Food and Agricultural Policy Research Institute

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University of Missouri

June 2014

Model Documentation: US Biofuels, Corn Processing, Biomass-based Diesel, and Cellulosic Biomass

FAPRI-MU Report #03-14

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Published by the Food and Agricultural Policy Research Institute (FAPRI) at the University of Missouri (MU), 101 Park DeVille Drive, Suite E; Columbia, MO 65203. FAPRI–MU is part of the College of Agriculture, Food and Natural Resources (CAFNR).

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This material is based upon work supported by the U.S. Department of Agriculture, under Agreement No. 58-0111-13-002.

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Overview of FAPRI-MU Biofuels, Corn processing, Distillers Grains, Biomass-based Diesel, and Cellulosic Biomass Model Documentation

This is a technical report. The model equations listed here represent US biofuel, corn processing, distillers grains, biomass-based diesel, and cellulosic biomass markets. The equations and data represent annual conditions on a crop or calendar year. The model is defined as follows.

• *These are a subset of FAPRI-MU models.*

These equations are linked to other equations that represent US markets for crops, other crop products, livestock, and livestock products, with additional equations to calculate consumer and government expenditures. These market representations include trade equations that simulate the responses in US exports or imports for changing market conditions. In addition, trade equations can be replaced by links to more complete international model systems.

• *The version is accurate as of March 2014.*

Data used in this and other FAPRI-MU models are updated twice each year. Equations are revised as circumstances warrant.

Policy representation reflects our understanding at that time. There are no blenders tax credits in effect. The Renewable Fuel Standard is represented based on the Environmental Protection Agency proposal to waive the mandate each year to lower levels than set in the Energy Independence and Security Act. A consequence of this choice is that the biofuel use mandate requirement will change with market conditions.

• *The equations and data document the deterministic version of the model.*

A model solution involves one set of input and one set of output. One path for each exogenous variable is taken for the ten-year period, then the model is solved over that ten year period. The alternative is stochastic simulation: many alternative paths for exogenous variables are used as input, and each one generates a corresponding set of output. Each stochastic simulation involves hundreds of solutions over a ten-year period, each consistent with a different set of assumptions about external conditioning factors. Although the equations listed below are very similar to the FAPRI-MU stochastic version, there are some differences.

The model is intended for forward-looking analysis of policy options. The equations represent current and expected market structures. Where possible, equations and parameters are based on historical data. However, in most instances, the rapid recent changes in biofuel market structure and policy prevent reliable statistical testing of model structure or parameters. Analysts seek feedback from industry experts at formal annual events and informally.

We also include a subset of impact multipliers. The reader is asked to look at the following publications that use some version of this model to see how other various shocks affect key market indicators.

Related FAPRI-MU publications, 2011-present

Westhoff, Pat, Scott Gerlt, Jarrett Whistance, Julian Binfield, Wyatt Thompson, Scott Brown, Daniel Madison, Mike Helmar, Eric Wailes, Eddie C. Chavez, and Darren Hudson. 2014. “U.S. Baseline Briefing Book.” *FAPRI-MU* #02-14.

Whistance, Jarrett, Wyatt Thompson, and Seth Meyer. 2014. “Biomass-based Diesel Policy Options: Larger RFS Requirements and Tax Credit Extension.” *FAPRI-MU* #01-14.

Whistance, Jarrett, Wyatt Thompson, and Seth Meyer. 2013. “Renewable Fuel Standard Waiver Options for 2014 and Beyond.” *FAPRI-MU* #07-13.

Westhoff, Pat, Scott Gerlt, Jarrett Whistance, Julian Binfield, Scott Brown, Daniel Madison, Mike Helmar, Eric Wailes, and Ed de la Cuesta Chavez. 2013. “August 2013 Baseline Update for U.S. Agricultural Markets.” *FAPRI-MU* #04-13.

Thompson, Wyatt, Jarrett Whistance, and Pat Westhoff. 2013. “Implied RIN Prices for E85 Expansion and the Effects of a Steeper Blend Wall.” *FAPRI-MU* #03-13.

Whistance, Jarrett and Wyatt Thompson. 2013. “FAPRI-MU Biofuel Baseline.” *FAPRI-MU* #02-13.

Westhoff, Pat, Scott Gerlt, Jarrett Whistance, Julian Binfield, Wyatt Thompson, Scott Brown, Daniel Madison, and Mike Helmar. 2013. “U.S. Baseline Briefing Book.” *FAPRI-MU* #01-13.

Thompson, Wyatt, Seth Meyer, Pat Westhoff, and Jarrett Whistance. 2012. “A Question Worth Billions: Why Isn’t the Conventional RIN Price Higher?” *FAPRI-MU* #12-12.

Thompson, Wyatt, Jarrett Whistance, Pat Westhoff, and Julian Binfield. 2012. “Renewable Fuel Standard Waiver Options during the Drought of 2012.” *FAPRI-MU* #11-12.

Thompson, Wyatt, Julian Binfield and Jarrett Whistance. 2012. “EPA and RFS2: Market Impacts of Biofuel Mandate Waiver Options.” *FAPRI-MU* #04-12.

Binfield, Julian, Jarrett Whistance, and Wyatt Thompson. 2012. “U.S. Biofuels Baseline and Impact of E-15 Expansion on Biofuel Markets.” *FAPRI-MU* #02-12.

Thompson, Wyatt, Seth Meyer, and Jarrett Whistance. 2011. “Model Documentation for Biomass, Cellulosic Biofuels, Renewable and Conventional Electricity, Natural Gas and Coal Markets.” *FAPRI-MU* #12-11.

Thompson, Wyatt, Seth Meyer, Jarrett Whistance, and Pat Westhoff. 2011. “Competition for Biomass among Renewable Energy Policies: Liquid Fuels Mandate versus Renewable Electricity Mandate.” *FAPRI-MU* #11-11.

Related FAPRI-MU staff publications, 2011-present

Whistance, Jarrett and Wyatt Thompson. 2014. "A Critical Assessment of RIN Price Behavior and the Implications for Corn, Ethanol, and Gasoline Price Relationships." *Applied Economic Perspectives and Policy*.

Whistance, Jarrett, Wyatt Thompson, and Seth Meyer. 2014. “The EPA Add-Up and the Biodiesel Blenders Tax Credit.” Farmdoc Daily blog

Thompson, Wyatt, and Seth Meyer. 2013. “Second Generation Biofuels and Food Crops: Co-Products or Competitors?” *Global Food Security* 2: 89-96.

Meyer, Seth, Julian Binfield, and Wyatt Thompson. 2013. “The Role of Biofuel Policy and Biotechnology in the Development of the Ethanol Industry in the United States.” *AgBioForum* 16(1), 66-78.

Whistance, Jarrett. 2012. "Domestic Energy Policy Effects on the U.S. Biomass Market." *Biomass and Bioenergy* 46:133-144. doi: 10.1016/j.biombioe.2012.09.013.

Meyer, Seth, and Wyatt Thompson. 2012. “How Do Biofuel Use Mandates Cause Uncertainty? United States Environmental Protection Agency Cellulosic Waiver Options.” *Applied Economic Policies and Perspectives* 34(4): 570-586.

Thompson, Wyatt, Jarrett Whistance, and Seth Meyer. 2011. “Effects of US Biofuel Policies on US and World Petroleum Product Markets with Consequences for Greenhouse Gas Emissions.” *Energy Policy* 39 (9): 5509–5518.

Meyer, Seth, and Wyatt Thompson. 2011. “Another Thing We Need Know about Biofuel Use Mandates: Waivers.” *Choices* 26(2).

Selected FAPRI-MU staff meeting presentations or proceedings papers, 2011-present

"U.S. Biofuels Outlook." Presented at 1st Annual Abner W. Womack Missouri Agriculture Outlook Conference held in Columbia, MO. March 2014.

"U.S. Biofuels Outlook." Presented at FAPRI-MU Annual Baseline Review held at U.S. Department of Agriculture, Washington DC. December 2013.

"U.S. Biofuels Outlook." Presented to representatives of the Office of Transportation and Air Quality, Environmental Protection Agency, Washington, DC. December 2013.

"Cellulosic Biofuels in FAPRI Baseline of 2013." Presented via WebEx to Workshop on Biofuels Projections in AEO held at U.S. Energy Information Administration, Washington DC. March 2013.

"Ethanol Policy Effects on Petroleum and Petroleum Product Markets." Presented at 13th Annual Missouri Economics Conference held in Columbia, MO. March 2013.

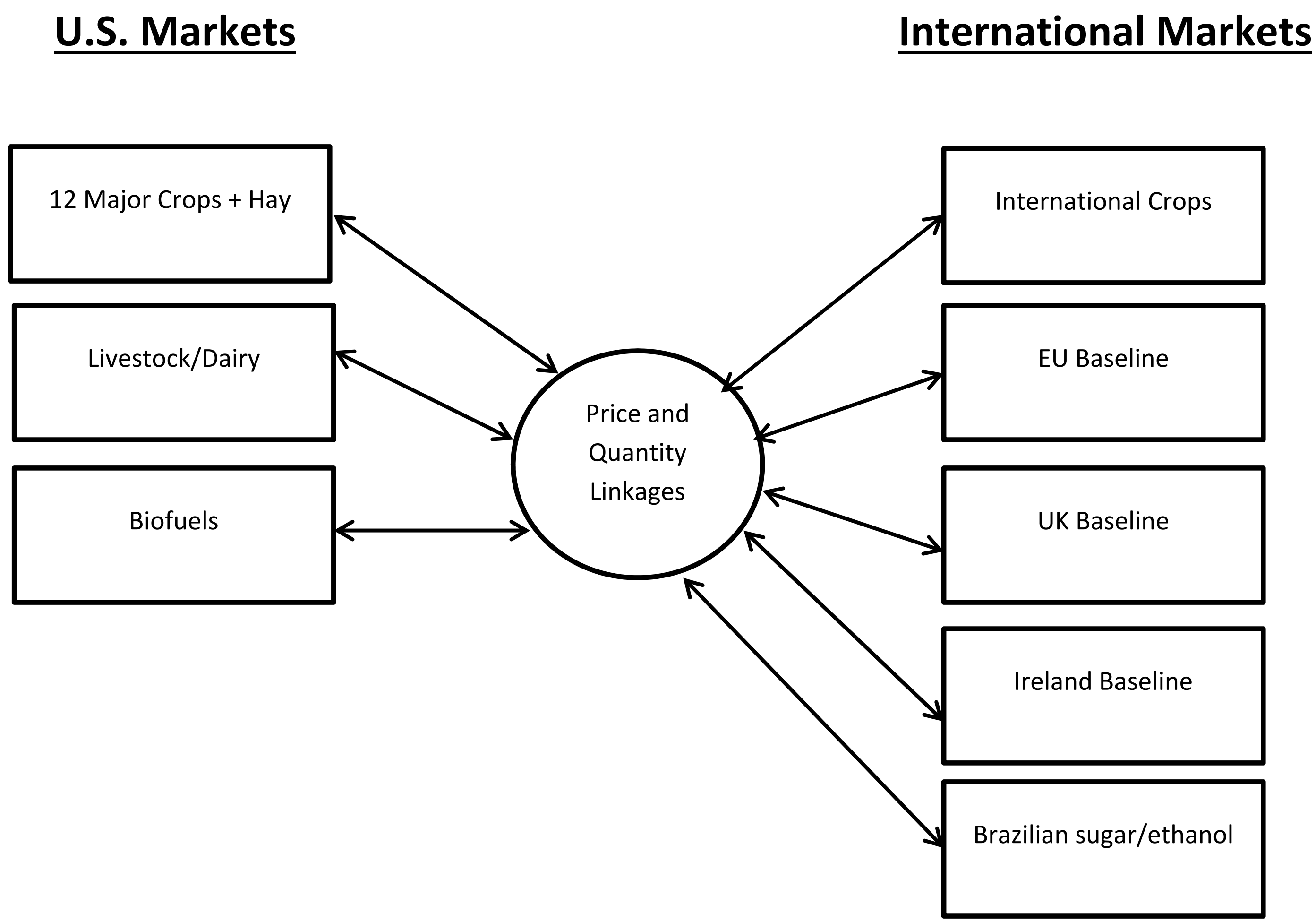
"Role of Economics in Biofuel Policy." Presented to a meeting of the Ethanol Committee, National Corn Growers Association held in St. Louis, MO. February 2013.

"U.S. Biofuels Outlook." Presented at FAPRI-MU Annual Baseline Review held at U.S. Department of Agriculture, Washington DC. December 2012.

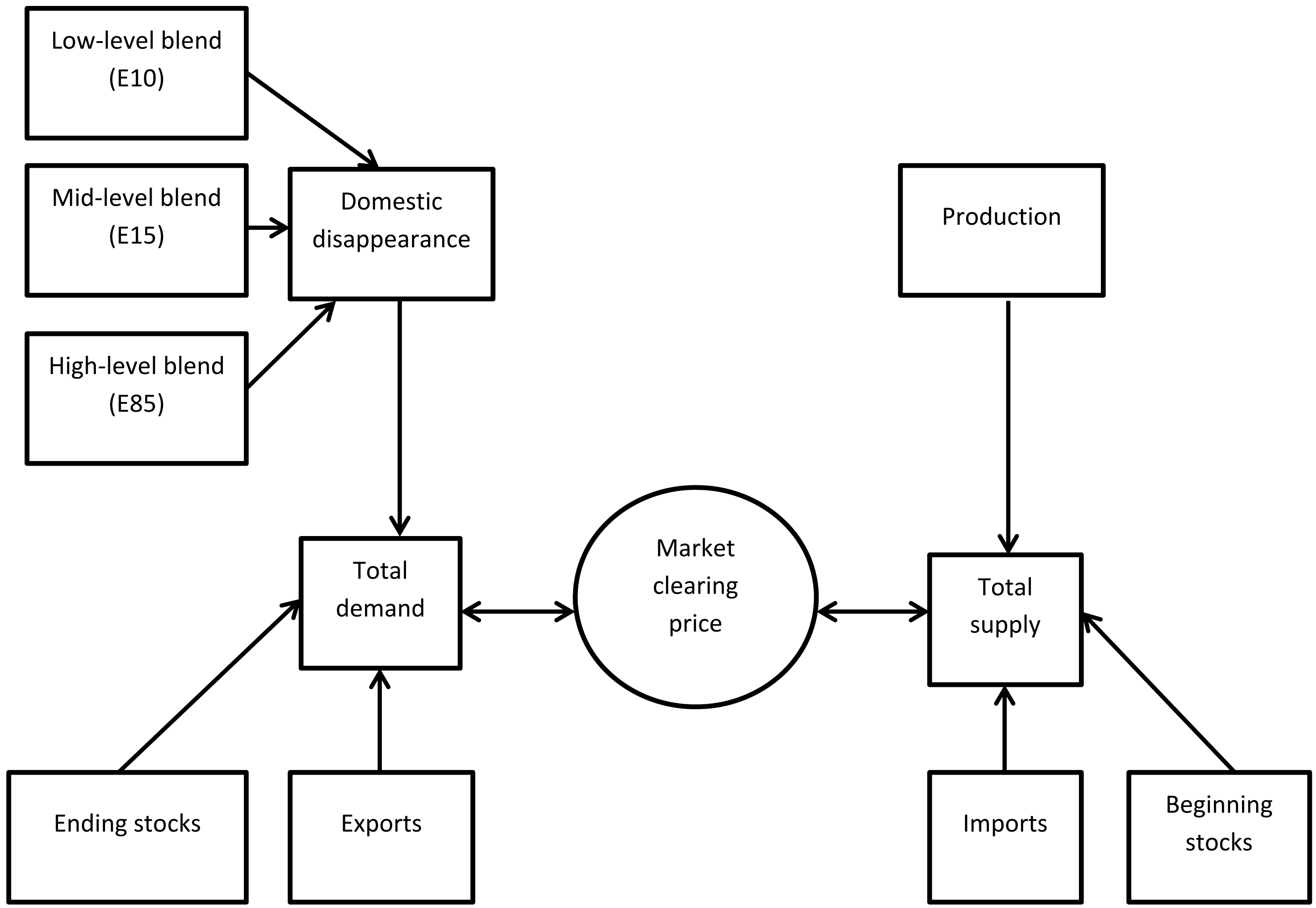
"Trade Implications of Renewable Fuel Standard Waivers." Presented at International Agricultural Trade Research Consortium Annual Meetings held in San Diego, CA. December 2012.

