C_{TB,vmt}(L_{rj}, X_{mrjvt}) = X_{mrjvt} \cdot c_{TB,vmt}(L_{rj}, X_{mrjvt})$$
$$= X_{mrjvt} \cdot (C_{0v} X_{mrjvt}{}^{e_{Q0}} + C_{Lv} \cdot L_{rj} \cdot X_{mrjvt}{}^{e_{Q1}})$$

Here *m* is an index over feedstock types, and *v* indexes the available transport modes. L_{rj} is the distance from biomass production site *r* to the conversion plant *j*. This can be an average distance for each country.

Constraints:

Shipment quantities must be positive, and total shipments cannot exceed the biomass production levels in each region.

$$0 \le X_{mrjvt}$$
$$\sum_{j,v} X_{mrjvt} \le Q_{mrt}$$

III. Biomass conversion to biofuels

I withdrew the conversion costs from the NREL paper by constructing a simple exponential objective function using the given costs. The costs include variable costs, capital costs, ethanol and co product input and output coefficients, as well as feedstock input output. Then using Microsoft Excel, I solved for three equations and three different points by minimizing the stated function. The three points are for three different plant sizes: twenty-five, fifty, and one hundred million metric tons. For wheat, not enough points were given, therefore I only solved for two points. After that, I took the estimated values and fitted it to the given values to construct a cost curve. The sample sizes were large enough so the three (two) points were enough to extract the needed information. More specifically based on estimates of plant-gate biofuels (ethanol or biodiesel) costs we can construct total biofuel conversion costs for each plant, and for the total quantity of biofuel supplied along a pathway.

Define the following variables and parameters:

Parameter	*Notes, description (Units)*
a_{mj}	Conversion (biorefinery) Other Variable Costs per unit
b_{mj}	Conversion (biorefinery) scale term, Leading Coeff.
$e_{K,mj}$	Conversion (biorefinery) scale term, Exponent.
K_{Rmj}	Reference Production Capacity (gal/yr)
P_{ji}	Input factor or Coproduct reference price ($/unit)
A_{ie}	I/O coefficients: Units of input factor (or output co-product) per gallon biofuels produced
A_{me}	Biomass IO Coeff. (dry short ton/gal biofuels produced)
P_{Rm}	Biomass reference price

Variables:

K_{mjt}	Plant Production Capacity for plant converting biomass type *m*
E_{mjt}	Biofuels (Ethanol) production level for plant *j* converting biomass type *m* to biofuels
n_{mjt}	Number of (assumed essentially identical) biorefineries for biomass type *m*, site/region *j*, time *t*.

Unit production costs for biofuels are composed of scale-independent variable costs per unit (α), scale-dependent costs which are a function of plant scale *K,* ($\beta(K/K_R)^{eK}$) and the costs of inputs to production. For inputs to production such as power and fuels indexed by i, inputs costs per unit production are given by the sum over the inputs of the price of the input P_{ji} times A_{if} the quantity of each input i required be unit of biofuels f production. Plant-level biomass conversion costs per unit of biofuel have the form;

Equation 5

$$c_{C,mjt} = \alpha_{mj} + \beta_{mj}\left(\frac{K_{mjt}}{K_{Rmj}}\right)^{e_{Kmj}} + \sum_i \mathrm{A}_{jif} \cdot \mathrm{P}_{ji}$$

Here the list of inputs i include factors of production *other than* the biomass input, since the costs of biomass production and delivery to the plant are accounted in the two modules described above. Coproducts are also included in the set indexed by I, and they have negative I/O coefficients in A.

Equation 6 Total Conversion Costs per Plant:

$$C_{C,mjt}(K_{mjt}, E_{mjt}) \int_{E_R}^{E_{mjt}} \left[\alpha_{mj} + \beta_{mj}\left(\frac{K_{mjt}}{K_{Rmj}}\right)^{e_{Kmj}} + \sum_i \mathrm{A}_{jif} \cdot \mathrm{P}_{ji}\right] dE$$

These are the costs for a single conversion plant j of size K_{jmt} producing biofuels quantity $E_{jmt.}$ If there are multiple (n_{mjt}) such plants, then the costs must be multiplied by n_{mjt}.

Constraints:

Plant scale must be less than the maximum size (beyond which there are no more scale economies) for that type m:

$$K_{mjt} \le K_{\max,m}$$

Plant scale constrains total biofuels output E_{mjt} per plant:

$$0 \le E_{mjt} \le K_{jmt}$$

The input input-output coefficient A_{me} for biomass to biofuels determines the total biomass required for a given plant production level. Shipments of biomass to all n_{mjt} plants in region j must be sufficient to meet input demands for feedstock:

Equation 7

$$\sum_{rv} X_{mrjvt} \geq n_{mjt} E_{mjt} \cdot A_{me} \forall m, j, t \text{ , For m=feedstock type}$$

They both represent the amount of ethanol produced from feedstock m from region r at refinery j at time t which must be less than or equal to the capacity of refinery j

Grouping products from conversion plants of type *m* into Biofuels types *f*:

Biofuel types f are composed of fuel produced from some subset of biomass types m. In particular, biofuel types are ethanol-from-grain (first generation), cellulosic-ethanol (2nd generation), and biodiesel.

Define:

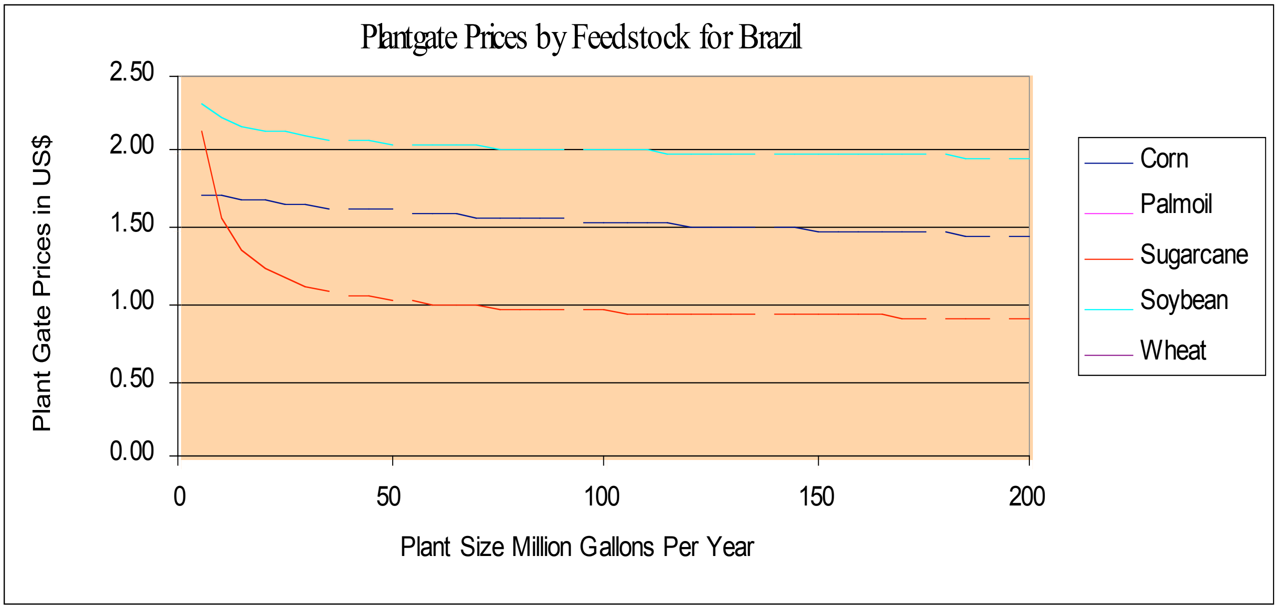
M_f the set of biomass types m that produce biofuel category f