"Ethanol Policy Effects on Petroleum and Petroleum Product Markets: A Stochastic Analysis." Presented at International Agricultural Trade Research Consortium Annual Meetings held in St. Petersburg, FL. December 2011.

Overview of FAPRI-MU modeling system



Selected model flowchart, US ethanol market



Model variables

Name	Description	Units	Average Values		
			2006-2009	2010-2013	2014-2017
Macro Variables					
POPTOTW	Population	Millions	303.07	313.21	322.90
ZCE92W	Real Consumer Expenditures	Billion Dollars	6938.32	7267.41	8077.72
PDCGNP	GDP Deflator	Index	137.54	146.16	155.92
PPI9NFZ	Nitrogen Fertilizer Prices Paid Ind.	Index, 90-92=100	266.00	310.73	282.08
PPIGASW	PPI for gas fuels, 1982=100	Index	267.46	186.05	219.79
PPIRPP	Refined petroleum product price index	Index	2.13	3.01	2.77
POILRAP	Refiners' crude oil acquisition price	$/barrel	70.39	101.61	95.39
POILWTI	West TX Intermediate oil price	$/barrel	74.92	95.75	96.18
WPI051	Coal Prices Paid Index	Index	1.50	2.09	2.22
PPIRPPSA	Refined petroleum product price index, marketing year	Index	2.17	2.98	2.77
POILRASA	Refiners' crude oil acquisition price, marketing year	$/barrel	72.55	100.80	95.53
Corn Processing					
CRDGAS	Corn Fuel Alcohol Use	Million Bushels	3367.19	4887.47	5094.30
CRDHFC	Corn HCFS Use	Million Bushels	514.82	501.34	508.02
CRDGLD	Corn Glucose & Dextrose	Million Bushels	254.44	286.18	287.98
CRDSTR	Corn Starch Use	Million Bushels	256.52	250.39	258.62
CRDBEV	Corn Beverage Alcohol	Million Bushels	134.80	138.87	144.45
CRDCER	Corn Cereals & Other	Million Bushels	192.15	206.33	211.84
CRDGDM	Corn Ethanol Dry Mill, Calendar Year	Million Bushels	2464.15	4346.14	4597.42
CRDGWM	Corn Ethanol Wet Mill, Calendar Year	Million Bushels	392.44	543.83	483.36
CRDOWM	Corn Other Wet Mill, Calendar Year	Million Bushels	1031.88	1047.68	1054.32
CROTCDM	Corn Other Dry Mill Costs	$/gallon	0.32	0.33	0.34
CRNRBDM	Corn Dry Mill Net Return, Calendar Year	$/bushel	2.12	1.36	0.70

Name	Description	Units	Average Values		
			2006-2009	2010-2013	2014-2017
CRNCC	Nominal Cost of Capital	$/bushel	0.75	0.73	0.65
CROTCWM	Corn, Other Wet Mill Costs	$/gallon	0.51	0.53	0.54
CRNRBWM	Corn Wet Mill Net Return, Calendar Year	$/bushel	2.47	1.43	0.70
CRGMWH	HFCS Wet Mill Gross Margin	$/bushel	5.35	4.87	5.12
ETCEVARC	Cellulosic Variable Costs	$/gallon	2.00	2.53	2.16
CRDGASCL	Corn Fuel Alcohol Use, Calendar Year	Million Bushels	2856.59	4870.84	5137.23
Calendar Year Processing					
MGSTOTCL	Motor gasoline supplied, Calendar Year	Million Gallons	140072.42	135131.14	132764.35
MGSTOTCL1	Projected motor gasoline supplied	Million Gallons	139076.44	133636.46	132281.90
UGPFBCL	Unleaded. Gasoline price, Omaha	$/gallon	2.13	2.73	2.75
UGPRTCL	Unleaded gasoline retail price, calendar year	$/gallon	2.75	3.37	3.36
ETPFBCL	Ethanol price, Omaha, calendar year	$/gallon	2.27	2.37	1.75
ETPRTCL	Ethanol implied retail price, calendar year	$/gallon	2.38	2.63	2.09
ETCAPTO	Ethanol total capacity, Jan nameplate	Million Gallons	7548.40	14211.03	15064.56
ETSPRDCL	Ethanol production, Calendar Year	Million Gallons	7912.99	13474.45	14370.84
ETSIMPCL	Ethanol imports, Calendar Year	Million Gallons	474.55	257.51	157.19
ETDEXPCL	Ethanol exports, Calendar Year	Million Gallons	109.63	728.26	891.24
ETSIMNCL	Ethyl alcohol net imports, Calendar Year	Million Gallons	364.91	-470.74	-734.05
ETDISCL	Ethanol Disappearance., Calendar Year	Million Gallons	8162.08	12965.84	13636.07
ETDISCL1	Projected Ethanol Disappearance	Million Gallons	10014.37	13103.59	13790.32
ETDTESCL	Ethanol ending stocks, Calendar Year	Million Gallons	526.21	805.65	849.50
ETTAXEX	Federal ethanol tax credit, Calendar Year	$/gallon	0.50	0.23	0.00
ETTARS	Ethanol specific tariff, Calendar year	$/gallon	0.54	0.27	0.00
ETTARV	Ethanol ad valorem tariff, Calendar Year	Percent	0.03	0.03	0.03
ETADD	Ethanol additive dummy	Proportion	0.03	0.04	0.04
RFTO	Renewable Fuel Standard	Million Gallons	7200.00	14662.50	21225.00
RFAD	Renewable Fuel Standard (Advanced Biofuels)	Million Gallons	150.00	1762.50	6375.00

Name	Description	Units	Average Values		
			2006-2009	2010-2013	2014-2017
RFCE	Renewable Fuel Standard (Cellulosic)	Million Gallons	0.00	462.50	3625.00
RFBD	Renewable Fuel Standard (Biodiesel)	Million Gallons	125.00	932.50	1280.00
RFCN	Implied Corn Starch Ethanol	Million Gallons	7050.00	12900.00	14850.00
Crop Year Ethanol					
ETYLDDM	Ethanol yield--dry mill	Gallons/Bushel	2.72	2.72	2.75
ETYLDWM	Ethanol yield--wet mill	Gallons/Bushel	2.68	2.69	2.70
MGSTOTSA	Motor gasoline supplied, marketing year	Million Gallons	139471.02	134273.02	132442.72
UGPFBSA	Unleaded Gasoline Price, Omaha, marketing year	$/gallon	2.14	2.86	2.75
UGPRTSA	Unleaded Gasoline retail price, marketing year	$/gallon	2.76	3.49	3.36
ETPFBSA	Ethanol price, Omaha, marketing year	$/gallon	2.10	2.38	1.75
ETCAPDM	Dry mill capacity, Operating	Million Gallons	8091.13	14145.53	14842.50
ETCAPWM	Wet mill capacity, Operating	Million Gallons	1365.00	1722.91	1795.73
ETCUSDM	Ethanol dry mill capacity use,	Proportion	0.85	0.84	0.85
ETCUSWM	Ethanol wet mill capacity use,	Proportion	0.77	0.84	0.73
ETSPNCCL	Ethanol non-corn production,	Million Gallons	170.62	241.13	327.33
ETSPCECL	Ethanol cellulosic production,	Million Gallons	0.00	0.05	37.08
ETSPOACL	Other advanced ethanol production, calendar year	Million Gallons	0.00	99.17	218.48
ETSPRDSA	Ethanol production,	Million Gallons	9306.17	13620.41	14446.16
ETDEXPSA	Ethanol exports, Marketing year	Million Gallons	153.20	832.05	863.26
ETSIMNSA	Ethyl alcohol net imp., Marketing year	Million Gallons	214.65	-543.87	-706.07
ETDADCL	Ethanol additive market, calendar year	Million Gallons	4510.54	4726.60	4682.01
ETME10CL	Ethanol E10 market, calendar year	Million Gallons	9157.08	8595.90	8328.58
ETE10PEN	Ethanol E10 pen. rate, calendar year	Proportion	0.40	0.94	0.99
ETDE10CL	Ethanol E10 use, calendar year	Million Gallons	3548.07	8104.59	8261.99
ETME15CL	Ethanol E15 market, calendar year	Million Gallons	0.00	687.16	1600.73
ETE15PEN	Ethanol E15 pen. Rate, calendar year	Proportion	0.00	0.00	0.12

Name	Description	Units	Average Values		
			2006-2009	2010-2013	2014-2017
ETDE15CL	Ethanol E15 use, calendar year	Million Gallons	0.00	1.07	203.59
ETME85CL	Ethanol E85 market, calendar year	Million Gallons	158.81	182.70	501.89
ETE85PEN	Ethanol E85 pen. rate, calendar year	Proportion	0.64	0.73	0.97
ETDE85CL	Ethanol E85 use, calendar year	Million Gallons	103.47	133.59	488.49
RFTOE	RFS, Effective total, calendar year	Calculated	6750.27	14484.02	15819.08
RFADE	RFS, Eff. other advanced biofuel , calendar year	Calculated	81.71	1824.46	2151.16
RFCEE	RFS, Effective cellulosic, calendar year	Calculated	0.00	462.50	3625.00
RFBDE	RFS, Effective biodiesel, calendar year	Calculated	183.43	975.40	1209.10
ETEQVCEL	Equivalence values, cellulosic	Conversion Factor	1.00	1.00	2750.00
BDEQV	Equivalence values, biodiesel	Conversion Factor	1.25	1.50	17600.00
ETNCADV	Non-corn ethanol as advanced	Percentage	0.00	0.00	0.00
ETCECRTC	Ethanol, cellulosic allowance trigger	$/gallon Gas	1.51	3.14	3.35
ETCECRMC	Ethanol, cellulosic allowance minimum	$/gallon Ethanol	0.13	0.26	0.28
ETCECRT	Ethanol, cellulosic. credit trigger, marketing year	$/gallon Gas	2.02	3.18	3.39
ETCECRM	Ethanol, cellulosic credit minimum, marketing year	$/gallon Ethanol	0.17	0.26	0.28
ETCECR10	Ethanol, cellulosic allowance, from 2010	$/gallon Ethanol	0.31	0.70	0.57
ETCECRFC	Ethanol, cellulosic credit, FCEA	$/gallon Ethanol	0.27	0.79	0.00
ETPADCL	Ethanol, other advanced price, calendar year	$/gallon	2.27	2.72	1.75
ETPCELCL	Ethanol, cellulosic price, calendar year	$/gallon	2.54	4.22	2.32
ETPRTRCL	Rack equivalent retail price, calendar year	$/gallon	1.75	1.99	1.48
RFCNCPG	Conventional RIN (D6) price, calendar year	$/gallon	0.08	0.15	0.28
RFADCPG	Advanced RIN (D5) price, calendar year	$/gallon	0.03	0.51	0.28
RFCECPG	Cellulosic RIN (D3)price, calendar year	$/gallon	0.07	1.22	0.84
RFCNC	Conventional ethanol mandate cost	Million Dollars	468.91	1950.26	3700.13
RFADC	Other advanced biofuel mandate cost	Million Dollars	5.37	166.54	43.72
RFCEC	Cellulosic mandate cost	Million Dollars	0.00	0.19	57.75

Name	Description	Units	Average Values		
			2006-2009	2010-2013	2014-2017
RFETC	Total ethanol cost of mandate	Million Dollars	630.59	2116.99	3801.60
RFBIOFC	Total biofuel cost of mandate	Million Dollars	644.39	3415.38	4388.68
RFBDRINS	Biodiesel carry out	Million RINs	324.77	172.01	133.55
RFCERINS	Cellulosic ethanol carry out	Million RINs	0.00	0.00	0.00
RFADRINS	Advanced ethanol, carry out	Million RINs	487.16	338.78	380.06
RFTORINS	Total biofuel carry out	Million RINs	1754.37	2368.27	1638.80
RFOAROLO	Other advanced carry out	Million RINs	0.00	80.77	179.74
RFCNROLO	Conventional ethanol carryout	Million RINs	1556.89	2029.49	1258.74
ETSSUGCL	Domestic sugar ethanol production, calendar year	Million gallons	0.00	3.75	1.75
RFBDROLO	Biodiesel carry out rate	Proportion	0.60	0.14	0.10
RFCEROLO	Cellulosic carry out rate	Proportion	0.00	0.00	0.00
RFADROLO	Advanced biofuel carry out rate	Proportion	0.66	0.15	0.12
RFTOROLO	Total biofuel carry out rate	Proportion	0.17	0.16	0.09
ETPBZAMA	Anhydrous ethanol price, Brazil	$/gallon	1.70	2.58	2.09
MTDISCL	MTBE disappearance, calendar year	Million Gallons	139.90	4.00	-37.42
HFYLDWM	HFCS yield, wet mill	Pounds/Bushel	34.77	35.55	35.91
HFSPRDOS	HFCS production, Marketing year.	Thousand Tons	8949.91	8999.25	9120.77
HFDDOMOS	HFCS domestic deliveries, Marketing year.	Thousand Tons	8255.57	7463.76	7443.78
HFDEXNOS	HFCS net exports, Marketing year.	Thousand Tons	694.35	1535.49	1676.99
HFDEXMOS	HFCS exports to Mexico, marketing year	Thousand Tons	533.39	1268.03	1342.97
HFSPRDCL	HFCS production, calendar year	Thousand Tons	9014.59	9068.11	9133.48
HFDDOM	HFCS domestic use, calendar year	Thousand Tons	8485.01	7559.49	7451.10
HFDEXN	HFCS net exports, calendar year	Thousand Tons	529.58	1508.62	1682.39
HFPRMW	HFCS-42 price, Midwest, marketing year	Cents/Pound	23.22	23.88	22.13
HFP55MW	HFCS-55 price, Midwest, marketing year	Cents/Pound	28.63	34.61	32.02
HFTRND	HFCS consumption trend	Units	14.75	12.75	10.75
DGYLDDM	DDG yield, dry mill	Pounds/Bushel	17.03	16.61	16.27

Name	Description	Units	Average Values		
			2006-2009	2010-2013	2014-2017
DGSPRD	Distillers grains production	Thousand Tons	25032.18	36200.00	37577.03
BGSPRD	Brewers grain production	Thousand Tons	1163.18	1094.17	1087.33
DGDEXN	DDG/Brewers net exports	Thousand Tons	4947.38	8618.59	29151.83
DGPMKT	DDG price, marketing year	$/ton	128.23	214.67	9512.52
DGPMKTCL	DDG price, calendar year	$/ton	122.48	203.93	156.77
DGDEXP	DDG (only) exports	Thousand Tons	4250.95	7922.17	8816.10
DGMAXCBE	Beef: corn technical maximum displacement	Proportion	0.95	0.95	0.95
DGMAXCPK	Pork: corn technical maximum displacement	Proportion	0.93	0.93	0.93
DGMAXCBR	Poultry: corn technical maximum displacement	Proportion	0.85	0.85	0.85
DGMAXCDY	Dairy: corn technical maximum displacement	Proportion	0.99	1.00	1.00
DGMINCBE	Beef: corn technical minimum displacement	Proportion	0.83	0.83	0.83
DGMINCPK	Pork: corn technical minimum displacement	Proportion	0.75	0.75	0.75
DGMINCBR	Poultry: corn technical minimum displacement	Proportion	0.40	0.40	0.40
DGMINCDY	Dairy: corn technical minimum displacement	Proportion	0.40	0.40	0.40
DGDCOBE	Beef: corn average displacement	Proportion	0.88	0.89	0.89
DGDCOPK	Pork: corn average displacement	Proportion	0.81	0.82	0.82
DGDCOBR	Poultry: corn average displacement	Proportion	0.61	0.64	0.64
DGDCODY	Dairy: corn average displacement	Proportion	0.52	0.54	0.54
DGDSMBE	Beef: soymeal average displacement	Proportion	0.12	0.11	0.11
DGDSMPK	Pork: soymeal average displacement	Proportion	0.19	0.18	0.18
DGDSMBR	Poultry: soymeal average displacement	Proportion	0.39	0.36	0.36
DGDSMDY	Dairy: soymeal average displacement	Proportion	0.48	0.46	0.46
DGDCOWT	Weighted average corn displacement	Proportion	0.79	0.78	0.78
DGMIBE	Beef maximum inclusion rate	Proportion	0.42	0.46	0.49
DGMIPK	Pork maximum inclusion rate	Proportion	0.21	0.23	0.25
DGMIBR	Poultry maximum inclusion rate	Proportion	0.21	0.23	0.25
DGMIDY	Dairy maximum inclusion rate	Proportion	0.26	0.28	0.30

Name	Description	Units	Average Values		
			2006-2009	2010-2013	2014-2017
DGVFEBE	Beef DDG feed value	$/ton	152.57	226.47	164.83
DGVFEPK	Pork DDG feed value	$/ton	163.05	239.25	175.97
DGVFEBR	Poultry DDG feed value	$/ton	196.34	277.88	209.57
DGVFEDY	Dairy DDG feed value	$/ton	211.71	297.72	226.94
DGARBE	Beef DDG adoption rate	Proportion	0.63	0.66	0.62
DGARPK	Pork DDG adoption rate	Proportion	0.25	0.44	0.37
DGARBR	Poultry DDG adoption rate	Proportion	0.25	0.50	0.48
DGARDY	Dairy DDG adoption rate	Proportion	0.74	0.90	0.90
DGVEN	Energy value of DDG	$/ton	32.90	44.69	48.61
DGDEN	DDG consumed for energy	Thousand Tons	0.00	0.00	0.00
DGVFZ	Fertilizer value of DDG	$/ton	74.79	87.43	79.59
DGDFZ	DDG consumed for fertilizer	Thousand Tons	0.00	0.00	0.00
DGCONLV	DDG consumed by livestock	Thousand Tons	20781.23	28277.82	28760.93
DGCONBE	DDG consumed by beef	Thousand Tons	13494.07	15168.88	15166.71
DGCONPK	DDG consumed by pork	Thousand Tons	2106.66	4075.94	3832.76
DGCONBR	DDG consumed by poultry	Thousand Tons	2123.31	4892.12	5260.42
DGCONDY	DDG consumed by dairy	Thousand Tons	3057.18	4140.91	4501.03
CLDFED	Corn oil used as feed ration	million pounds		575.93	1656.06
GFYLDWM	Gluten feed yield, wet mill	Pounds/Bushel	11.40	11.40	11.40
GFSPRD	Gluten feed production	Thousand Tons	8230.42	9044.17	8728.09
GFDDOM	Gluten feed domestic use	Thousand Tons	6893.07	7935.80	7677.94
GFDEXN	Gluten net exports	Thousand Tons	1337.35	1108.37	1050.15
GFPR21	Gluten feed price, 21%, marketing year	$/ton	86.37	155.35	113.41
GFPR21CL	Gluten feed price, 21%, calendar year	$/ton	83.70	146.94	115.74
GMYLDWM	Gluten meal yield, wet mill	Pounds/Bushel	3.00	3.00	3.00
GMSPRD	Gluten meal production	Thousand Tons	2165.90	2380.05	2296.87
GMDDOM	Gluten meal domestic use	Thousand Tons	1210.57	1413.62	1230.85

Name	Description	Units	Average Values		
			2006-2009	2010-2013	2014-2017
GMDEXN	Gluten meal net exports	Thousand Tons	955.33	966.42	1066.01
GMPR60	Gluten meal price, 60%, marketing year	$/ton	471.58	575.81	489.17
GMPR60CL	Gluten meal price, 60%, calendar year	$/ton	426.09	552.90	485.56
CLYLDWM	Corn oil yield, wet mill	Pounds/Bushel	1.80	1.76	1.77
CLSPRD	Corn oil production	Million Pounds	2640.22	4027.92	6237.50
CLDDOM	Corn oil domestic use	Million Pounds	1910.47	3061.54	5166.18
CLDFOD	Corn oil, food use	Million Pounds	1762.75	1580.78	1555.12
CLDEXN	Corn oil net exports	Million Pounds	745.50	945.02	1045.07
CLDTES	Corn oil ending stocks	Million Pounds	202.16	198.62	286.59
CLPRCH	Corn oil price, Chicago	Cents/Pound	43.32	50.68	38.42
CLPRCHCL	Corn oil price, Chicago, calendar year	Cents/Pound	40.52	50.63	36.81
FCYLDCL	Corn oil yield on extraction	Pounds/Bushel	0.19	0.49	0.79
FCNRT	Extraction net return, excluding corn	$/gallon	0.08	0.17	0.10
FCSHRCH	Change in share of dry mills extracting	Proportion	0.05	0.16	0.03
FCSHR	Share of dry mills extracting oil	Proportion	0.09	0.55	0.94
FCDCR	Dry-mill corn with corn oil extraction	Million Bushels	284.24	2376.02	4306.04
FCPRDCL	Corn oil produced from extraction	Million Pounds	83.14	1107.83	3308.14
Biodiesel					
DISLS	Highway diesel sales, calendar year	Million Gallons	49360.55	47499.65	50486.65
DISLS1	Projected highway diesel sales, calendar year PROJ	Million Gallons	48159.33	48740.90	51405.60
DIPRT	Retail #2 diesel price, calendar year	$/gallon	2.96	3.68	3.62
DIPRTM	Retail #2 diesel price, marketing year	$/gallon	3.00	3.83	3.63
DIPRS	Diesel, refiner sales price, calendar year	$/gallon	2.22	2.85	2.77
DIPRSM	Diesel, refiner sales price, marketing year	$/gallon	2.24	2.98	2.77
BDPPLT	Biodiesel price, rack, calendar year	$/gallon	3.58	4.42	3.26
BDPPLTM	Biodiesel price, rack, marketing year	$/gallon	3.58	4.43	3.24
BDPREQ	Biodiesel retail price equivalent, calendar year	$/gallon	2.54	2.65	2.80

Name	Description	Units	Average Values		
			2006-2009	2010-2013	2014-2017
RFBDC	Biodiesel cost of mandate	Million Dollars	10.35	1298.39	587.08
RFBDCPG	Biodiesel RIN (D4) price, calendar year	$/gallon	0.03	1.22	0.46
GYPR	Glycerin price, calendar year	$/Pound	0.04	0.06	0.08
BDTAXCR	Biodiesel tax credit, calendar year	$/gallon	1.00	1.00	0.00
BDSYLD	Biodiesel yield,	Pounds/Gallon	7.70	7.70	7.70
BDOTCCL	Biodiesel other operating costs, calendar year	$/gallon	0.54	0.56	0.58
BDNRTCL	Biodiesel net returns, calendar year	$/gallon	0.34	0.28	0.06
BDCAPSO	Biodiesel capacity, marketing year avg.	Million Gallons	1846.31	2475.99	2449.22
BDCUSSO	Biodiesel capacity use-soyoil, calendar year	Proportion	0.19	0.19	0.26
BDSPRD	Biodiesel production, calendar year	Million Gallons	483.54	979.20	1323.16
BDSOPRD	Biodiesel from soyoil, calendar year	Million Gallons	327.99	478.30	635.87
BDOTPRD	Other biodiesel, calendar year (exc. canola)	Million Gallons	140.86	313.93	243.14
SODBIO	Soybean oil for biodiesel, calendar year	Million Pounds	2525.53	3682.89	4896.22
BDDDOMTR	Biodiesel consumption (transport), calendar year	Million Gallons	310.01	870.81	1205.35
BDDDOMTR1	Projected Biodiesel consumption (transport), calendar year	Million Gallons	309.79	985.38	1316.69
BDDDOM	Biodiesel consumption, calendar year	Million Gallons	310.01	901.72	1285.86
BDDEXN	Biodiesel net exports, calendar year	Million Gallons	173.77	24.17	51.20
BDDTESCL	Biodiesel, ending stocks, calendar year	Million Gallons	30.32	72.93	93.15
BDPGER	Biodiesel price, Germany, marketing year	$/gallon	4.33	5.32	3.90
BDTAREU	EU tariff on US, marketing year	$/gallon	0.44	1.00	1.00
BDNRTRO	Canola oil biodiesel net returns, calendar year	$/gallon	-0.39	-0.22	-0.16
BDCAPRO	Canola oil biodiesel capacity, calendar year	Million gallons	27.50	160.75	183.25
BDROPRD	Biodiesel from canola oil, calendar year	Million Gallons	5.74	83.18	65.36
BDCUSRO	Biodiesel capacity use-canola oil, calendar year	Proportion	0.21	0.50	0.36
BDNRTCL	Non-food corn oil net returns, calendar year	$/gallon	0.34	0.75	0.16
CLPNF	Non-food corn oil price, calendar year	$/cwt	35.46	41.19	33.83

Name	Description	Units	Average Values		
			2006-2009	2010-2013	2014-2017
BDCAPCL	Non-food corn oil biodiesel capacity, calendar year	Million gallons	29.85	332.62	1008.26
BDCUSCL	Biodiesel capacity use-non-food corn oil, calendar year	Proportion	0.30	0.25	0.21
BDCLPRD	Biodiesel from non-food corn oil, calendar year	Million Gallons	8.96	69.08	214.56
CLDBIO	Corn oil used for biodiesel, calendar year	Million Pounds	68.96	531.89	1652.08
CLSYLD	Biodiesel yield non-food corn oil, calendar year	Pounds/Gallon	7.70	7.70	7.70
BDRDPRD	Other Renewable Diesel	Million Gallons	0.00	75.88	164.23
Biomass					
ETYLDST	Ethanol yield, stover	Gallons/Dry	71.90	73.34	75.15
CEWAIVE	Cellulosic RFS-2 Waiver 1=waived	Binary variable	1.00	1.00	1.00
ETIMCECL	Ethanol cellulosic Imports, calendar year	Million Gallons	0.00	0.00	0.00
ETYLDWG	Ethanol yield per dry ton, Warm-season Grasses	Gallons/Dry Ton	82.73	83.67	85.48
ETPBPWG	By-product price in producing ethanol, Warm season grasses	$/dry ton in 2012	0.00	0.00	0.00
BPYLDWG	By-product yield in production ethanol, Warm season grasses	Index	1.00	1.00	1.00
ETPSUBWG	Producer (ethanol) subsidy per gallon, Warm season grasses	$/gallon	0.00	0.00	0.00
WGLFCTEK	Trend, Cost (ethanol) per gallon, Warm season grasses	growth rate, 1 as base	3.39	2.80	2.37
ETNGASWG	Natural gas cost (ethanol) per gallon, Warm season grasses	$/gallon	0.00	0.00	0.00
ETCOILWG	Oil cost (ethanol) per gallon, Warm season grasses	$/gallon	0.00	0.00	0.00
ELYLLFWG	Electricity yield (ethanol) per gallon, Warm season grasses	kWh/gallon	1.80	1.80	1.80
WGLFOTC	Other cost (ethanol) per gallon, Warm season grasses	$/gallon	1.18	0.71	0.69
WGLFPPLT	Warm season grasses price for ethanol production at plant	$/dry ton	80.00	100.80	-10.92
ETYLDWS	Ethanol yield per dry ton, Wheat straw	Gallons/Dry Ton	79.65	80.59	82.40

Name	Description	Units	Average Values		
			2006-2009	2010-2013	2014-2017
ETPBPWS	By-product price in producing ethanol, Wheat straw	$/dry ton in 2012	0.00	0.00	0.00
BPYLDWS	By-product yield in production ethanol, Wheat straw	Index	1.00	1.00	1.00
ETPSUBWS	Producer (ethanol) subsidy per gallon, Wheat straw	$/gallon	0.00	0.00	0.00
WSLFCTEK	Trend, Cost (ethanol) per gallon, Wheat straw	Growth rate, 1 as base	3.39	2.80	2.37
ETNGASWS	Natural gas cost (ethanol) per gallon, Wheat straw	$/gallon	0.00	0.00	0.00
ETCOILWS	Oil cost (ethanol) per gallon, Wheat straw	$/gallon	0.00	0.00	0.00
ELYLLFWS	Electricity yield (ethanol) per gallon, Wheat straw	kWh/gallon	1.80	1.80	1.80
WSLFOTC	Other cost (ethanol) per gallon, Wheat straw	$/gallon	1.18	0.71	0.69
WSLFPPLT	Wheat straw price for ethanol production at plant	$/dry ton	80.00	97.84	-10.52
STLFCTEK	Trend, Cost (ethanol) per gallon, Corn stover	growth rate, 1 as base	3.39	2.80	2.37
ETNGASST	Natural gas cost (ethanol) per gallon, Corn stover	$/gallon	0.00	0.00	0.00
ETCOILST	Oil cost (ethanol) per gallon, Corn stover	$/gallon	0.00	0.00	0.00
ELYLLFST	Electricity yield (ethanol) per gallon, Corn stover	kWh/gallon	1.80	1.80	1.80
STLFOTC	Other cost (ethanol) per gallon, Corn stover	$/gallon	1.18	0.71	0.69
STLFPPLT	Corn stover price for ethanol production at plant	$/dry ton	80.00	91.03	-9.59
ETYLDMW	Ethanol yield per dry ton, Muni-waste	gallons/dry ton	89.55	90.49	92.30
ETPBPMW	By-product price in producing ethanol, Muni-waste	$/dry ton in 2012	0.00	0.00	0.00
BPYLDMW	By-product yield in production ethanol, Muni-waste	Index	1.00	1.00	1.00
ETPSUBMW	Producer (ethanol) subsidy per gallon, Muni-waste	$/gallon	0.00	0.00	0.00
MWLFCTEK	Trend, Cost (ethanol) per gallon, Muni-waste	Growth rate, 1 as base	3.39	2.80	2.37

Name	Description	Units	Average Values		
			2006-2009	2010-2013	2014-2017
ETNGASMW	Natural gas cost (ethanol) per gallon, Muni-waste	$/gallon	0.00	0.00	0.00
ETCOILMW	Oil cost (ethanol) per gallon, Muni-waste	$/gallon	0.00	0.00	0.00
ELYLLFMW	Electricity yield (ethanol) per gallon, Muni-waste	kWh/gallon	2.65	2.65	2.65
MWLFPPLT	Municipal Waste price for ethanol production at plant	$/dry ton	80.00	26.99	-108.13
ETYLDFM	Ethanol yield per dry ton, Forest materials	gallons/dry ton	68.40	69.34	71.15
ETPBPFM	By-product price in producing ethanol, Forest materials	$/dry ton in 2012	0.00	0.00	0.00
BPYLDFM	By-product yield in production ethanol, Forest materials	Index	1.00	1.00	1.00
ETPSUBFM	Producer (ethanol) subsidy per gallon, Forest materials	$/gallon	0.00	0.00	0.00
FMLFCTEK	Trend, Cost (ethanol) per gallon, Forest materials	Growth rate, 1 as base	3.39	2.80	2.37
ETNGASFM	Natural gas cost (ethanol) per gallon, Forest materials	$/gallon	0.00	0.00	0.00
ETCOILFM	Oil cost (ethanol) per gallon, Forest materials	$/gallon	0.00	0.00	0.00
ELYLLFFM	Electricity yield (ethanol) per gallon, Forest materials	$/gallon	2.65	2.65	2.65
FMLFOTC	Other cost (ethanol) per gallon, Forest materials	$/gallon	2.12	1.16	1.08
FMLFPPLT	Forest matter price for ethanol production at plant	$/dry ton	80.00	25.39	-83.34
ELYLDWG	Electricity yield per dry ton, Warm season grasses	Btu/dry ton	5538920.57	5586397.03	5713000.93
WGELCTEK	Trend, Cost (electricity) per btu, Warm season grasses	Growth rate, 1 as base	1.00	1.00	1.00
WGELOTC	Other cost (electricity) per btu, Warm season grasses	$/btu	0.00	0.00	0.00
WGELPPLT	Warm season grasses price for electricity production at plant	$/dry ton	80.00	101.36	105.99
ELYLDWS	Electricity yield per dry ton, Wheat straw	Btu/dry ton	5475078.29	5522007.53	5647152.17