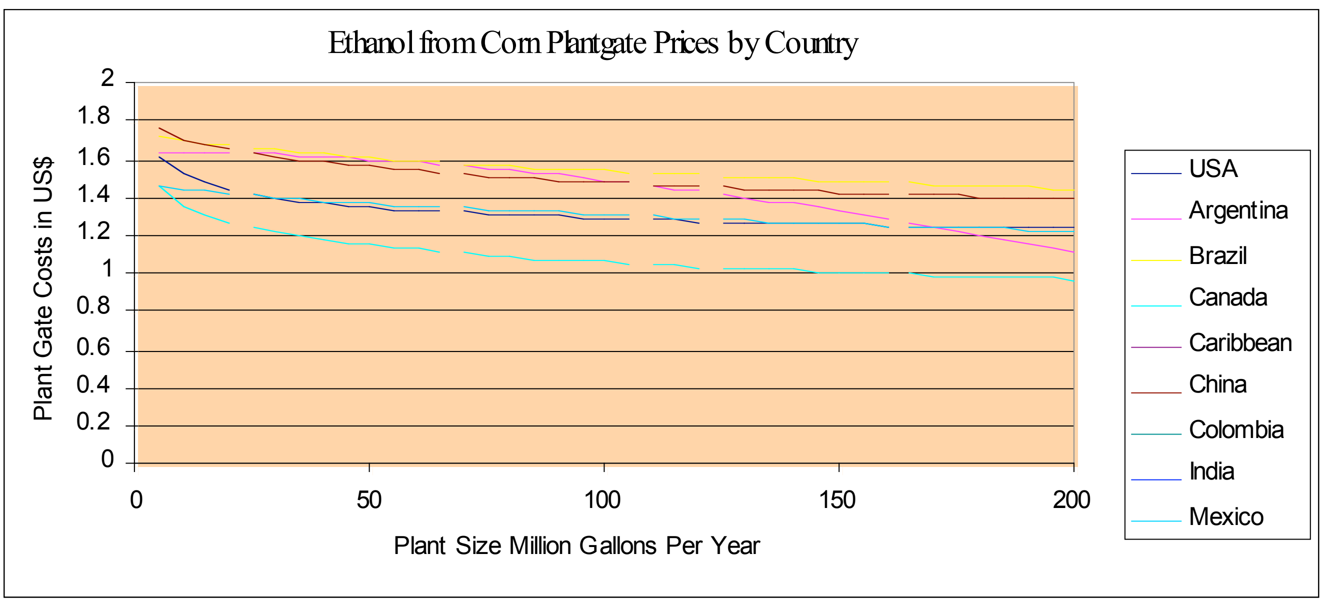
The total biofuel production from conversion plants in region j is determined by the type and number and output of the plants:

Equation 8

$$F_{fjt} = \sum_{m \in M_f} n_{mjt} E_{mjt} \forall f, j, t$$

The following are two sample graphs from the worksheet. The first one displays all the plant gate prices for all the feedstocks for the given country (Brazil), and the second one shows the plant gate for all the countries for a given feedstock.





These curves are fitted to the following equation with an optimization algorithm found in Microsoft Solver that is available in Microsoft Excel.

IV. Biofuels ground transport from plant to market or port

Define the following parameters and variables:

D_{jk} = Distance ([Miles]) from the biomass conversion plant to an end market (or port) k. This can be an average distance for each country.

$P_{DF,t}$ = Price for (diesel) fuel at time t

W_{fjkvt} = Amount of biofuel f shipped from biorefinery j to market k via ground mode v at time t

Based on the collaboration with Bruce Peterson from National Transportation Research Center (e-mail included in appendix), unit cost ($/gallon) is linear in fuel prices and distance, for modes v in {truck, rail, barge}:

Equation 5

$$c_{TE,vt}(D_{jk}, W_{fjkvt}) = c_{TE0,v} + c_{TEF,v}P_{DF,t} + c_{TED,v} \cdot D_{jk}$$

Total cost of shipping quantity W_{fjkvt} from refinery location j to market k is:

Equation 6

$$C_{TE,jkvt}(W_{fjkvt}) = W_{fjkvt} \cdot (c_{TE0,v} + c_{TEF,v}P_{DF,t} + c_{TED,v} \cdot D_{jk})$$

Taking motor fuel (diesel) prices (for each transport mode) as fixed and given the distance from j to k, there is a fixed unit charge to deliver biofuel from j to k:

$$C_{TE,jkvt}(W_{fjkvt}) = W_{fjkvt} \cdot c_{TE,jkvt}$$
$$for$$
$$c_{TE,jkvt} \equiv c_{TE0,v} + c_{TEF,v}P_{DF,t} + c_{TED,v} \cdot D_{jk}$$

Constraints:

Shipment of biofuels product is subject to constraints requiring non-negative shipment quantities and shipment quantities that do not exceed biofuels production from each conversion plant/biorefinery:

$$0 \le W_{fjkvt}$$
$$\sum_{k,v} W_{fjkvt} \le F_{fjt}$$

V. Biofuels shipping (marine) from origin port to destination port

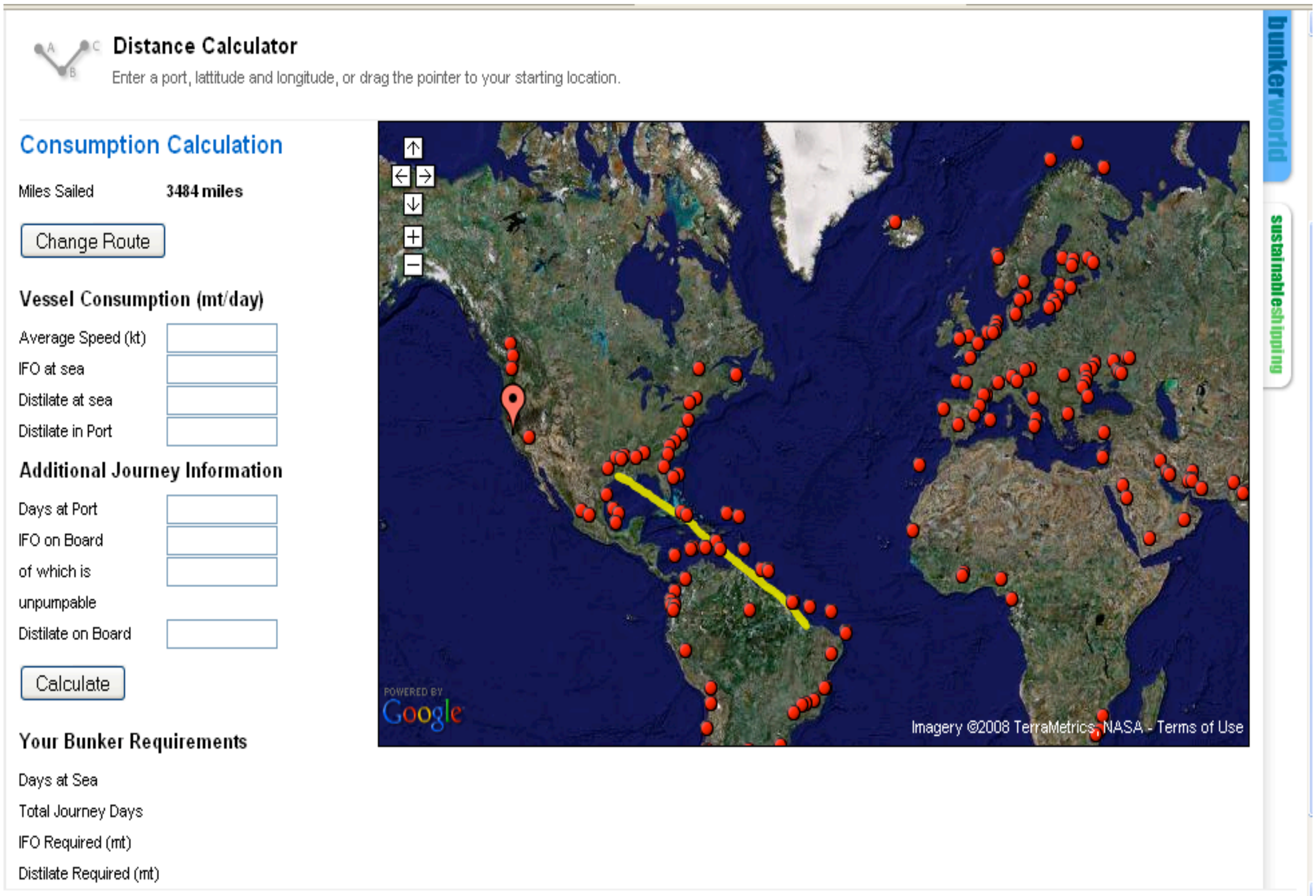
The overseas shipping costs are based off clean tanker rates (clean means petroleum products, dirty means the actual oil) for the years 2005-2008 from the Argus Freight Report July 2007 edition. The Caribbean distance from the report is used as the base as well. Ports were picked in the United States as well as the eight ethanol producing regions. The ports used are Argentina: Bahia Blanca, Brazil: Itaqui, Canada: Halifax, CBI: Puerto Cabello, China: Shanghai, Colombia: Barranquilla, India: Chennai, Mexico: Veracruz. The destination ports selected are Gulf Port: Port Arthur, Atlantic Port: New York City, and the West Coast Port: Los Angeles. The distances are mapped out on www.portworld.com. To get the transportation costs one looks at conversion rate for ethanol is 333.48 gal/ton = 7.94 barrels. This conversion is taken from bioenergy.ornl.gov. Then the clean tanker rates for the US from each region which is given in US dollars per million tons, convert to US dollars per gallon of ethanol and then convert to dollars per mile for a gallon of ethanol. The following is a table of the transportation costs of ethanol.

	Transportation Costs $/gal	$/mile for a gallon of Ethanol	Miles	Country	Destination
Argentina.USGC	0.142391462	2.22001E-05	6414	Argentina	USGC
Argentina.USAC	0.136264233	2.22001E-05	6138	Argentina	USAC
Argentina.USWC	0.152048507	2.22001E-05	6849	Argentina	USWC
Brazil.USGC	0.085425997	2.22001E-05	3848	Brazil	USGC
Brazil.USAC	0.068576119	2.22001E-05	3089	Brazil	USAC
Brazil.USWC	0.119480955	2.22001E-05	5382	Brazil	USWC
Canada.USGC	0.049106628	2.22001E-05	2212	Canada	USGC
Canada.USAC	0.011743855	2.22001E-05	529	Canada	USAC
Canada.USWC	0.116306341	2.22001E-05	5239	Canada	USWC
CBI.USGC	0.041780594	2.22001E-05	1882	CBI	USGC
CBI.USAC	0.041447593	2.22001E-05	1867	CBI	USAC
CBI.USWC	0.082362383	2.22001E-05	3710	CBI	USWC
China.USGC	0.224198842	2.22001E-05	10099	China	USGC
China.USAC	0.24313553	2.22001E-05	10952	China	USAC
China.USWC	0.127250991	2.22001E-05	5732	China	USWC
Colombia.USGC	0.034876362	2.22001E-05	1571	Colombia	USGC
Colombia.USAC	0.039937986	2.22001E-05	1799	Colombia	USAC
Colombia.USWC	0.072305736	2.22001E-05	3257	Colombia	USWC
India.USGC	0.2366753	2.22001E-05	10661	India	USGC
India.USAC	0.20435195	2.22001E-05	9205	India	USAC
India.USWC	0.20659416	2.22001E-05	9306	India	USWC
Mexico.USGC	0.014696468	2.22001E-05	662	Mexico	USGC
Mexico.USAC	0.043046	2.22001E-05	1939	Mexico	USAC
Mexico.USWC	0.095815645	2.22001E-05	4316	Mexico	USWC

Key:

Rule of Thumb	
Destination	Destination
United States Gulf Coast	USGC
United States Atlantic Coast	USAC
United States West Coast	USWC

The picture below shows the method chosen to map oversea and oceanic shipments through portworld.com.