Name	Description	Units	Average Values		
			2006-2009	2010-2013	2014-2017
WSELCTEK	Trend, Cost (electricity) per btu, Wheat straw	Growth rate, 1 as base	1.00	1.00	1.00
WSELOTC	Other cost (electricity) per btu, Wheat straw	$/btu	0.00	0.00	0.00
WSELPPLT	Wheat straw price for electricity production at plant	$/dry ton	80.00	102.15	115.89
ELYLDFM	Electricity yield per dry ton, Forest materials	Btu/dry ton	5653053.71	5701508.46	5830721.12
FMELCTEK	Trend, Cost (electricity) per btu, Forest materials	Growth rate, 1 as base	1.00	1.00	1.00
FMELOTC	Other cost (electricity) per btu, Forest materials	$/btu	0.00	0.00	0.00
FMELPPLT	Forest materials price for electricity production at plant	$/dry ton	80.00	104.82	119.66
ELYLDST	Electricity yield per dry ton, Corn stover	Btu/dry ton	5215192.00	5259893.65	5379098.03
STELCTEK	Trend, Cost (electricity) per btu, Corn stover	Growth rate, 1 as base	1.00	1.00	1.00
STELOTC	Other cost (electricity) per btu, Corn stover	$/btu	0.00	0.00	0.00
STELPPLT	Corn stover price for electricity production at plant	$/dry ton	80.00	98.25	110.39
ELYLDMW	Electricity yield per dry ton, Muni-waste	Btu/dry ton	5569637.14	5617376.89	5744682.88
MWELCTEK	Trend, Cost (electricity) per btu, Muni-waste	Growth rate, 1 as base	1.00	1.00	1.00
MWELOTC	Other cost (electricity) per btu, Muni-waste	$/btu	0.00	0.00	0.00
MWELPPLT	Muni-waste price for electricity production at plant	$/dry ton	80.00	103.57	117.89
WGELCVTR	Trend, Transportation Cost (electricity), Warm season grasses	$/dry ton	1.00	1.00	1.00
WSELCVTR	Trend, Transportation Cost (electricity), Wheat straw	$/dry ton	1.00	1.00	1.00
FMELCVTR	Trend, Transportation Cost (electricity), Forest materials	$/dry ton	1.00	1.00	1.00
STELCVTR	Trend, Transportation Cost (electricity), Corn stover	$/dry ton	1.00	1.00	1.00
MWELCVTR	Trend, Transportation Cost (electricity), Muni-waste	$/dry ton	1.00	1.00	1.00
WGLFCVTR	Trend, Transportation Cost (liquid fuels), Warm season grasses	$/dry ton	1.00	1.00	1.00

Name	Description	Units	Average Values		
			2006-2009	2010-2013	2014-2017
WSLFCVTR	Trend, Transportation Cost (liquid fuels), Wheat straw	$/dry ton	1.00	1.00	1.00
FMLFCVTR	Trend, Transportation Cost (liquid fuels), Forest materials	$/dry ton	1.00	1.00	1.00
STLFCVTR	Trend, Transportation Cost (liquid fuels), Corn stover	$/dry ton	1.00	1.00	1.00
MWLFCVTR	Trend, Transportation Cost (liquid fuels), Muni-waste	$/dry ton	1.00	1.00	1.00
WGELCR	Warm season grasses, electricity corn area effects	Competition Parameter.	-0.05	-0.05	-0.05
WGELSB	Warm season grasses, electricity soybean area effects	Competition Parameter.	-0.05	-0.05	-0.05
WGELWH	Warm season grasses, electricity wheat area effects	Competition Parameter.	-0.10	-0.10	-0.10
WGLFQ	Warm season grasses Electricity effects from liquid fuels use	Competition Parameter.	0.25	0.25	0.25
WGELSPRD	Warm season grasses production for Electricity production	Million Dry Tons	0.00	0.63	1.03
WSELCR	Wheat straw, electricity corn area effects	Competition Parameter	0.00	0.00	0.00
WSLFQ	Wheat straw electricity effects from liquid fuels use	Competition Parameter	0.25	0.25	0.25
WSELSPRD	Wheat straw production for Electricity production	Million Dry Tons	0.00	0.06	0.00
FMELCR	Forest materials, electricity corn area effects	Competition Parameter	-0.01	-0.01	-0.01
FMELSB	Forest materials, electricity soybean area effects	Competition Parameter	-0.01	-0.01	-0.01
FMELWH	Forest materials, electricity wheat area effects	Competition Parameter	-0.01	-0.01	-0.01
FMLFQ	Forest materials electricity effects from liquid fuels use	Competition Parameter	0.25	0.25	0.25
FMELSPRD	Forest materials production for Electricity production	Million Dry Tons	0.00	23.47	29.84
STELCR	Corn stover, electricity corn area effects	Competition Parameter	1.00	1.00	1.00
STLFQ	Corn stover electricity effects from liquid fuels use	Competition Parameter	0.25	0.25	0.25

Name	Description	Units	Average Values		
			2006-2009	2010-2013	2014-2017
STELSPRD	Corn stover production for electricity production	Million Dry Tons	0.00	0.78	2.81
MWELCR	Muni-waste, electricity corn area effects	Competition Parameter	0.00	0.00	0.00
MWLFQ	Muni-waste electricity effects from liquid fuels use	Competition Parameter	0.25	0.25	0.25
MWELSPRD	Muni-waste production for electricity production	Million Dry Tons	0.00	10.98	9.72
WGLFCR	Warm season grasses, liquid fuels corn area effects	Competition Parameter	-0.05	-0.05	-0.05
WGLFSB	Warm season grasses, liquid fuels soybean area effects	Competition Parameter	-0.05	-0.05	-0.05
WGLFWH	Warm season grasses, liquid fuels wheat area effects	Competition Parameter	-0.10	-0.10	-0.10
WGELQ	Warm season grasses Liquid fuels effects from electricity use	Competition Parameter	0.25	0.25	0.25
WGLFSPRD	Warm season grasses production for liquid fuels production	Million Dry Tons	0.00	0.01	0.10
WSLFCR	Wheat straw, liquid fuels corn area effects	Competition Parameter	0.00	0.00	0.00
WSELQ	Wheat straw liquid fuels effects from electricity use	Competition Parameter	0.25	0.25	0.25
WSLFSPRD	Wheat straw production for liquid fuels production	Million Dry Tons	0.00	0.01	0.00
FMLFCR	Forest materials, liquid fuels corn area effects	Competition Parameter	-0.01	-0.01	-0.01
FMLFSB	Forest materials, liquid fuels soybean area effects	Competition Parameter	-0.01	-0.01	-0.01
FMLFWH	Forest materials, liquid fuels wheat area effects	Competition Parameter	-0.01	-0.01	-0.01
FMELQ	Forest materials liquid fuels effects from electricity use	Competition Parameter	0.25	0.25	0.25
FMLFSPRD	Forest materials production for liquid fuels production	Million Dry Tons	0.00	0.04	0.27
STLFCR	Corn stover, liquid fuels corn area effects	Competition Parameter	1.00	1.00	1.00
STELQ	Corn stover liquid fuels effects from electricity use	Competition Parameter	0.25	0.25	0.25

Name	Description	Units	Average Values		
			2006-2009	2010-2013	2014-2017
STLFSPRD	Corn stover production for liquid fuels production	Million Dry Tons	0.00	0.03	0.31
MWELQ	Muni-waste liquid fuels effects from electricity use	Competition Parameter	0.25	0.25	0.25
MWLFSPRD	Muni-waste production for liquid fuels production	Million Dry Tons	0.00	0.02	0.22
LFSPRDWG	Liquid fuel production from Warm season grasses	Million Gallons	0.00	0.00	8.26
LFSPRDWS	Liquid fuel production from Wheat straw	Million Gallons	0.00	0.00	0.00
LFSPRDFM	Liquid fuel production from Forest materials.	Million Gallons	0.00	0.26	19.46
LFSPRDST	Liquid fuel production from Corn stover	Million Gallons	0.00	0.00	23.68
LFSPRDMW	Liquid fuel production from Muni-waste	Million Gallons	0.00	0.11	20.36
LFSPRDBM	Liquid fuel production from all Biomass	Million Gallons	0.00	0.38	71.76
CDRFSBD	Cellulosic diesel toward biodiesel RFS	Million Gallons	0.00	0.00	0.00
LFSPRDCD	Cellulosic Diesel fuel production	Million gallons	0.00	0.09	14.48
CDSHRBD	Share of cellulosic diesel toward biodiesel RFS	Proportion	0.00	0.00	0.00
ELSPRDWG	Electricity production from Warm season grasses	Million btus	1.17	3.55	5.88
ELSPRDWS	Electricity production from Wheat straw	Million btus	1.17	0.32	0.00
ELSPRDFM	Electricity production from Forest materials.	Million btus	128.91	133.85	174.09
ELSPRDST	Electricity production from Corn stover	Million btus	1.17	4.12	15.15
ELSPRDMW	Electricity production from Muni-waste	Million btus	55.04	61.66	55.83
ELSPRDBM	Electricity production from all Biomass	Million btus	187.46	203.53	251.51
WGLFPTEK	Trend, Production Cost (liquid fuels), Warm season grasses	Growth rate, 1 as base	0.09	0.11	0.13
WSLFPTEK	Trend, Production Cost (liquid fuels), Wheat straw	Growth rate, 1 as base	0.09	0.11	0.13
FMLFPTEK	Trend, Production Cost (liquid fuels), Forest materials	Growth rate, 1 as base	0.09	0.11	0.13
STLFPTEK	Trend, Production Cost (liquid fuels), Corn stover	Growth rate, 1 as base	0.09	0.11	0.13

Name	Description	Units	Average Values		
			2006-2009	2010-2013	2014-2017
MWLFPTEK	Trend, Production Cost (liquid fuels), Muni-waste	Growth rate, 1 as base	0.09	0.11	0.13
WGELPTEK	Trend, Production Cost (electricity), Warm season grasses	Growth rate, 1 as base	0.09	0.11	0.13
WSELPTEK	Trend, Production Cost (electricity), Wheat straw	Growth rate, 1 as base	0.09	0.11	0.13
FMELPTEK	Trend, Production Cost (electricity), Forest materials	Growth rate, 1 as base	0.09	0.11	0.13
STELPTEK	Trend, Production Cost (electricity), Corn stover	Growth rate, 1 as base	0.09	0.11	0.13
MWELPTEK	Trend, Production Cost (electricity), Muni-waste	Growth rate, 1 as base	0.09	0.11	0.13
ELRINDEX	Renewable electricity price index	Index	1.00	15.09	20.52
WGELTVC	Non-Petrol transport costs for (electricity), Warm season grasses	$/ton	25.34	27.13	29.01
WSELTVC	Non-Petrol transport costs for (electricity), Wheat straw	$/ton	25.34	27.13	29.01
FMELTVC	Non-Petrol transport costs for (electricity), Forest materials	$/ton	25.34	27.13	29.01
STELTVC	Non-Petrol transport costs for (electricity), Corn stover	$/ton	25.34	27.13	29.01
MWELTVC	Non-Petrol transport costs for (electricity), Muni-waste	$/ton	25.34	27.13	29.01
WGLFTVC	Non-Petrol transport costs for (liquid fuels), Warm season grasses	$/ton	25.34	27.13	29.01
WSLFTVC	Non-Petrol transport costs for (liquid fuels), Wheat straw	$/ton	25.34	27.13	29.01
FMLFTVC	Non-Petrol transport costs for (liquid fuels), Forest materials	$/ton	25.34	27.13	29.01
STLFTVC	Non-Petrol transport costs for (liquid fuels), Corn stover	$/ton	25.34	27.13	29.01
MWLFTVC	Non-Petrol transport costs for (liquid fuels), Muni-waste	$/ton	25.34	27.13	29.01
ENELPIND	Industrial electricity price	$/MMBtu	19.21	19.61	20.52
WGSPLT	Warm season grasses area planted	Million Acres	0.00	0.11	0.20

Name	Description	Units	Average Values		
			2006-2009	2010-2013	2014-2017
STNRPTON	Net return per-ton Corn stover, required 'hassle factor'	$/ton	10.00	10.38	11.13
WSNRPTON	Net return per-ton Wheat straw, required 'hassle factor'	$/ton	10.00	10.38	11.13
WGSYLD	Warm season grasses yield per acre	Tons/Acre	4.82	5.32	5.87
WGSHAR	Warm season grasses area harvested	Million Acres	0.00	0.11	0.19
LFCCAPWG	Warm season grasses to liquid fuels processing cost of capital	$/gallon	1.49	1.11	0.96
LFCCAPWS	Wheat straw to liquid fuels processing cost of capital	$/gallon	1.49	1.11	0.96
LFCCAPFM	Forest material to liquid fuels processing cost of capital	$/gallon	1.57	1.11	1.13
LFCCAPST	Corn stover to liquid fuels processing cost of capital	$/gallon	1.49	1.11	0.96
LFCCAPMW	Muni-waste to liquid fuels processing cost of capital	$/gallon	1.57	1.11	1.13
ELCCAPWG	Warm season grasses to EL processing cost of capital	$/btu	0.00	0.00	0.00
ELCCAPWS	Wheat straw to electricity processing cost of capital	$/btu	0.00	0.00	0.00
ELCCAPFM	Forest material to electricity processing cost of capital	$/btu	0.00	0.00	0.00
ELCCAPST	Corn stover to electricity processing cost of capital	$/btu	0.00	0.00	0.00
ELCCAPMW	Muni-waste to electricity processing cost of capital	$/btu	0.00	0.00	0.00
PDC2022	2022 Year base price deflator	Index	0.79	0.84	0.90
PSUBELWG	Producer subsidy for Warm season grasses going into electricity production	$/dry ton	0.00	0.00	0.00
PSUBELWS	Producer subsidy for Wheat straw going into electricity production	$/dry ton	0.00	0.00	0.00
PSUBELFM	Producer subsidy for Forest material going into electricity production	$/dry ton	0.00	0.00	0.00
PSUBELST	Producer subsidy for Corn stover going into electricity production	$/dry ton	0.00	0.00	0.00

Name	Description	Units	Average Values		
			2006-2009	2010-2013	2014-2017
PSUBELMW	Producer subsidy for Muni-waste going into electricity production	$/dry ton	0.00	0.00	0.00
PSUBLFWG	Producer subsidy for Warm season grasses going into liquid fuels production	$/dry ton	0.00	0.00	0.00
PSUBLFWS	Producer subsidy for Wheat straw going into liquid fuels production	$/dry ton	0.00	0.00	0.00
PSUBLFFM	Producer subsidy for Forest material going into liquid fuels production	$/dry ton	0.00	0.00	0.00
PSUBLFST	Producer subsidy for Corn stover going into liquid fuels production	$/dry ton	0.00	0.00	0.00
PSUBLFMW	Producer subsidy for Muni-waste going into liquid fuels production	$/dry ton	0.00	0.00	0.00
ESUBELWG	Establishment subsidy for Warm season grasses going into electricity production	$/dry ton	2.58	0.00	0.00
ESUBELWS	Establishment subsidy for Wheat straw going into electricity production	$/dry ton	0.00	0.00	0.00
ESUBELFM	Establishment subsidy for Forest material going into electricity production	$/dry ton	10.54	0.00	0.00
ESUBELST	Establishment subsidy for Corn stover going into electricity production	$/dry ton	0.00	0.00	0.00
ESUBELMW	Establishment subsidy for Muni-waste going into electricity production	$/dry ton	0.00	0.00	0.00
ESUBLFWG	Establishment subsidy for Warm season grasses going into liquid fuels production	$/dry ton	2.93	0.00	0.00
ESUBLFWS	Establishment subsidy for Wheat straw going into liquid fuels production	$/dry ton	0.00	0.00	0.00
ESUBLFFM	Establishment subsidy for Forest material going into liquid fuels production	$/dry ton	12.00	0.00	0.00
ESUBLFST	Establishment subsidy for Corn stover going into liquid fuels production	$/dry ton	0.00	0.00	0.00
ESUBLFMW	Establishment subsidy for Muni-waste going into liquid fuels production	$/dry ton	0.00	0.00	0.00
WGELTRAN	Transportation Cost (electricity), Warm season grasses	$/dry ton	58.43	58.71	59.68
WSELTRAN	Transportation Cost (electricity), Wheat straw	$/dry ton	64.33	64.61	65.16

Name	Description	Units	Average Values		
			2006-2009	2010-2013	2014-2017
FMELTRAN	Transportation Cost (electricity), Forest materials	$/dry ton	38.43	38.71	39.68
STELTRAN	Transportation Cost (electricity), Corn stover	$/dry ton	64.33	64.61	65.16
MWELTRAN	Transportation Cost (electricity), Muni-waste	$/dry ton	38.43	38.71	39.68
WGLFTRAN	Transportation Cost (liquid fuels), Warm season grasses	$/dry ton	38.43	38.71	39.68
WSLFTRAN	Transportation Cost (liquid fuels), Wheat straw	$/dry ton	44.33	44.61	45.16
FMLFTRAN	Transportation Cost (liquid fuels), Forest materials	$/dry ton	38.43	38.71	39.68
STLFTRAN	Transportation Cost (liquid fuels), Corn stover	$/dry ton	44.33	44.61	45.16
MWLFTRAN	Transportation Cost (liquid fuels), Muni-waste	$/dry ton	58.43	58.71	59.68
WGELPFRM	Warm season grasses farm price for ethanol production	$/dry ton	43.09	48.03	46.30
WSELPFRM	Wheat straw farm price for ethanol production	$/dry ton	36.02	42.63	50.72
FMELPFRM	Forest materials farm price for ethanol production	$/dry ton	65.19	72.01	79.97
STELPFRM	Corn stover farm price for ethanol production	$/dry ton	31.26	37.54	45.22
MWELPFRM	Muni-waste farm price for ethanol production	$/dry ton	63.66	70.38	78.20
WGLFPFRM	Warm season grasses farm price for liquid fuels production	$/dry ton	37.88	61.17	0.00
WSLFPFRM	Wheat straw farm price for liquid fuels production	$/dry ton	29.14	51.60	0.00
FMLFPFRM	Forest materials farm price for liquid fuels production	$/dry ton	0.00	0.26	0.00
STLFPFRM	Corn stover farm price for liquid fuels production	$/dry ton	23.38	43.35	0.00
MWLFPFRM	Muni-waste farm price for liquid fuels production	$/dry ton	-20.00	-16.72	-20.00
WGELINT	Calibration intercept	Parameter	-100.00	-100.00	-100.00
WSELINT	Calibration intercept	Parameter	-100.00	-100.00	-100.00
FMELINT	Calibration intercept	Parameter	-100.00	-100.00	-100.00
STELINT	Calibration intercept	Parameter	-100.00	-100.00	-100.00

Name	Description	Units	Average Values		
			2006-2009	2010-2013	2014-2017
MWELINT	Calibration intercept	Parameter	-100.00	-100.00	-100.00
WGLFINT	Calibration intercept	Parameter	-100.00	-100.00	-100.00
WSLFINT	Calibration intercept	Parameter	-100.00	-100.00	-100.00
FMLFINT	Calibration intercept	Parameter	-100.00	-100.00	-100.00
STLFINT	Calibration intercept	Parameter	-100.00	-100.00	-100.00
MWLFINT	Calibration intercept	Parameter	-100.00	-100.00	-100.00
ELFMSADJ	Electricity production Forest materials calibration adjustment	Trillion btu	0.00	131.31	131.31
WGNRPTON	Net return per-ton Warm season grasses, required 'hassle factor'	$/ton	10.00	10.38	11.13
FIRWS	Farm Receipts, Wheat straw	Billion Dollars	0.00	0.00	0.00
FIRWG	Farm Receipts, Warm season grasses	Billion Dollars	0.00	0.02	0.05
FIRST	Farm Receipts, Corn stover	Billion Dollars	0.00	0.02	0.13
FIPXWS	Farm costs, Wheat straw	Billion Dollars	0.00	0.00	0.00
FIPXWG	Farm costs, Warm season grasses	Billion Dollars	0.00	0.02	0.04
FIPXST	Farm costs, Corn stover	Billion Dollars	0.00	0.02	0.10
FIPXBIO	Farm costs, Cellulosic biomass	Billion Dollars	0.00	0.04	0.13
ELSTSADJ	Electricity production Corn stover calibration adjustment	Trillion btu	0.00	0.00	0.00
ELWSSADJ	Electricity production Wheat straw calibration adjustment	Trillion btu	0.00	0.00	0.00
ELWGSADJ	Electricity production warm season grasses calibration adjustment	Trillion btu	0.00	0.00	0.00
ELSPRCWG	Electricity production as liquid fuel co-product, warm season grasses	Million btus	0.00	0.01	0.05
ELSPRCWS	Electricity production as liquid fuel co-product, Wheat straw	Million btus	0.00	0.01	0.00
ELSPRCFM	Electricity production as liquid fuel co-product, forest material	Million btus	0.00	0.03	0.18
ELSPRCST	Electricity production as liquid fuel co-product, Corn stover	Million btus	0.00	0.01	0.15

Name	Description	Units		Average Values	
			2006-2009	2010-2013	2014-2017
ELSPRCMW	Electricity production as liquid fuel co-product, municipal waste	Million btus	0.00	0.02	0.18
ENELSSBB_RATE	Federal grant rate as percent of costs	Proportion	0.00	0.00	0.00
ENELSSBF_UNIT	Tax credit for renewable energy	$/watt	0.00	0.00	0.00
ENELPMAN_BM	Compliance cost of federal Renewable Portfolio Standard	Index	0.00	0.00	0.00
ETE10INI	Low blend indicator	Proportion	0.88	0.99	1.00
WGLFMIN	Warm season grasses for liquid fuels, minimum	Million Dry Tons	0.00	0.00	0.10
STLFMIN	Corn stover for liquid fuels, minimum	Million Dry Tons	0.00	0.00	0.31
WSLFMIN	Wheat straw for liquid fuels, minimum	Million Dry Tons	0.00	0.00	0.00
FMLFMIN	Forest material for liquid fuels, minimum	Million Dry Tons	0.00	0.00	0.27
MWLFMIN	Municipal waste for liquid fuels, minimum	Million Dry Tons	0.00	0.00	0.22
WSLFMAX	Wheat straw for liquid fuels, maximum	Million Dry Tons	0.00	0.00	0.00
FMLFMAX	Forest material for liquid fuels, maximum	Million Dry Tons	0.00	0.26	19.46
MWLFMAX	Municipal waste for liquid fuels, maximum	Million Dry Tons	0.00	0.11	20.36
CRPRFMCL	Corn farm price, calendar year	$/bushel	3.55	5.67	4.17
WHPFRMCL	Wheat farm price, calendar year	$/bushel	5.78	6.90	5.59
SOPMKTCL	Soybean oil price, calendar year	$/cwt	35.46	47.26	35.14
ROPMKTCL	Rape oil price, calendar year	$/cwt	44.97	53.81	38.00
LFSPRDWGCL	Liquid fuel production from Warm season grasses	Million gallons	0.00	0.00	5.32
LFSPRDWSCL	Liquid fuel production from Wheat straw	Million gallons	0.00	0.00	0.00
LFSPRDFMCL	Liquid fuel production from Forest materials.	Million gallons	0.00	0.09	14.48
LFSPRDSTCL	Liquid fuel production from Corn stover	Million gallons	0.00	0.00	16.91
LFSPRDMWCl	Liquid fuel production from Muni-waste	Million gallons	0.00	0.04	14.85
LFSPRDBMCL	Liquid fuel production from all Biomass	Million gallons	0.00	0.13	51.56

Model equations

Price linkages

Crude oil price - Refiners acquisition

POILRAP = -2
+0.95*POILWTI

Producer Price Index – Refined Petroleum Products

PPIRPP= 0.1
+0.003*PDCGNP
+0.023*POILRAP

Unleaded gasoline price, Omaha (Sep-Aug)

UGPFBSA = UGPFBCL/3
+ UGPFBCL1*2/3

Regular unleaded gasoline retail price (calendar year)

UGPRTCL = 0.47
+UGPFBCL
+RFETC/MGSTOTCL
+0.001*PDCGNP

Regular unleaded gasoline retail price (Sep-Aug)

UGPRTSA = UGPRTCL/3
+ UGPRTCL1*2/3

Ethanol price, FOB Omaha (Sep-Aug)

ETPFBSA = ETPFBCL/3
+ETPFBCL1*2/3

#2 diesel, refiner sales price, (Oct-Sep)

DIPRSM = DIPRS/4
+DIPRS1*3/4

#2 diesel retail price, calendar year

DIPRT = 0.6
+DIPRS
+RFBDC/DISLS
+0.001*PDCGNP

#2 diesel retail price, Oct-Sep

DIPRTM = DIPRT/4
+DIPRT1*3/4

Rack equivalent retail ethanol price

ETPRTRCL = ETPRTCL
-(UGPRTCL-UGPFBCL)

Motor fuel use

Motor gasoline supplied, per capita (calendar year)

MGSTOTCL = 90
+0.75*lag(MGSTOTCL)/lag(POPTOTW)
-2000*UGPRTCL/PDCGNP
-1500*lag(UGPRTCL)/(lagPDCGNP)
-140*ETPRTCL/PDCGNP
-105*lag(ETPRTCL)/(lag(PDCGNP)
+50*log(ZCE92W/POPTOTW)
-2.5*(ZTIME-1980)

Motor gasoline supplied (Sep-Aug)

MGSTOTSA = MGSTOTCL/3
+ MGSTOTCL1*2/3

Diesel sales, per capita (calendar year)

DISLS = -50
-800*DIPRT/PDCGNP
+60*ln(ZCE92W/POPTOTW)

Projected gasoline use

Ln(MGSTOTPRJ) = 2.919764559
+0.752594433*ln(LAG(MGSTOTCL))
-0.0277665*ln(POILRAP)
+0.004098233*Trend

Projected diesel sales

Ln(DISLSPROJ) = 1.337706134
+0.879644118*ln(DISLS(t-1)
-0.019329035*lnPOILRAP
+0.000768147*Trend

Projected ethanol disappearance

ETDISCLPROJ = 1400
+0.098*MGSTOTCL1)

Projected biodiesel sales

BDDDOMTRPROJ = 2000
-750*BDPREQ/DIPRS

Ethanol use

Additive use of ethanol

ETDADCL = 100
-100*(ETPRTCL)/PPIRPP
+MGSTOTCL*ETADD*(1-ETDE85CL/MGSTOTCL/.74)
-0.9*MTDISCL

Potential maximum conventional blend (SET TO 10%)

ETIBCAP = 0.1

E-15 pump penetration (set to 0.7 in 2011)
ETE15PROP (2012-forward) = lag(ETE15PROP) +0.2/7

Potential E-15 market
ETME15CL = Max(0.95*lag(ETME15CL),
(1500
+0.15*lag(ETME15CL)
+1000*max(0,0.7-ETPRTCL/UGPRTCL)
+2000*max(0,0.67-lag(ETPRTCL/UGPRTCL)))*ETE15PROP*(1 - ETDET85CL/MGSTOTCL /0.74))

Share of E-15 potential market
ETE15PEN =Max(0, MIN(0.95,
(0.005
+0.65*Lag(ETE15PEN)
-0.2*ETPRTCL/UGPRTCL
+max(0,0.7-ETPRTCL/UGPRTCL)
+max(0,0.67-lag(ETPRTCL/UGPRTCL))/3)))

E-15 use of ethanol
ETDE15CL= ETME15CL*ETE15PEN

Potential E10 market
ETME10CL =0.98*(MGSTOTCL*(ETIBCAP-ETADD)*(1-ETDE85CL/MGSTOTCL/.74
- ETDE15SA/MGSTOTSA/0.15))

Voluntary E10 share of potential market
ETE10PEN = 2.8
-2*ETPRTCL/UGPRTCL
+6*max(0,ETE10INI-ETPRTCL/UGPRTCL)
+3*max(0,ETE10INI-lag(ETPRTCL/UGPRTCL))

E-10 use of ethanol
ETDE10CL ETME10CL*ETE10PEN

Potential E-85 market

```
ETME85CL = MAX(0.95*LAG(ETME85CL),
                    (0.15*Lag(ETME85CL)
                    + 3*(ZTIME - 1980)
                    + 2000*max(0,0.67-ETPRTCL/UGPRTCL)
                    + 4000*max(0,0.67-(lag2(ETPRTCL/UGPRTCL)
                                        + lag(ETPRTCL/UGPRTCL)
                                        + (ETPRTCL/UGPRTCL))/3)
                    + 4000*max(0,0.64-ETPRTCL/UGPRTCL)
                    + 6000*max(0,0.64-(lag2(ETPRTCL/UGPRTCL)
                                        + lag(ETPRTCL/UGPRTCL)
                                        + (ETPRTCL/UGPRTCL))/3)
                     + 8000*max(0,0.61-ETPRTCL/UGPRTCL)))
```

E-85 share of potential market

```
Ln(ETE85PEN/(1- ETE85PEN) =   0.05
                              -2*ETPRTCL/UGPRTCL
                              +25*max(0,0.67-ETPRTCL/UGPRTCL)
```

E-85 use of ethanol

```
ETDE85CL=       ETME85CL*ETE85PEN
```

Total ethanol use

```
ETDISCL=        ETDADCL
                +ETDE10CL
                +ETD15CL
                +ETDE85CL
```

Ethanol net imports, Sep-Aug

```
ETSIMNSA =      ETSIMNCL)/3
                + ETSIMNCL1*2/3
```

Ethanol exports Sep-Aug

ETDEXPSA = ETDEXPCL)/3
+ ETDEXPCL1*2/3

Ethanol ending stocks (calendar year)

ETDTESCL = -15
+0.9*lag(ETDTESCL)
+0.007*ETSPRDCL

Conventional ethanol production

Gluten feed price, 21%, calendar year

GFPR21CL = lag(GFPR21)*3/4
+ GFPR21/4

Gluten meal price, 60%, calendar year

GMPR60CL = lag(GMPR60)*3/4
+ GMPR60/4

Corn oil price, calendar year

CLPRCHCL = lag(CLPRCH)*3/4
+ CLPRCH/4

Corn farm price, calendar year

CRPFRMCL = lag(CRPFRM)*2/3
+ CRPFRM/3

Sorghum farm price, calendar year

SGPFRMCL = lag(SGPFRM)*2/3
+ SGPFRM/3

Wheat farm price, calendar year

WHPFRMCL = lag(WHPFRM)*2/3
+ WHPFRM/3

Corn dry mill net operating margin/bushel, calendar year

CRNRBDM = ETPFBCL*ETYLDDM
+DGPMKT*DGYLDDM/2000
+FCSHR * FCNRT*ETYLDDM
-CRPFRMCL
-0.00095*PPIGASW*ETYLDDM
-CROTCDM*ETYLDDM

Other dry mill operating costs

CROTCDM= CROTCDM(t-1)*AVERAGE(PDCGNP/PDCGNP(t-1),1)

Dry mill ethanol capacity, calendar year

ETCAPDM = MAX(
+ 1*lag(ETCAPDM)
- 0.01*lag10(ETCAPDM)
+ 13500*(CRNRBDM-CRNCC)/PDCGNP
+ 31500*lag((CRNRBDM-CRNCC)/PDCGNP)
+ 67500*lag2((CRNRBDM-CRNCC)/PDCGNP)
+ 40500*lag3((CRNRBDM-CRNCC)/PDCGNP)
+ 13500*lag4((CRNRBDM-CRNCC)/PDCGNP) ,
(1*lag(ETCAPDM)- 0.01*lag10(ETCAPDM)))