Define the following parameters and variables:

For origin and destination ports indexed by k,d, define

D_{od} The typical marine shipping distance in miles from port k to port d

c_{TM} The estimated $/mile for a gallon of Ethanol

$c_{TM,kd}$ The transportation cost per gallon biofuels from port o to destination port d

$c_{TM,kd} = c_{TM} * D_{kd}$

Y_{fkdt} Quantity of biofuel type m shipped by sea from origin port k to port d

Marine Shipping costs

$$C_{TM,kd}(Y_{fkdt}) = Y_{fkdt}\, c_{TM,kd}$$

Constraints:

Shipments must be positive, and shipments to all destination ports *d* must be no more than ground shipments into market/port *k*.

NOTE: This current formulation omits consumption in market k, so it currently is only treated as a trans-shipment point. If there is demand for biofuels in markets *k,* it must be subtracted from available outbound marine shipments in the constraint below.

$$0 \le Y_{fkdt}$$

$$\sum_{d} Y_{fkdt} \le \sum_{j,v} W_{fjkvt}$$

VI. Satisfaction of Final Demand

For this version, final demand is specified as a desired quantity D of biofuel *f* at location (U.S. port) *d*.

Define:

$\underline{D}_{dft}$ the exogenously stated demand for biofuel *f* at destination market *d* in time *t*.

Constraints:

Shipments of each biofuel *f* into each destination (port) *d* from all sources *k* must be sufficient to meet stated demand:

$$\sum_{f} Y_{fkdt} \ge \underline{D}_{dft}$$

Results:

For this specific study, the 2017 baseline case from the ORNL study is used as the data set. Also railway is the mode of transportation chosen within a country to move the biofeedstocks and biofuels. Each exporting country is able to deliver the biofuel to all three coastal regions of the United States. Now the first thing to look at is the least cost combination of biofuels at varying gasoline displacements. President Bush is hoping for fifteen percent gasoline displacement by 2017, so this model will start at five percent and gradually increase the displacement by 5 percent until the model is no longer able to find a solution. All prices are stated in 2006 United States Dollars.

Five Percent Displacement:

At five percent displacement of gasoline, a total of 7,755 million barrels of ethanol will be shipped to the United States. 3,646 million barrels will be shipped to the Gulf Coast, 1,422 million barrels will be shipped to the Atlantic Coast, and 2,685 million barrels will be shipped to the West Coast. The following are charts showing the amount of each country and the type of biofuel shipped to the United States.

Gulf Coast:

Country	Biofeedstock	Barrels of Ethanol (million tons per year
Argentina	Bagasse	3.8998
CBI	Bagasse	9.5998
CBI	Palm Residue	0.7998
Colombia	Bagasse	4.9998
Colombia	Palm Residue	0.9998
India	Bagasse	24.07564973
Mexico	Bagasse	5.9998
Mexico	Corn Stover	3.9998

Atlantic Coast:

Country	Biofeedstock	Barrels of Ethanol (million tons per year
India	Bagasse	20.6399316

West Coast:

Country	Biofeedstock	Barrels of Ethanol (million tons per year
China	Wheat Straw	9.9998
China	Bagasse	8.9998
China	Corn Stover	6.315736432
India	Bagasse	5.284418667

An interesting result is that only one country, India, produces ethanol cheap enough to be sent to the Atlantic Coast at five percent displacement. Another interesting thing to note is that most of the ethanol being shipped is the second-generation cellulosic based ethanol. Now using these results, we must find a tax gasoline tax that will allow ethanol to be competitive in the energy market at five percent displacement. The resulting price of a gallon of ethanol is $1.27. According to the Annual Energy Outlook 2008 report, the projected wholesale price of gasoline for 2017 is $2.63. Since there are not many cars that run on pure ethanol, this study will focus on E85, which is 85% ethanol and 15% gasoline. Thus to find the resulting price of E85, one takes eight-five percent of the price of ethanol and add it to fifteen percent of the price of gasoline , which is $1.47. According to the Annual Energy Outlook 2008 Report, the BTU Content (average heat content per volume) of Gasoline (MMBTU/gal) is 0.1199 compared to the BTU Content of Ethanol (MMBTU/gal), which is 0.0842. Ethanol only contains seventy percent as much BTU content as gasoline. Because of this disparity people will want to know the gallon of gasoline equivalence, which converts the BTU content of ethanol in terms of the same BTU content. This is important because people want to know how much ethanol one has to burn to travel the same amount of miles on gasoline. Since this study focuses on E85 the BTU Content of Ethanol must be converted to E85. To accomplish this goal one takes eight-five percent of the BTU content of ethanol and add it to fifteen percent of the BTU content of gasoline. The resulting value is .0895 MMBTU/gal. To find the price of a gallon of E85 equivalent to the BTU content of a gallon of gasoline, one multiplies the price of a physical gallon of E85 by the BTU Content of Gasoline divided by the BTU Content of E85. The resulting price is $1.97. This is lower than the AEO 2008 stated wholesale price of a gallon of gasoline; therefore a gasoline tax is not needed at a five percent gasoline displacement.

Ten Percent Displacement:

At a ten percent gasoline displacement, a total of 19,929 million barrels of ethanol will be shipped to the United States. 10,956 million barrels will be shipped to the Gulf Coast, 3,823 million barrels to the Atlantic Coast, and 5,150 will be shipped to the West Coast. The following are charts showing the amount of each country and the type of biofuel shipped to the United States.

Gulf Coast:

Country	Biofeedstock	Barrels of Ethanol (million tons per year
Argentina	Corn	15.36050857
Argentina	Wheat Straw	3.1791021
Argentina	Bagasse	3.899803399
Argentina	Corn Stover	6.999799888
Brazil	Corn	10.48904858
Canada	Wheat Straw	0.900700243
Canada	Corn Stover	0.971339713
CBI	Bagasse	9.599799999
CBI	Palm Residue	0.7998
Colombia	Bagasse	4.999804358

Colombia	Palm Residue	0.9998
India	Bagasse	9.805573603
Mexico	Corn	18.46503628
Mexico	Bagasse	5.999805229
Mexico	Corn Stover	3.999803999

Atlantic Coast:

Country	Biofeedstock	Barrels of Ethanol (million tons per year
Canada	Corn	15.48662543
Canada	Wheat Straw	3.099199683
Canada	Corn Stover	3.028560262
India	Bagasse	15.36812451

West Coast:

Country	Biofeedstock	Barrels of Ethanol (million tons per year
Argentina	Wheat Straw	0.220797939
China	Wheat Straw	9.999799999
China	Bagasse	8.999799999
China	Corn Stover	16.9998
India	Bagasse	24.82634512

At ten percent displacement, a majority of the ethanol is still being shipped to the Gulf Coast. It seems Central and South America are able to produce ethanol the cheapest at this displacement. Second-generation cellulosic-based ethanol still makes up a most of the ethanol being shipped to the United States. Corn, however, is starting to make up a prominent portion of the ethanol being shipped. Canada has also emerged as a source of ethanol. The resulting price of a gallon of ethanol is \$1.60. After being converted to E85 the resulting price is \$1.75. The gallon of gasoline equivalence price is \$2.35. This is still lower than the AEO 2008 stated wholesale price of a gallon of gasoline of \$2.63; therefore a gasoline tax is not needed at a ten percent gasoline displacement.