Dry mill capacity utilization rate

Ln(ETCUSDM/(1- ETCUSDM)) = 400*CRNRBDM/PDCGNP

Corn dry milled for ethanol, calendar year

CRDGDM =ETCUSDM*ETCAPDM/ETYLDDM

Wet mill ethanol net operating margin/bu., calendar year

```
CRNRBWM =     ETPFBCL*ETYLDWM
              +GFPR21CL*GFYLDWM/2000
              +GMPR60CL*GMYLDWM/2000
              +CLPRCHCL*CLYLDWM/100
              -CRPFRMCL
              -0.00075*(PPIGASW)*ETYLDWM
              -CROTCWM*ETYLDWM
```

Other wet mill operating costs

```
CROTCWM       CROTCWM*AVERAGE(PDCGNP/PDCGNP(t-1),1)
```

Wet mill ethanol capacity

```
ETCAPWM = max(
      1*lag(ETCAPWM)
      - 0.02*lag10(ETCAPWM)
      + 1350*(CRNRBWM-CRNCC)/PDCGNP
      + 3150*lag((CRNRBWM-CRNCC)/PDCGNP)
      + 4500*lag2((CRNRBWM-CRNCC)/PDCGNP)
      + 3000*lag3((CRNRBWM-CRNCC)/PDCGNP),
(1*lag(ETCAPWM)  - 0.02*lag10(ETCAPWM))      )
```

Wet mill capacity utilization rate

```
Ln(ETCUSWM/(1- ETCUSWM)) =     0.5
                               +400*CRNRBWM/PDCGNP
                               -20*CRGMWH/PDCGNP
```

Corn wet milled for ethanol, calendar year

```
CRDGWM =ETCUSWM*ETCAPWM/ETYLDWM
```

Corn used for ethanol, calendar year

```
CRDGASCL =     CRDGDM+CRDGWM
```

Corn used for ethanol, Sep-Aug

CRDGAS = CRDGASCL/3
+ CRDGASCL1*2/3

Corn used for other wet mill products, calendar year

CRDOWMCL = LAG(CRDHFC+CRDGLD+CRDSTR)*2/3
+ (CRDHFC+CRDGLD+CRDSTR)/3

Ethanol from non-corn sources, calendar year

ETSPNCCL = -130
+0.6*LAG(ETSPNCCL)
+5000*(ETCADNV*ETPADCL+(1-ETCADNV)*ETPFBCL)/PDCGNP
+250*(ETCADNV*ETPADCL+(1-ETCADNV)*ETPFBCL)/SGPFRMCL
+150*(ETCADNV*ETPADCL+(1-ETCADNV)*ETPFBCL)/WHPFRMCL

Ethanol production, calendar year

ETSPRDCL = ETYLDDM*CRDGDM
+ETYLDWM*CRDGWM
+ETSPNCCL
+ETSPCECL
+ETSSUGCL

Ethanol production Sep-Aug

ETSPRDSA = ETSPRDCL/3
+ ETSPRDCL1*2/3

Corn oil extraction

Average corn oil yield/bushel de-oiled

FCYLDCL =0.3
+0.075*Trend (ZTIME - 2009)

Corn oil extraction returns/gallon (including discount to ethanol costs)
FCNRT = -1*0.0135*GDPD + .0227*PPINGAS
+ ((0.1618*CLPNF)/2 + (0.1618*CRPRFMCL)/2)
-1*2.95*(17/56)*DGPMKT/2000

Change in share of dry mills extracting corn oil
FCSHRCH = MAX(-0.005,
6*(FCNRT / PDCGNP)
+12*lag(FCNRT / PDCGNP)
+6*lag2(FCNRT / PDCGNP))

Share of dry mill capacity extracting corn oil
FCSHR = MAX(0, MIN(1,
lag(FCSHR)
+FCSHRCH))

Average dry mill distillers grain yield/bushel of corn
DGYLDDM = 16.85
+0.01*(ZTIME-1980)
-1*FCSHR

Corn being de-oiled
FCDCR = CRDGDM*FCSHR

Corn oil from extraction
FCPRDCL = FCYLDCL*FCDCR

Renewable Identification Numbers

Biodiesel RIN rollover demand (share of requirement)
RFBDROLO= 0.15
-0.13*min(1,RFBDCPG*.66)
-0.02*RFBDCPG*.66

Biodiesel RINS carried over
RFBDRINS = RFBD1*RFBDROLO

Cellulosic RIN rollover demand (share of requirement)

RFCEROLO= 0.2
-0.18*min(1,RFCECPG*1.5)
-0.02*RFCDCPG*1.5

Cellulosic RINs carried over
RFCERINS = RFCE1*RFCEROLO

Advanced RIN rollover demand (share of requirement)

RFADROLO= 0.2
-0.18*min(1,RFADCPG*1.5)
-0.02*RFADCPG*1.5

Advanced RINs carried over
RFADRINS= MAX((RFAD1-RFCE1)*RFADROLO, RFBDRINS*1.5)

Conventional (D6) RIN rollover demand (share of requirement)

RFTOROLO = 0.2
-0.18*min(1,RFCNCPG*2)
-0.02*RFCNCPG*2

Conventional (D6) RINs carried over
RFTORINS= MAX((RFTO1 –RFCE1)*RFTOROLO, RFADRINS)

RFS standards

Projected overall standard, applicable percent

```
RFTOPCT1 =    (ETDISCL1
              + MAX(RFBD1, BDDDOMTR1)*1.5
              + ETSPOACL
              + ETSPCECL)/
              (      (MGSTOTPRJ – ETDISCL1-ETSPCECL-ETSPOACL)
                     +(DISLPRJ – BDDDOMTR1)     )
```

Projected advanced standard, applicable percent

```
RFADPCT1 =    MAX(RFBD1, BDDDOMTR1)*1.5
              + ETSPOACL
              + ETSPCECL)/
              (      (MGSTOTPRJ – ETDISCL1-ETSPCECL-ETSPOACL)
                     +(DISLPRJ – BDDDOMTR1)     )
```

Projected biomass-based diesel standard, applicable percent

```
RFBDPCT1 =    RFBD1*1.5/
              (      (MGSTOTPRJ – ETDISCL1-ETSPCECL-ETSPOACL)
                     +(DISLPRJ – BDDDOMTR1)     )
```

Projected cellulosic standard, applicable percent

```
RFCEPCT1 =    (ETSPCECL
              +ETIMCECL
              +(LFSPRCCD – CDRFSBD)*1.7)/
              (      (MGSTOTPRJ – ETDISCL1-ETSPCECL-ETSPOACL)
                     +(DISLPRJ – BDDDOMTR1)     )
```

Overall volume requirement, adjusted for RIN stocks

```
RFTOE =       lag(RFTOPCT1)*
              (      (MGSTOTCL – ETDISCL – ETSPCECL – ETSPOACL)
                     + (DISLS – BDDDOMTR)  )
              + (lag(RFTORINS) – RFTORINS)
```

Advanced volume requirement, adjusted for RIN stocks

```
RFADE =     lag(RFADPCT1)*
            (     (MGSTOTCL – ETDISCL – ETSPCECL – ETSPOACL)
                  + (DISLS – BDDDOMTR)  )
            + (lag(RFADRINS) – RFADRINS)
```

Biomass-based diesel volume requirement, adjusted for RIN stocks

```
RFBDE =     (lag(RFBDPCT1)*
            (     (MGSTOTCL – ETDISCL – ETSPCECL – ETSPOACL)
                  + (DISLS – BDDDOMTR)  )/1.5 )
            + (lag(RFBDRINS) – RFBDRINS)
```

Mandate cost from conventional ethanol

```
RFCNC=      RFCNCPG*
            ((ETSPRDCL-ETSPNCCL*ETNCADV-ETSPCECL-ETSSUGCL)
            +ETDTESCL(t-1)
            -ETDTESCL
            -(ETSIMPCL-ETSIMNCL))
```

Mandate cost from advanced ethanol

```
RFADC=      RFADCPG*
            (ETSPNCCL*ETNCADV
            +ETSIMPCL
            +ETSSUGCL)
```

Mandate cost from cellulosic ethanol

```
RFCEC=      RFCECPG*
            (ETSPCECL
            +ETIMCECL
            +(LFSPRCCD – CDRFSBD)*1.7)
```

Mandate cost from total ethanol

RFETC=	RFCNC +RFADC +RFCEC

Mandate cost from biodiesel

RFBDC=	RFBDCPG* (BDSPRDCL -BDDEXN + CDRFSBD)

RFBIOFC=	RFETC + RFBDC

Wholesale ethanol price, Omaha, calendar year

ETPFBCL =	ETPRTRCL +ETTAXEX +RFCNCPG

Biodiesel price, rack, calendar year

BDPPLTCL =	BDPREQ +BDTAXCR +RFBDCPG

Other advanced ethanol price , calendar year

ETPADCL=	ETPRTRCL +ETTAXEX +RFADCPG

Cellulosic ethanol price, calendar year

ETPCELCL =	ETPRTRCL +ETTAXEX +ETCECRFC +RFCECPG

Distillers Grains

Beef DDG feed value
DGVFEBE = DGDCOBE*CRPFRM*2000/56
+DGDSMBE*SMP48D

Pork DDG feed value
DGVFEPK = DGDCOPK*CRPFRM*2000/56
+DGDSMPK*SMP48D

Poultry DDG feed value
DGVFEBR = DGDCOPK*CRPFRM*2000/56
+DGDSMPK*SMP48D

Dairy DDG feed value
DGVFEDY = DGDCOPK*CRPFRM*2000/56
+DGDSMPK*SMP48D

Beef DDG avg. disp. rate, corn
Ln(((DGDCOBE-DGMINCBE) – (DGMAXCBE – DGDCOBE))
/(1-((DGDCOBE-DGMINCBE) – (DGMAXCBE – DGDCOBE))) = -0.6
+(CRPFRM*2000/56)/SMP48D

Beef DDG avg. disp. rate, soybean meal
DGDSMBE= 1-DGDCOBE

Pork DDG disp. rate, corn
Ln(((DGDCOPK-DGMINCPK) – (DGMAXCPK – DGDCOPK))
/(1-((DGDCOPK-DGMINCPK) – (DGMAXCPK – DGDCOPK)))= -0.9
+(CRPFRM*2000/56)/SMP48D

Pork DDG disp. rate, soybean meal
DGDSMPK= 1-DGDCOPK

Poultry DDG disp. rate, corn
Ln(((DGDCOBR-DGMINCBR) – (DGMAXCBR – DGDCOBR))
/(1-((DGDCOBR-DGMINCBR) – (DGMAXCBR – DGDCOBR)))= -0.5
+(CRPFRM*2000/56)/SMP48D

Poultry DDG disp. rate, soybean meal
DGDSMBR 1-DGDCOBR

Dairy DDG disp. rate, corn
Ln(((DGDCODY-DGMINCDY) – (DGMAXCDY – DGDCODY))
/(1-((DGDCODY-DGMINCDY) – (DGMAXCDY – DGDCODY)))= -1.7
+(CRPFRM*2000/56)/SMP48D

Dairy DDG disp. rate, soybean meal
DGDSMDY= 1-DGDCODY

Beef DDG adoption rate
LN(DGARBE/(1- DGARBE)) = -12
+10*DGVFEBE/DGPMKT
+0.01*TREND

Pork DDG adoption rate
LN(DGARPK/(1- DGARPK))= -13
+9.4*DGVFEPK/DGPMKT
+0.01*TREND

Poultry DDG adoption rate
LN(DGARBR/(1- DGARBR))= -11
+8*DGVFEBR/DGPMKT
+0.01*TREND

Dairy DDG adoption rate

LN(DGARDY/(1- DGARDY))= -12.5
+10*DGVFEDY/DGPMKT
+0.01*TREND

Livestock DDG consumption identity

LDDGC = (GBEEF1*DGMIBE*DGARBE*56/2000*1000)*DGDCOBE
+(HBEEF1*DGMIBE*DGARBE)*DGDSMBE
+(GPORK1*DGMIPK*DGARPK*56/2000*1000)*DGDCOPK
+(HPORK1*DGMIPK*DGARPK)*DGDSMPK
+(GBROIL1+GLAYER1+GTURKEY1)*DGMIBR*DGARBR*56/2000*1000*DGDCOBR
+(HBROIL1+HLAYER1+HTURKEY1)*DGMIBR*DGARBR*DGDSMBR
+GDAIRY1*DGMIDY*DGARDY*56/2000*1000*DGDCODY
+HDAIRY1*DGMIDY*DGARDY*DGDSMDY

Distillers grain production, calendar year

DGSPRDCL= CRDGDM*DGYLDDM/2

Distillers grain production, marketing year

DGSPRD= DGSPRDCL/3
+DGSPRDCL1*2/3

DDG Supply DGSPRD

DDG Demand

LDDGC
+DGDEN
+DGDFZ
+DGDEXP

Weighted average corn displacement

```
DGDCOWT=    DGDCOBE*DGCONBE/DGCONLV
            +DGDCOPK*DGCONPK/DGCONLV
            +DGDCOBR*DGCONBR/DGCONLV
            +DGDCODY*DGCONDY/DGCONLV
```

Energy value of DDG

```
DGVEN =     0.7*(WPI051/WPI0511996)*36.48
```

DDG consumed for energy

```
DGDEN =     500*max(0,(DGVEN-DGPMKT))
```

Fertilizer value of DDG

```
DGVFZ =     180*PPI9NFZ/PPI9NFZ1997*0.26/0.82
```

DDG consumed for fertilizer

```
DGDFZ =     500*max(0,(DGFZV-DGPMKT))
```

Distillers grains exports

```
DGDEXP=     DGDEXN
            -lag(DGDEXN)
            +lag(DGDEXP)
```

Distillers/Brewers grain production

```
BGSPRD=     17*48/56*BRDFOD/2
```

Non-food corn oil used for feed per grain-consuming animal unit

```
CLDFED/GCAU =       MAX(0,
            0.2
            -0.001*CLPNF/SOPMKT
            -0.05*MIN(0, CLPNF- SOPMKT))
```

Other Corn Processing

Corn gluten feed price, 21% protein, IL points

GFPR21= 230
+0.03*SMP48D
+10*CRPFRM
+0.3*DGPMKT
-25*(LN(MAX(0.001,GFDDOM))

Corn gluten feed production, calendar year

GFSPRDCL= (CRDGWM+CRDOWM)*GFYLDWM/2

Corn gluten feed production, marketing year

GFSPRD = GFSPRDCL/3
+GFSPRDCL1*2/3

Corn gluten meal price, 60% protein, IL Points

GMPR60= 240
+1.2*SMP48D
-20*(LN(MAX(0.001, GMDDOM))

Corn oil price, Chicago

CLPRCH = 40
+SOPMKT
-5*(LN(MAX(0.001, CLDFOD))

Corn HFCS wet mill gross margin

CRGMWH = HFPRMW*HFYLDWM/100
+GFPR21*GFYLDWM/2000
+GMPR60*GMYLDWM/2000
+CLPRCH*CLYLDWM/100
-CRPFRM
-0.00384*PPINGAS1*2/3+lag(PPINGAS1)/3

Corn wet milled for HFCS
CRDHFC = 20
+0.5*Lag(CRDHFC)
+5000*CRGMWH/PDCGNP
-2500*(CRNRBWM/3 + CRNRBWM1*2/3)/PDCGNP
+3*(ZTIME-1980)

Corn for glucose & dextrose
CRDGLD = 240
-150*CRPFRM/SUPRAW
+(ZTIME-1980)

Corn for starch
CRDSTR = 220
-1000*CRPFRM/PDCGNP
+2*(ZTIME-1980)

Corn for beverage alcohol
CRDBEV = 120
-500*CRPFRM/PDCGNP
+(ZTIME-1980)

Corn for cereals and other
CRDCER = 170
-750*CRPFRM/PDCGNP
+1.5*(ZTIME-1980)