Fifteen Percent Displacement:

At fifteen percent displacement of gasoline, a total of 35,020 million barrels of ethanol will be shipped to the United States. 18,229 million barrels will be shipped to the Gulf Coast, 5,293 million barrels will be shipped to the Atlantic Coast, and 11,497 million barrels will be shipped to the West Coast. The following are charts showing the amount of each country and the type of biofuel shipped to the United States.

Gulf Coast:

Country	Biofeedstock	Barrels of Ethanol (million tons per year
Argentina	Corn	24.65168864
Argentina	Wheat Straw	0.005023145
Argentina	Bagasse	0.121376575
Argentina	Corn Stover	6.999799867
Brazil	Corn	33.86245503
CBI	Bagasse	9.599800044
CBI	Palm Residue	0.000185511
China	Corn	0.4043017
Colombia	Bagasse	4.999799883
Colombia	Palm Residue	0.000281241
India	Bagasse	21.02658682
Mexico	Corn	27.49398972
Mexico	Bagasse	5.999799966
Mexico	Corn Stover	3.999800039

Atlantic Coast:

Country	Biofeedstock	Barrels of Ethanol (million tons per year
Argentina	Bagasse	3.778523405
Canada	Corn	15.50791962
Canada	Wheat Straw	3.9998
Canada	Corn Stover	3.9998
CBI	Palm Residue	0.767902715
Colombia	Palm Residue	0.487537746
India	Sugarcane	0.0001
India	Bagasse	28.97331158

West Coast:

Country	Biofeedstock	Barrels of Ethanol (million tons per year
Argentina	Wheat Straw	3.394876855
CBI	Palm Residue	0.031911782
China	Corn	40.56544595
China	Wheat Straw	9.9998
China	Bagasse	8.9998
China	Corn Stover	16.9998
Colombia	Palm Residue	0.512181018

At fifteen percent displacement, a majority of the ethanol is still being shipped to the Gulf Coast. It seems Central and South America are still able to produce ethanol the cheapest at this displacement. Second-generation cellulosic-based ethanol still makes up a most of the ethanol being shipped to the United States. Corn continues to make up a prominent portion of the ethanol being shipped. The resulting price of a gallon of ethanol is $1.96, which is the same price at fifteen percent displacement. The converted price to E85 is $2.06. The gallon of gasoline equivalence price is $2.76. This resulting price is higher than the AEO 2008 stated wholesale price of a gallon of gasoline of $2.63; therefore a gasoline tax is to make E85 competitive in the energy market. For the sake of simplicity it is assumed that the supply of gasoline is perfectly elastic. With this assumption, to make E85 competitive against gasoline in the energy market, a gas tax of $.13 or higher should be emplaced. In the low price case, gasoline is listed as $2.19. This price would require and even higher tax of $.57. For the high price case, gasoline is listed at $3.06. In this case a tax would not be needed. This tax is taken from the difference between the price of E85 and gasoline because of the perfectly elastic supply of gasoline.

Twenty Percent Displacement:

At twenty percent displacement of gasoline, a total of 51,186 million barrels of ethanol. 28,405 million barrels will be shipped to the Gulf Coast, 6,699 million barrels will be shipped to the Atlantic Coast, and 16,081 million barrels will be shipped to the West Coast. The following are charts showing the amount of each country and the type of biofuel shipped to the United States.

Gulf Coast:

Country	Biofeedstock	Barrels of Ethanol (million tons per year
Argentina	Corn	24.65168868
Argentina	Wheat Straw	0.011166082
Argentina	Bagasse	0.120735507
Argentina	Corn Stover	6.9998
Brazil	Corn	34.83237583
CBI	Bagasse	9.5998
CBI	Palm Residue	0.000185509
China	Corn	57.53883343
Colombia	Bagasse	4.9998
Colombia	Palm Residue	0.000281408
India	Bagasse	1.033368809
Mexico	Corn	27.68450542
Mexico	Bagasse	5.9998
Mexico	Corn Stover	3.9998

Atlantic Coast:

Country	Biofeedstock	Barrels of Ethanol (million tons per year
Argentina	Bagasse	3.779164493
Canada	Corn	15.50791962
Canada	Wheat Straw	3.9998
Canada	Corn Stover	3.9998
CBI	Palm Residue	0.799714491
Colombia	Palm Residue	0.999618592
India	Bagasse	48.96653119

West Coast:

Country	Biofeedstock	Barrels of Ethanol (million tons per year
Argentina	Wheat Straw	3.388733918
China	Corn	64.95481364
China	Wheat Straw	9.9998
China	Bagasse	8.9998
China	Corn Stover	16.9998

At twenty percent displacement, a majority of the ethanol continues to be shipped to the Gulf Coast. It seems Central and South America are still able to produce ethanol the cheapest at this displacement. Second-generation cellulosic-based ethanol still makes up a most of the ethanol being shipped to the United States. Corn continues to make up a prominent portion of the ethanol being shipped. The resulting price of a gallon of ethanol is $1.96. After being converted to E85 the resulting price is $2.06. The gallon of gasoline equivalence price is $2.76. The gasoline tax is to make E85 competitive in the energy market is set at the same $.13 or higher. In the low price case, gasoline is listed as $2.19. This price would require and even higher tax of $.57. For the high price case, gasoline is listed at $3.06. In this case a tax would not be needed.

Twenty-Five Percent Displacement:

At twenty-five percent displacement of gasoline, a total of 67,367 million barrels of ethanol 36,603 million barrels will be shipped to the Gulf Coast, 9,879 million barrels will be shipped to the Atlantic Coast, and 20,884 million barrels will be shipped to the West Coast. The following are charts showing the amount of each country and the type of biofuel shipped to the United States.