HFCS-55 price, Midwest, Oct.-Sep. year
HFP55MW = 1
+1.2*HFPRMW

HFCS deliveries, Oct-Sep. year (per capita)
HFDDOMOS = 13
-3.5*HFP55MW/average(SUPRAW,SUPREF)
-0.4*max(0,HFP55MW-average(SUPRAW,SUPREF))
+3*ln(ZCE92W1/POPTOTW1)
+0.4*HFTRND

HFCS exports to Mexico
HFDEXMOS = -100
+0.5*lag(HFDEXMOS)
-200*HFPRMW/average(SUPRAW,SUPREF)
-20*HFPRMW/CRPFRM
+25*(ZTIME-1980)

HFCS net exports - exports to Mexico
HFDEXMOS = 140
-40*HFPRMW/average(SUPRAW,SUPREF)
-4*HFPRMW/CRPFRM

HFCS production, cal. yr.
HFSPRDCL = 0.75*Lag(HFSPRDOS)
+0.25*HFSPRDOS

HFCS net exports, cal. yr.
HFDEXN = 0.75*lag(HFDEXNOS)
+0.25*HFDEXNOS

Corn gluten feed net exports.
GFDEXN = 3500
-2500*GFPR21/PDCGNP
+32000*CRPFRM/PDCGNP
+180*SMP48D/PDCGNP
-30*(ZTIME-1980)

Corn gluten meal net exports.
GMDEXN = 1100
-300*GMPR60/PDCGNP
+300*SMP48D/PDCGNP
+5*(ZTIME-1980)

Domestic demand for corn gluten meal
GMDDOM= GMSPRD-GMDEXN

Corn gluten meal production, calendar year
GMSPRDCL= (CRDGWM+CRDOWM)*GMYLDWM/2

Corn gluten meal production, marketing year
GMSPRD= GMSPRDCL/3
+ GMSPRDCL1*2/3

Corn oil production
CLSPRD = (CRDGWM/3+CRDGWM1*2/3)*CLYLDWM
+(CRDOWM/3+CRDOWM1*2/3)*CLYLDWM
+(FCPRDCL/3+FCPRDCL1*2/3)

Corn oil net exports.
CLDEXN = 950
-1500*CLPRCH/PDCGNP
+1000*SOPMKT/PDCGNP
-2*(ZTIME-1980)

Corn oil ending stocks
CLDTES = -250
-500*CLPRCH/PDCGNP
0.05*CLSPRD
-2*(Year-1980)

Domestic corn oil demand
CLDDOM=CLSPRD+CLDTES(t-1)-CLDEXN-CLDTES

Biodiesel

Biodiesel consumption (transport), calendar year
BDDDOMTR = 4300
-4675*(BDPREQ/(DIPRSM))
+0.03*DISLS

Other costs, biodiesel production
BDOTCCL=BDOTCCL(t-1)*AVERAGE(PDCGNP/PDCGNP(t-1),1)

Soybean-oil based biodiesel net returns, calendar year
BDNRTSO = BDPPLT
+0.97*GYPR
-SOPMKT*BDSYLD/100
-BDOTCCL

Soybean oil price, calendar year
SOPMKTCL = lag(SOPMKT)*3/4
+ SOPMKT/4

Biodiesel capacity, calendar year
BDCAPSO = max (lag(BDCAPSO)
- 0.05*lag10(BDCAPSO)
+ 10000*(BDNRTSO-0.2)/PDCGNP
+ 25000*lag((BDNRTSO-0.2)/PDCGNP)
+ 60000*lag2((BDNRTSO-0.2)/PDCGNP)
+ 20000*lag3((BDNRTSO-0.2)/PDCGNP),
1*lag(BDCAPSO) - 0.05*lag10(BDCAPSO))

Biodiesel capacity util. rate-soyoil, calendar year
Ln(BDCUSSO/(1- BDCUSSO)) = -3.5
+550*BDNRTSO/PDCGNP

Biodiesel from soyoil production, calendar year
BDSOPRD = BDCAPSO*BDCUSSO

Soybean oil use for biodiesel
SODBIO = BDSOPRD*BDSYLD

Biodiesel production not from soy, canola or corn oil
BDOTPRD = MAX(0,
-100
+0.2*lag(BDOTPRD)
+0.2*BDSOPRD
+7000*BDPPLT/PDCGNP

Rape oil price, calendar year
ROPMKTCL = lag(ROPMKT)*3/4
+ ROPMKT/4

Canola biodiesel net returns, calendar year
BDNRTRO= BDPPLT
+0.97*GYPR
-ROPMKTCL*BDSYLD/100
-BDOTCCL

Canola biodiesel capacity, calendar year

```
BDCAPRO =       max( 0 + 1*lag(BDCAPRO)
                 - 0.05*lag10(BDCAPRO)
                 + 4000*(BDNRTRO)/PDCGNP1
                 + 5000*lag((BDNRTRO)/PDCGNP1)
                 + 12500*lag2((BDNRTRO)/PDCGNP1)
                 + 6250*lag3((BDNRTRO)/PDCGNP1) ,
                   1*lag(BDCAPRO)- 0.05*lag10(BDCAPRO) )
```

Biodiesel capacity util. rate-canola oil

```
Ln(BDCUSRO/(1- BDCUSRO)) =   -1.5
                             +250*BDNRTRO/PDCGNP
```

Biodiesel from canola oil production, MY

```
BDROPRD =       BDCAPRO*BDCUSRO
```

Canola oil used for biodiesel

```
RODBIO =        BDROPRD*BDSYLD
```

Cornoil (non-food) biodiesel net returns, MY

```
BDNRTCL =       BDPPLTM
                +0.97*GYPR
                -CLPNF*CLSYLD/100
                -BDOTCCL
```

Non-food corn oil biodiesel capacity

```
BDCAPCL =       max( 0 + 1*lag(BDCAPCL)
                 - 0.05*lag10(BDCAPCL)
                 + 3750*(BDNRTCL-0.1)/PDCGNP1
                 + 7500*lag((BDNRTCL-0.1)/PDCGNP1)
                 + 15000*lag2((BDNRTCL-0.1)/PDCGNP1)
                 + 7500*lag3((BDNRTCL-0.1)/PDCGNP1) ,
                   1*lag(BDCAPCL)- 0.05*lag10(BDCAPCL) )
```

Biodiesel capacity util. rate-non-food corn oil
Ln(BDCUSCL/(1- BDCUSCL)) = -1.55
+550*BDNRTCL/PDCGNP

Biodiesel from non-food corn oil production, MY
BDCLPRD = BDCAPCL*BDCUSCL

Non-food corn oil used for biodiesel
CLDBIO= BDCLPRD*CLSYLD

Biodiesel ending stocks
BDDTESCL = 10
+0.5*lag(BDTESCL)
+0.007*BDSPRD

Trade Equations

Ethanol imports

```
ETSIMPCL  = max( 30*ETPADCL/((LAG(ETPBZAMA)/4 + ETPBZAMA*3/4)*(1+ETTARV)+ETTARS)
                  + 0.001*MGSTOTCL,
            MIN(  30*ETPADCL/((LAG(ETPBZAMA)/4 + ETPBZAMA*3/4)*(1+ETTARV)+ETTARS)
                  + 0.001*MGSTOTCL
                 +1200*MAX(0, BDPPLT/1.5-ETTARS-(1-ETTARV)
                 *(LAG(ETPBZAMA)/4 + ETPBZAMA*3/4))
                 - LAG(RFADRINS),
      MAX(0,    (lag(RFADPCT1)*(MGSTOTCL - (ETDISCL + ETSPOACL ) + DISLS - (BDDDOMTR)) )
            - MAX(ETSPCECL+ETIMCECL+(LFSPRDCD-CDRFSBD)*1.7,RFCE*(1-CEWAIVE))
      - (lag(RFBDPCT1)*(MGSTOTCL - (ETDISCL + ETSPOACL) + DISLS - (BDDDOMTR ))) )))
+3000*MAX(0,  ETPFBCL - ETTARS - (1-ETTARV)*(LAG(ETPBZAMA)/4 + ETPBZAMA*3/4) - 0.2)
```

Ethanol exports

ETDEXPCL = 1000
-1000*ETPFBCL/ETPBZACL
+2000*max(0,ETPBZACL-0.05-ETPFBCL)

Brazil anhydrous ethanol price, May-April

ETPBZAMA = 0.8
+0.008832*POILRASA
+0.000124*ETSIMNSA

Biodiesel price, Germany, MY

BDPGER = 3.5
+0.012*POILRASA
-0.0005*BDDEXN/4+BDEXN1*3/4

Biodiesel net exports

BDDEXN = 100
+0.2*lag(BDDEXN)
-100*(BDPPLT-BDTAXCR+BDTAREU+0.2)/(lag(BDPGER)*3/4 + BDPGER/4)
+1*(ZTIME-1980)

Distilllers/brewers grain net exports

DGDEXN = 9000
-5000*DGPMKT/PDCGNP
+120000*CRPFRM/PDCGNP
+500*SMP48D/PDCGNP
+1000*max(0,0.85*CRPFRM/56*2000-DGPMKT)
+0*(ZTIME-1980)

Cellulosic biofuels/Biomass

Cellulosic RIN minimum allowance (initial value = $0.25 in 2008)
ETCECRMC= lag(ETCERMC)*(PDCGNP/LAG(PDCGNP))

Cellulosic RIN allowance trigger (initial value = $3.00 in 2008)
ETCECRTC= lag(ETCERTC)*(PDCGNP/LAG(PDCGNP))

Cellulosic RIN credit allowance
ETCECR10=MAX(ETCECRMC,ETCECRTC-UGPFBCL(t-1))

Cellulosic (2^{nd} generation) producers credit
ETCECRFC=1.01-ETTAXEX

Variable costs of cellulosic ethanol, exc. stover, switchgrass
ETCEVARC = 0.0005*CRVARC
+0.001*WHVARC
+0.001*SBVARC
+0.002*HAPFRM
+0.0005*CRNRML
+0.002*WHNRML
+0.0008*SBNRML
+0.0005*(PPINGAS1*2/3+lag(PPINGAS1)/3)
+2*CROTCDM

Other advanced biofuel production
ETSPOASA = 50*ETPADCL/PDCGNP*lag(ETSPOACL)
+15*max(0,ZTIME-2010)

Other renewable diesel production
BDRDPRD = 20*BDPPLTCL/PDCGNP*lag(BDSRDPRD)
+10*MAX(0, ZTIME - 2010)

Ethanol yield from stover
ETYLDST = 71.9
+ETYTECSW*(ZTIME-2009)

Warm season grasses price for liquid fuel production at plant
WGLFPPLT= ETPCEL*ETYLDWG
+ETPBPWG*BPYLDWG
+ETPSUBWG*ETYLDWG
-WGLFCTEK*(ETNGASWG*(1/3*LAG(PPINGAS1) + 2/3*PPINGAS1)
+ETCOILWG*(POILRASA/2 + LAG(POILRASA)/2) + WGLFOTC*ETYLDWG)
+(ELRINDEX*3412/1000000)*ELYLLFWG*ETYLDWG
-LFCCAPWG*ETYLDWG

Wheat straw price for liquid fuel production at plant
WSLFPPLT = ETPCEL*ETYLDWS
+ETPBPWS*BPYLDWS
+ETPSUBWS*ETYLDWS
-WSLFCTEK*(ETNGASWS*(1/3*LAG(PPINGAS1) + 2/3*PPINGAS1)
+ ETCOILWS*(POILRASA/2 + LAG(POILRASA)/2) + WSLFOTC*ETYLDWS)
+(ELRINDEX*3412/1000000)*ELYLLFWS*ETYLDWS
-LFCCAPWS*ETYLDWS

Forest matter price for liquid fuel production at plant
FMLFPPLT = ETPCEL*ETYLDFM
+ETPBPFM*BPYLDFM
+ETPSUBFM*ETYLDFM
-FMLFCTEK*(ETNGASFM*(1/3*LAG(PPINGAS1) + 2/3*PPINGAS1)
+ ETCOILFM*(POILRASA/2 + LAG(POILRASA)/2) + FMLFOTC*ETYLDFM)
+(ELRINDEX*3412/1000000)*ELYLLFFM*ETYLDFM
-LFCCAPFM*ETYLDFM

Corn stover price for liquid fuel production at plant

```
STLFPPLT =    ETPCEL*ETYLDST
              +ETPBPST*BPYLDST
              +ETPSUBST*ETYLDST
              -STLFCTEK*(ETNGASST*(1/3*LAG(PPINGAS1) + 2/3*PPINGAS1)
                        + ETCOILST*(POILRASA/2 + LAG(POILRASA)/2) + STLFOTC*ETYLDST)
              +(ELRINDEX*3412/1000000)*ELYLLFST*ETYLDST
              -LFCCAPST*ETYLDST
```

Municipal waste price for liquid fuel production at plant

```
MWLFPPLT =    ETPCEL*ETYLDMW
              +ETPBPMW*BPYLDMW
              +ETPSUBMW*ETYLDMW
              -MWLFCTEK*(ETNGASMW*(1/3*LAG(PPINGAS1) + 2/3*PPINGAS1)
                        + ETCOILMW*(POILRASA/2 + LAG(POILRASA)/2) + WLFOTC*ETYLDMW)
              +(ELRINDEX*3412/1000000)*ELYLLFMW*ETYLDMW
              -LFCCAPMW*ETYLDMW
```

Warm season grasses price for electricity production at plant

```
WGELPPLT =    (ELYLDWG/1000000)*(ELRINDEX)
              -WGELCTEK*(WGELOTC)
              -(ELCCAPWG*(1-ENELSSBB_RATE) - ENELSSBF_UNIT*7008*3412/1000000)
```

Wheat straw price for electricity production at plant

```
WSELPPLT =    (ELYLDWS/1000000)*(ELRINDEX)
              -WSELCTEK*(WSELOTC)
              -(ELCCAPWS*(1-ENELSSBB_RATE) - ENELSSBF_UNIT*7008*3412/1000000)
```

Forest materials price for electricity production at plant

```
FMELPPLT =    (ELYLDFM/1000000)*(ELRINDEX)
              -FMELCTEK*(FMELOTC)
              -(ELCCAPFM*(1-ENELSSBB_RATE) - ENELSSBF_UNIT*7008*3412/1000000)
```

Corn stover price for electricity production at plant

```
STELPPLT =    (ELYLDST/1000000)*(ELRINDEX)
              -STELCTEK*(STELOTC)
              -(ELCCAPST*(1-ENELSSBB_RATE) - ENELSSBF_UNIT*7008*3412/1000000)
```

Municipal waste price for electricity production at plant

```
MWELPPLT =    (ELYLDMW/1000000)*(ELRINDEX)
              -MWELCTEK*(MWELOTC)
              -(ELCCAPMW*(1-ENELSSBB_RATE) - ENELSSBF_UNIT*7008*3412/1000000)
```

Transportation cost (electricity), Warm season grasses

```
WGELTRAN =    20
              +WGELTVC*WGELCVTR
              +7.008928703*PPIRPPSA/1.806
```

Transportation cost (electricity), Wheat straw

```
WSELTRAN =    20
              +WSELTVC*WSELCVTR
              +10.60452251*PPIRPPSA/1.806
```

Transportation cost (electricity), Forest materials

```
FMELTRAN =    FMELTVC*FMELCVTR
              +7.008928703*PPIRPPSA/1.806
```

Transportation cost (electricity), Corn stover

```
STELTRAN =    20
              +STELTVC*STELCVTR
              +10.60452251*PPIRPPSA/1.806
```

Transportation cost (electricity), Municipal waste

```
MWELTRAN =    MWELTVC*MWELCVTR
              +7.008928703*PPIRPPSA/1.806
```

Transportation cost (liquid fuel), Warm season grasses

```
WGLFTRAN =    WGLFTVC*WGLFCVTR
              +7.008928703*PPIRPPSA/1.806
```

Transportation cost (liquid fuel), Wheat straw

```
WSLFTRAN =    WSLFTVC*WSLFCVTR
              +10.60452251*PPIRPPSA/1.806
```