Gulf Coast:

Country	Biofeedstock	Barrels of Ethanol (million tons per year
Argentina	Corn	24.65168848
Argentina	Wheat Straw	3.399799924
Argentina	Bagasse	3.899799983
Argentina	Corn Stover	6.999800078
Brazil	Corn	19.65786348
CBI	Bagasse	9.599799953
CBI	Palm Residue	0.799799997
China	Corn	105.7414955
China	Corn Stover	3.137173762
Colombia	Bagasse	4.999799982
Colombia	Palm Residue	0.999799996
Mexico	Corn	28.51346303
Mexico	Bagasse	5.999799978
Mexico	Corn Stover	3.999799985

Atlantic Coast:

Country	Biofeedstock	Barrels of Ethanol (million tons per year
Brazil	Corn	19.73608078
Canada	Corn	15.50791956
Canada	Wheat Straw	3.999799962
Canada	Corn Stover	3.999800105
India	Bagasse	49.99980113

West Coast:

Country	Biofeedstock	Barrels of Ethanol (million tons per year
China	Corn	94.0460598
China	Wheat Straw	9.999799967
China	Bagasse	8.999799971
China	Corn Stover	13.86272618

At twenty-five percent displacement, a majority of the ethanol continues to be shipped to the Gulf Coast. Less variety is being shipped to the Atlantic and West Coasts at this displacement. Seems not as many types of biofuels can be shipped cheaply across those distances. An interesting result to note is that only China is shipping to the West Coast at this displacement. Second-generation cellulosic-based ethanol is still a key provider of ethanol but due to low amounts and high conversion costs, the first generation ethanol is becoming a more prominent source of biofuels. Corn continues to make up a prominent portion of the ethanol being shipped. The resulting price of a gallon of ethanol is $2.03. After being converted to E85 the resulting price is $2.12. The gallon of gasoline equivalence price is $2.84. The gasoline tax is to make E85 competitive in the energy market needs to be set at $.21 or higher. In the low price case, gasoline is listed as $2.19. This price would require and even higher tax of $.65. For the high price case, gasoline is listed at $3.06. In this case a tax would not be needed.

Thirty Percent Displacement:

At thirty percent displacement of gasoline, a total of 89,029 million barrels of ethanol will be shipped to the United States. 46,077 million of the 89,029 million would be shipped to the Gulf Coast, 17,533 million to the Atlantic Coast, and 25,148 million to the West Coast. The following are charts showing the amount of each country and the type of biofuel shipped to the United States.

Gulf Coast:

Country	Biofeedstock	Barrels of Ethanol (million tons per year)
Argentina	Corn	24.65168848
Argentina	Wheat Straw	3.399799924
Argentina	Bagasse	3.899799983
Argentina	Corn Stover	6.999800078
Brazil	Corn	53.05573274
CBI	Sugarcane	45.73735746
CBI	Bagasse	9.599799953
CBI	Palm Residue	0.799799997
China	Corn	81.76674323
China	Corn Stover	3.16026839
Colombia	Bagasse	4.999799982
Colombia	Palm	0.999799996

	Residue	
India	Sugarcane	134.299668
India	Bagasse	9.976001751
Mexico	Corn	31.77802179
Mexico	Sugarcane	1.853449167
Mexico	Bagasse	5.999799978
Mexico	Corn Stover	3.999799985

Atlantic Coast:

Country	Biofeedstock	Barrels of Ethanol (million tons per year)
Brazil	Corn	1.02047524
Canada	Wheat	26.85230597
Canada	Corn	15.50791956
Canada	Wheat Straw	3.999799962
Canada	Corn Stover	3.999800105
India	Sugarcane	149.6820243
India	Bagasse	40.02389985

West Coast:

Country	Biofeedstock	Barrels of Ethanol (million tons per year)
China	Corn	118.0208119
China	Wheat Straw	9.999799967
China	Bagasse	8.999799971
China	Corn Stover	13.83963155

At thirty percent displacement, a majority of the ethanol continues to be shipped to the Gulf Coast. Less variety is still being shipped to the Atlantic and West Coasts at this displacement. An interesting result to note is that only China is shipping to the West Coast at this displacement as well. Sugarcane from India begins to be a prominent source of biofuel at this displacement. Corn continues to make up a prominent portion of the ethanol being shipped. The resulting price of a gallon of ethanol is $2.84. After being converted to E85 the resulting price is $2.81. The gallon of gasoline equivalence price is $3.76. The gasoline tax is to make E85 competitive in the energy market needs to be set at $1.13 or higher. Note that the price of ethanol rose significantly at thirty percent displacement.

Thirty-Five Percent Displacement:

At thirty-five percent displacement of gasoline, a total of 113,785 million barrels of ethanol 54,867 million barrels will be shipped to the Gulf Coast, 28,759 million barrels will be shipped to the Atlantic Coast, and 30,159 million barrels will be shipped to the West Coast. The following are charts showing the amount of each country and the type of biofuel shipped to the United States.

Gulf Coast:

Country	Biofeedstock	Barrels of Ethanol (million tons per year)
Argentina	Wheat	15.02380505
Argentina	Corn	24.65168767
Argentina	Wheat Straw	3.399796367
Argentina	Bagasse	3.8997952
Argentina	Corn Stover	6.999796195
Brazil	Corn	53.42300705
Brazil	Sugarcane	281.6636052
CBI	Sugarcane	58.82536487
CBI	Bagasse	9.599797818
CBI	Palm Residue	0.799795904
China	Corn	54.32592491
China	Corn Stover	7.588458765
Colombia	Bagasse	4.999799872
Colombia	Palm Residue	0.9998
India	Bagasse	49.60524224
Mexico	Corn	31.77801778
Mexico	Sugarcane	16.62779514
Mexico	Bagasse	5.999798008
Mexico	Corn Stover	3.999797073

Atlantic Coast:

Country	Biofeedstock	Barrels of Ethanol (million tons per year)
Argentina	Wheat	1.440924261
Brazil	Corn	0.653196968
Brazil	Sugarcane	170.7490691
Canada	Wheat	29.92153706
Canada	Corn	15.50791545
Canada	Wheat Straw	3.999795832
Canada	Corn Stover	3.999793528
India	Sugarcane	338.9961206
India	Bagasse	0.394657764

West Coast:

Country	Biofeedstock	Barrels of Ethanol (million tons per year)
China	Corn	145.4616327
China	Sugarcane	0.0001
China	Wheat Straw	9.999799629
China	Bagasse	8.999799685
China	Corn Stover	9.411440307

At thirty-five percent displacement, a majority of the ethanol continues to be shipped to the Gulf Coast. Almost every variety of biofuel is being shipped to the Gulf Coast at this displacement. The amount shipped to the Atlantic is now almost the same as the amount being shipped to the West Coast. Less variety is still being shipped to the Atlantic and West Coasts at this displacement. An interesting result to note is that only China is shipping to the West Coast at this displacement as well. Sugarcane from India as well as sugarcane from Brazil begins to be a prominent source of biofuel at this displacement. Canadian wheat has also become a viable source of biofuel. Corn continues to make up a prominent portion of the ethanol being shipped. The resulting price of a gallon of ethanol is \$3.00. After being converted to E85 the resulting price is \$2.94. The gallon of gasoline equivalence price is \$3.94. The gasoline tax is to make E85 competitive in the energy market needs to be set at $1.31 or higher. Note that the price of ethanol continues to rise significantly at thirty-five percent displacement.

Forty Percent Displacement:

At forty percent displacement of gasoline, a total of 142,409 million barrels of ethanol 68,774 million barrels will be shipped to the Gulf Coast, 34,019 million barrels will be shipped to the Atlantic Coast, and 39,614 million barrels will be shipped to the West Coast. The following are charts showing the amount of each country and the type of biofuel shipped to the United States.

Gulf Coast:

Country	Biofeedstock	Barrels of Ethanol (million tons per year)
Argentina	Wheat	14.99510883
Argentina	Corn	24.65168766
Argentina	Wheat Straw	3.399796382
Argentina	Bagasse	3.899795198
Argentina	Corn Stover	6.99979615
Brazil	Corn	53.41120225
Brazil	Sugarcane	486.2644855
CBI	Sugarcane	77.71179098
CBI	Bagasse	9.599788405
CBI	Palm Residue	0.799795509
China	Corn	54.02883581
China	Sugarcane	58.96462889
China	Corn Stover	7.808690543
Colombia	Sugarcane	23.95854528
Colombia	Bagasse	4.999796692
Colombia	Palm Residue	0.9998
India	Bagasse	49.60871044
Mexico	Corn	31.77801778
Mexico	Sugarcane	63.27083184
Mexico	Bagasse	5.999798007
Mexico	Corn Stover	3.999797072

Atlantic Coast:

Country	Biofeedstock	Barrels of Ethanol (million tons per year)
Argentina	Wheat	1.46962068
Brazil	Corn	0.665001757
Brazil	Sugarcane	252.586065
Canada	Wheat	29.92153706
Canada	Corn	15.50791545
Canada	Wheat Straw	3.999795829
Canada	Corn Stover	3.999793526
China	Sugarcane	15.46243677
Colombia	Sugarcane	19.31574872
India	Sugarcane	355.6175464
India	Bagasse	0.391189554

West Coast:

Country	Biofeedstock	Barrels of Ethanol (million tons per year)
China	Wheat	17.08640439
China	Corn	145.7587182
China	Sugarcane	58.63341853
China	Wheat Straw	9.999799628
China	Bagasse	8.999799685
China	Corn Stover	9.191207677
Colombia	Sugarcane	8.901266452

At forty percent displacement, a majority of the ethanol continues to be shipped to the Gulf Coast. Almost every variety of biofuel is being shipped to the Gulf Coast at this displacement. The amount shipped to the Atlantic is now almost the same as the amount being shipped to the West Coast. Less variety is still being shipped to the Atlantic and West Coasts at this displacement. China is no longer the only country shipping to the West Coast at this displacement. Columbian sugarcane is now being shipped to the United States West Coast. Sugarcane from India as well as sugarcane from Brazil begins to be a prominent source of biofuel at this displacement. Argentina and China have joined Canada by providing wheat has also become a viable source of biofuel. Corn continues to make up a prominent portion of the ethanol being shipped. The resulting price of a gallon of ethanol is $4.22. After being converted to E85 the resulting price is $3.98. The gallon of gasoline equivalence price is $5.33. The gasoline tax is to make E85 competitive in the energy market needs to be set at $2.70 or higher. Note that the price of ethanol continues to rise significantly at thirty-five percent displacement.

Forty-Five Percent Displacement

At forty percent displacement of gasoline, a total of 177,690 million barrels of ethanol 75,449 million barrels will be shipped to the Gulf Coast, 38,971 million barrels will be shipped to the Atlantic Coast, and 63,269 million barrels will be shipped to the West Coast. The following are charts showing the amount of each country and the type of biofuel shipped to the United States.

Gulf Coast:

Country	Biofeedstock	Barrels of Ethanol (million tons per year)
Argentina	Wheat	14.96397119
Argentina	Corn	24.65168766
Argentina	Wheat Straw	3.399796365
Argentina	Bagasse	3.899795198
Argentina	Corn Stover	6.99979615
Brazil	Corn	53.40402618
Brazil	Sugarcane	354.2013548
CBI	Sugarcane	77.71525525
CBI	Bagasse	9.599797816
CBI	Palm Residue	0.799795509
China	Corn	113.2931927
China	Sugarcane	55.86761971
China	Corn Stover	7.536536246
Colombia	Sugarcane	23.23031409
Colombia	Bagasse	4.999799855
Colombia	Palm Residue	0.9998
India	Bagasse	49.60666953
Mexico	Corn	31.77801778
Mexico	Sugarcane	63.27083184
Mexico	Bagasse	5.999798007

Mexico	Corn Stover	3.999797072

Atlantic Coast:

Country	Biofeedstock	Barrels of Ethanol (million tons per year)
Argentina	Wheat	1.500758124
Brazil	Corn	0.672177834
Brazil	Sugarcane	384.6518158
Canada	Wheat	29.92153706
Canada	Corn	15.50791545
Canada	Wheat Straw	3.999795829
Canada	Corn Stover	3.999793525
China	Sugarcane	15.89784647
Colombia	Sugarcane	20.04321735
India	Sugarcane	355.6092946
India	Bagasse	0.393230472

West Coast:

Country	Biofeedstock	Barrels of Ethanol (million tons per year)
China	Wheat	107.303887
China	Corn	86.49436206
China	Sugarcane	61.29501811
China	Wheat Straw	9.999799629
China	Bagasse	8.999799685
China	Corn Stover	9.463361973
Colombia	Sugarcane	8.902028692

The model maxes out at forty-five percent displacement. A majority of the ethanol continues to be shipped to the Gulf Coast. Almost every variety of biofuel is being shipped to the Gulf Coast at this displacement. The amount shipped to the West Coast is drastically increased. The amount is almost double of what is being shipped to the Atlantic coast. Less variety is still being shipped to the Atlantic and West Coasts at this displacement. China and Columbian sugarcane are still the sole providers to the United States West Coast. Sugarcane from India as well as sugarcane from Brazil are still a prominent source of biofuel at this displacement. Argentina, China, and Canada are still providing wheat as a viable source of biofuel. Second-generation cellulosic-based ethanol still makes up a most of the ethanol being shipped to the United States. Corn continues to make up a prominent portion of the ethanol being shipped. The resulting price of a gallon of ethanol is $4.22, which is the same as the price at forty percent displacement. The converted E85 price is still $3.98. The gallon of gasoline equivalence price is still $5.33. The gasoline tax is to make E85 competitive in the energy market needs to be set at $2.70 or higher.

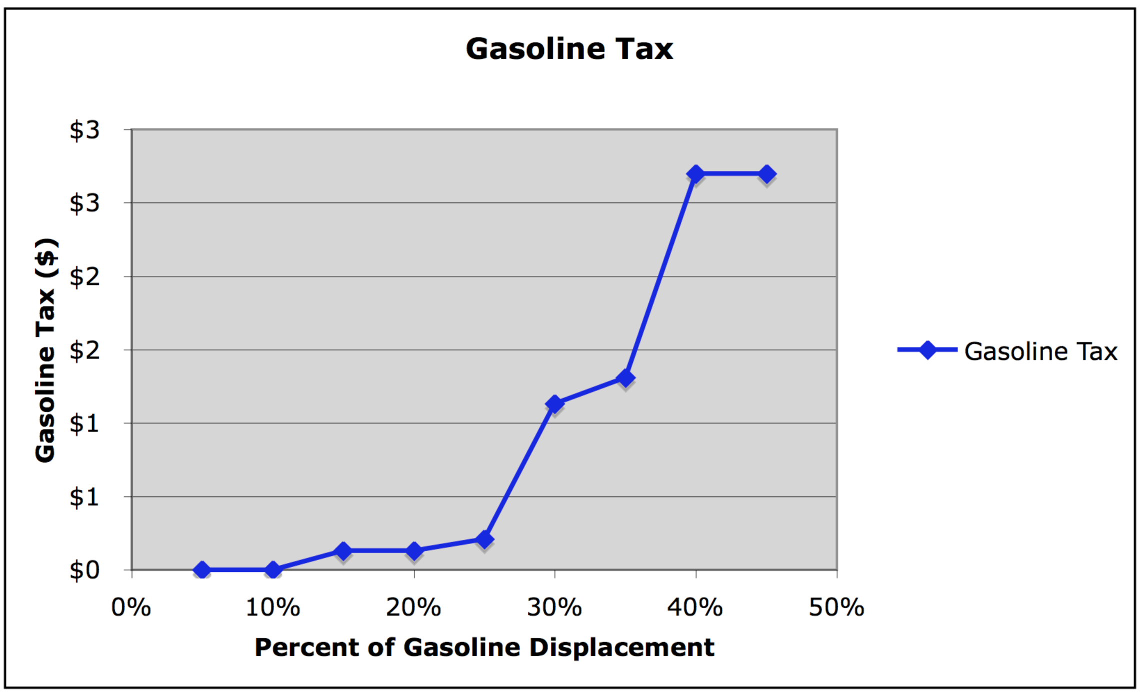
Conclusion:

To summarize, the BDPM model shows the production costs of producing and importing biofuels from differing countries into the United States. The current level of gasoline displacement with biofuels is around two percent. An increase to five or even ten percent would be a large feat. According to the model even at a ten percent displacement for the baseline and high price cases, no gasoline tax would be necessary for E85 to be competitive in the energy market. At a zero tax scenario most of the ethanol sources are the second generation cellulosic-based ethanol mainly from South America, China and India shipped to the West and Gulf Coasts.

Now as more gasoline is displaced, more of the biofuels will come from the first generation biofeedstocks, mainly corn, sugarcane, and wheat. This transition to the first generation of biofeedstocks takes place around a twenty percent gasoline displacement. This change is most likely due to the limited quantity of cellulosic biofeedstocks as well as the high conversion costs. As more ethanol is being produced, the price of the first generation biofuels starts to fall.

Unfortunately with this growth come some possible environmental sacrifices. The argument against first generation ethanol is that it uses food crops that both humans and animals consume. This effect in turn causes a rise in food prices as well as competition over land use, thus, creating a sustainability and renewability issue. Many developing nations may force land to be used strictly for energy to fuel the needs of the industrialized world. This shift along with the rise in food prices would lead to the starvation of many people. The use of food crops also provides an economic sustainability issue for the farmers growing the crops. They may be forced to grow more crops to meet both food and energy demands, thus draining the land of nutrients at a faster rate. This may not allow farmers to stay in business as long. First generation ethanol also produces more carbon emissions than the second-generation cellulosic-based ethanol. Thus, as more gasoline is displaced, the less "green" the ethanol portions become. In the end, however, it is still cleaner than gasoline.

A majority of the biofuels is being shipped to the Gulf Coast rather than the Atlantic and the West. This is most likely due to the cheaper production costs being incurred in Central and South America who are closer to the Gulf Coast. As higher displacement occurs, China becomes the sole provider to the West Coast until around forty percent displacement, where Colombian sugarcane becomes a viable source to be shipped to the West Coast. Now the resulting price of ethanol as well as its converted E85 value is relatively cheap at the lower displacement percentages. At fifteen percent displacement, however, the price of ethanol and E85 begins to exceed the projected wholesale price of gasoline. At this point a gasoline tax needs to be emplaced to make E85 competitive in the energy market. So if the United States wanted to keep a gasoline tax from being emplaced, the must maintain between a ten and fifteen percent displacement with ethanol. The tax remains relatively low until at thirty percent displacement, the tax rises above a dollar. Then at forty percent displacement, the cost of E85 rises dramatically, which in turns raises the gasoline tax dramatically. For the low price case a gas tax would need to be emplaced after a five percent displacement. At the high price scenario a gas tax would not have to be emplaced until after thirty percent displacement. At thirty percent, the price of a gallon of gasoline equivalence of E85 is equal to the projected price of gasoline. Therefore, E85 is still able to compete. Below is a graph that shows the change in the gasoline tax as the gasoline displacement increases.



The BPDM model used in this study uses data from many early studies and contains many assumptions especially with those regarding transportation costs. As more studies are done in this area, the model needs to be updated to provide better estimates of the imported supply to the United States. This model also only looks at imported supply. Domestic production should be added in for future studies. Also the gasoline tax is created based on a perfectly elastic gasoline demand for simplicity. To have a more accurate idea of a gasoline tax, the elasticity demand of gasoline must be found and inserted into the model. This study is a basic and first attempt to see what the necessary means are needed to make biofuels a competitive source of energy in the United States. As more studies are done, the model used in this study can be updated and provide an overall better result.

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