Transportation cost (liquid fuel), Forest materials

```
FMLFTRAN =    FMLFTVC*FMLFCVTR
              +7.008928703*PPIRPPSA/1.806
```

Transportation cost (liquid fuel), Corn stover

```
STLFTRAN =    STLFTVC*STLFCVTR
              +10.60452251*PPIRPPSA/1.806
```

Transportation cost (liquid fuel), Municipal waste

```
MWLFTRAN =    20
              +MWLFTVC*MWLFCVTR
              +7.008928703*PPIRPPSA/1.806
```

Warm season grasses production for electricity production

```
WGELSPRD =    MIN(max( WGELMIN,  ELWGSADJ +
    WGELPTEK* ( + 310.177/2    + WGELINT
   + 40.43832919*(max(0.0,(   (PSUBELWG + ESUBELWG + WGELPFRM)/3
              + lag(PSUBELWG + ESUBELWG + WGELPFRM)/3
             + lag2(PSUBELWG + ESUBELWG + WGELPFRM)/3            )/PDC2022)   )**0.5
         * ( (CRENRMKS + STNRPTON*(STLFSPRD+STELSPRD)/lag(CRSHAR1))/PDC2022 )**(WGELCR)
         * (SBENRMKS/PDC2022)**(WGELSB)
         * ((WHENRMKS + WSNRPTON*(WSLFSPRD+WSELSPRD)/lag(WHSHAR1))/PDC2022)**(WGELWH)   )
   - WGLFQ*max(0, WGLFSPRD-10)  ), WGELMAX                        )
```

Wheat straw production for electricity production

```
WSELSPRD =      max(0,  ELWSSADJ +
      WSELPTEK*(   + 12.67533/2 + WSELINT
     + 5.491053383*(   max(0.0,(    (PSUBELWS + ESUBELWS + WSELPFRM)/3
                              +lag(PSUBELWS + ESUBELWS + WSELPFRM)/3
                               +lag2(PSUBELWS + ESUBELWS + WSELPFRM)/3 )/PDC2022)   ) **0.5
     + WSELCR*log10(lag(lag(WHSPRD1)) )    )
     - WSLFQ*max(0, WSLFSPRD -10)  )
```

Forest materials production for electricity production

```
FMELSPRD =      max(0,  ELFMSADJ +
     FMELPTEK*(    + 70.09523/2   + FMELINT
     + 38.46741837*( max(0.0,(           (PSUBELFM + ESUBELFM + FMELPFRM)/3
                                 + lag(PSUBELFM + ESUBELFM + FMELPFRM)/3
                                 + lag2(PSUBELFM + ESUBELFM + FMELPFRM)/3   )/PDC2022))**0.5
     *  ( (CRENRMKS + STNRPTON*(STLFSPRD+STELSPRD)/lag(CRSHAR1))/PDC2022  )**(FMELCR)
     *  (SBENRMKS/PDC2022 )**(FMELSB)
     *  ( (WHENRMKS + WSNRPTON*(WSLFSPRD+WSELSPRD)/lag(WHSHAR1))/PDC2022  )**(FMELWH)        )
     - FMLFQ*max(0, FMLFSPRD -10)  )
```

Corn stover production for electricity production

```
STELSPRD =        max(0,  ELSTSADJ +
     STELPTEK*(   +  93.76518/2 + STELINT
     + 19.84742072*(max(0.0,(   (PSUBELST + ESUBELST + STELPFRM)/3
                          + lag(PSUBELST + ESUBELST + STELPFRM)/3
                          + lag2(PSUBELST + ESUBELST + STELPFRM)/3  )/PDC2022))**0.5
     + STELCR*log10(lag(lag(CRSPRD1)))       )
     - STLFQ*max(0, STLFSPRD -10) )
```

Municipal waste production for electricity production

```
MWELSPRD =     max(0,
     MWELPTEK*( 38/2  + MWELINT
     + 1.906151666*(max(0.0,(    (PSUBELMW + ESUBELMW + MWELPFRM)/3
                        + lag(PSUBELMW + ESUBELMW + MWELPFRM)/3
                        + lag2(PSUBELMW + ESUBELMW + MWELPFRM)/3 )/PDC2022))**0.5)
     - MWLFQ*max(0, MWLFSPRD -5))
```

Warm season grasses production for liquid fuel production

```
WGLFSPRD =      min(max(WGLFMIN,
      WGLFPTEK*(   + 310.177/2 + WGLFINT
     + 89.43832919*(max(0.0,(    (PSUBLFWG + ESUBLFWG + WGLFPFRM)/3
                        + lag(PSUBLFWG + ESUBLFWG + WGLFPFRM)/3
                        + lag2(PSUBLFWG + ESUBLFWG + WGLFPFRM)/3 )/PDC2022))**0.5
     *  ( (CRENRMKS + STNRPTON*(STLFSPRD+STELSPRD)/lag(CRSHAR1))/PDC2022 )**(WGLFCR)
     *  ( SBENRMKS/PDC2022 )**(WGLFSB)
     *  ( (WHENRMKS + WSNRPTON*(WSLFSPRD+WSELSPRD)/lag(WHSHAR1))/PDC2022  )**(WGLFWH)  )
     - WGELQ*max(0, WGELSPRD -10) ), WGLFMAX)
```

Wheat straw production for liquid fuel production

```
WSLFSPRD =      MIN(max(WSLFMIN,
      WSLFPTEK*(  + 12.67533/2  + WSLFINT
     + 5.491053383*(max(0.0,(           (PSUBLFWS + ESUBLFWS + WSLFPFRM)/3
                                   + lag(PSUBLFWS + ESUBLFWS + WSLFPFRM)/3
                                    + lag2(PSUBLFWS + ESUBLFWS + WSLFPFRM)/3 )/PDC2022))**0.5
     + WSLFCR*log10(lag(lag(WHSPRD1)) )    )
     - WSELQ*max(0, WSELSPRD -10)), WSLFMAX)
```

Forest materials production for liquid fuel production

```
FMLFSPRD =      MIN(max(FMLFMIN,
     FMLFPTEK*(   + 70.09523/2  + FMLFINT
     + 38.46741837*(max(0.0,(           (PSUBLFFM + ESUBLFFM + FMLFPFRM)/3
                              + lag(PSUBLFFM + ESUBLFFM + FMLFPFRM)/3
                              + lag2(PSUBLFFM + ESUBLFFM + FMLFPFRM)/3 )/PDC2022))**0.5
     *  ( (CRENRMKS + STNRPTON*(STLFSPRD+STELSPRD)/lag(CRSHAR1))/PDC2022  )**(FMLFCR)
     *  ( SBENRMKS/PDC2022  )**(FMLFSB)
     *  ( (WHENRMKS + WSNRPTON*(WSLFSPRD+WSELSPRD)/lag(WHSHAR1))/PDC2022  )**(FMLFWH)   )
     - FMELQ*max(0, FMELSPRD -10)), FMLFMAX)             .
```

Corn stover production for liquid fuel production

```
STLFSPRD =       min(max(STLFMIN,
     STLFPTEK*(   +  93.76518/2  + STLFINT
     + 19.84742072*(max(0.0,(              (PSUBLFST + ESUBLFST + STLFPFRM)/3
       + lag(PSUBLFST + ESUBLFST + STLFPFRM)/3
       + lag2(PSUBLFST + ESUBLFST + STLFPFRM)/3 )/PDC2022))**0.5
     + STLFCR*log10(lag(lag(CRSPRD1)  )) )
     - STELQ*max(0, STELSPRD -10)),STLFMAX)
```

Municipal waste production for liquid fuel production

```
MWLFSPRD =    MIN(max(MWLFMIN,
     MWLFPTEK*( 38/2   + MWLFINT
     + 1.906151666*(max(0.0,(          (PSUBLFMW + ESUBLFMW + MWLFPFRM)/3
                              + lag(PSUBLFMW + ESUBLFMW + MWLFPFRM)/3
                              + lag2(PSUBLFMW + ESUBLFMW + MWLFPFRM)/3 )/PDC2022))**0.5)
     - MWELQ*max(0, MWELSPRD -5) ), MWLFMAX)
```

Liquid fuel production from Warm season grasses

```
LFSPRDWG =     WGLFSPRD*ETYLDWG
```

Liquid fuel production from Warm season grasses, calendar year

```
LFSPRDWGCL = lag(LFSPRDWG)*2/3 + LFSPRDWG/3
```

Liquid fuel production from Wheat straw
LFSPRDWS = WSLFSPRD*ETYLDWS

Liquid fuel production from Wheat straw
LFSPRDWSCL = LAG(LFSPRDWS)*2/3 + LFSPRDWS/3

Liquid fuel production from Forest materials
LFSPRDFM = FMLFSPRD*ETYLDFM

Liquid fuel production from Forest materials
LFSPRDFMCL = LAG(LFSPRDFM)*2/3 + LFSPRDFM/3

Liquid fuel production from corn stover
LFSPRDST = STLFSPRD*ETYLDST

Liquid fuel production from corn stover
LFSPRDSTCL = LAG(LFSPRDST)*2/3 + LFSPRDST/3

Liquid fuel production from Municipal waste
LFSPRDMW = MWLFSPRD*ETYLDMW

Liquid fuel production from Municipal waste
LFSPRDMWCL = LAG(LFSPRDMW)*2/3 + LFSPRDMW/3

Electricity production from Warm season grasses
ELSPRDWG = (ELYLDWG/1000000000000)*WGELSPRD*1000000

Electricity production from Warm season grasses
ELSPRDWGCL = LAG(ELSPRDWG*2/3 + ELSPRDWG/3

Electricity production from Wheat straw
ELSPRDWS = (ELYLDWS/1000000000000)*WSELSPRD*1000000

Electricity production from Forest materials
ELSPRDFM = (ELYLDFM/1000000000000)*FMELSPRD*1000000

Electricity production from corn stover
ELSPRDST = (ELYLDST/1000000000000)*STELSPRD*1000000

Electricity production from Municipal waste
ELSPRDMW = (ELYLDMW/1000000000000)*MWELSPRD*1000000

Electricity production as cellulosic co-product, warm-season grasses
ELSPRCWG = (WGLFSPRD*1000000*ELYLLFWG*ETYLDWG*3412/1000000000000)

Electricity production as cellulosic co-product, wheat straw
ELSPRCWS = (WSLFSPRD*1000000*ELYLLFWS*ETYLDWS*3412/1000000000000)

Electricity production as cellulosic co-product, forest materials
ELSPRCFM = (FMLFSPRD*1000000*ELYLLFFM*ETYLDFM*3412/1000000000000)

Electricity production as cellulosic co-product, corn stover
ELSPRCST = (STLFSPRD*1000000*ELYLLFST*ETYLDST*3412/1000000000000)

Electricity production as cellulosic co-product, municipal waste
ELSPRCMW = (MWLFSPRD*1000000*ELYLLFMW*ETYLDMW*3412/1000000000000)

Liquid fuel production from all Biomass
LFSPRDBMCL = LFSPRDWGCL
+LFSPRDWSCL
+LFSPRDFMCL
+LFSPRDSTCL
+LFSPRDMWCL

Electricity production from all BioMass

ELSPRDBM = ELSPRDWG
+ELSPRDWS
+ELSPRDFM
+ELSPRDST
+ELSPRDMW
+ELSPRCWG
+ELSPRCWS
+ELSPRCFM
+ELSPRCST
+ELSPRCMW

Area harvested, warm season grasses

WGSHAR = (WGLFSPRD + WGELSPRD)/WGSYLD

Area planted, warm season grasses

WGSPLT = 1.052631579*WGSHAR

Warm season grass price for electricity production, farm price

WGELPFRM = max(0, (WGELPPLT - WGELTRAN))

Wheat straw price for electricity production, farm price

WSELPFRM = max(0, (WSELPPLT - WSELTRAN))

Forest material price for electricity production, farm price

FMELPFRM = max(0, (FMELPPLT - FMELTRAN))

Corn stover price for electricity production, farm price

STELPFRM = max(0, (STELPPLT - STELTRAN))

Municipal waste price for electricity production, farm price

MWELPFRM = max(-20, (MWELPPLT - MWELTRAN))

Warm season grass price for liquid fuel production, farm price
WGLFPFRM =max(0, (WGLFPPLT - WGLFTRAN))

Wheat straw price for liquid fuel production, farm price
WSLFPFRM = max(0, (WSLFPPLT - WSLFTRAN))

Forest material price for liquid fuel production, farm price
FMLFPFRM = max(0, (FMLFPPLT - FMLFTRAN))

Corn stover price for liquid fuel production, farm price
STLFPFRM = max(0, (STLFPPLT - STLFTRAN))

Municipal waste grass price for liquid fuel production, farm price
MWLFPFRM = max(-20, (MWLFPPLT - MWLFTRAN))

Renewable electricity price index
ELRINDEX = ENELPIND
+1*ENELPMAN_BM

Cellulosic ethanol imports, marketing year
ETIMCESA = 0.65*(ETPCEL)/ETCEVARC*lag(ETIMCESA)
+0.1*MAX(0,ETPCEL-10)/ETCEVARC
+0.1*MAX(0,ETPCEL-15)/ETCEVARC
+0.1*MAX(0,ETPCEL-20)/ETCEVARC
+5*max(0,ZTIME-2010)

E-10 demand inflection point
ETE10INI = 0.18
+0.04*lag(ETE10PEN)
+0.02*lag2(ETE10PEN)
+0.8*lag(ETE10INFP)
+0.02*ETE15PEN

Share of cellulosic diesel applied toward biodiesel mandate
CDSHRBD = 0.25*max(0,(RFBDCPG/(RFCECPG*1.5)-1)

Cellulosic Diesel applied toward biodiesel mandate
CDRFSBD = CDSHRBD*LFSPRDCD

Cellulosic Diesel production
LFSPRDCD = 1
+3*Trend (ZTIME-2005)

Farm Receipts Wheat Straw (WS)
FIRWS = Max(0,WSLFPFRM*WSLFSPRD)/1000
+Max(0,WSELPFRM*WSELSPRD)/1000

Farm Receipts Warm season Grasses (WG)
FIRWG = Max(0,WGLFPFRM*WGLFSPRD)/1000
+Max(0,WGELPFRM*WGELSPRD)/1000

Farm Receipts corn STover (ST)
FIRST = Max(0,STLFPFRM*STLFSPRD)/1000
+Max(0,STELPFRM*STELSPRD)/1000

Farm costs Wheat Straw (WS)
FIPXWS = Max(0,(WSLFPFRM-WSNRPTON)*WSLFSPRD)/1000
+Max(0,(WSELPFRM-WSNRPTON)*WSELSPRD)/1000

Farm costs Warm season Grasses (WG)
FIPXWG = Max(0,(WGLFPFRM-WGNRPTON)*WGLFSPRD)/1000
+Max(0,(WGELPFRM-WGNRPTON)*WGELSPRD)/1000

Farm costs corn STover (ST)
FIPXST = Max(0,(STLFPFRM-STNRPTON)*STLFSPRD)/1000
+Max(0,(STELPFRM-STNRPTON)*STELSPRD)/1000

Market clearing equations

RIN markets

Conventional RIN price

Conventional RIN clearing, with complementary slackness

```
0=	(ETSPRDCL
	+ETDTESCL(t-1)
	-ETDTESCL
	+(ETSIMNCL)
	+BDEQV*(BDSPRD-BDDEXN-BDRDPRD-BDDTESCL+ BDDTESCL(t-1))
	+CDRFSBD*1.7
	+ETSPOACL
	+ETIMCECL
	+(LFSPRDCD-CDRFSBD)*1.7
	+BDRDPRD*1.7
	 -RFTOE)*RFCNCPG
```

Advanced RIN price

Alternative 1

Advanced RIN clearing, with complementary slackness

```
0=		(ETSPNCCL*ETNCADV
		+ETSIMPCL
		+ETSSUGCL
		+ETSPOACL
		+BDEQV*(BDSPRD-BDDEXN-BDRDPRD-BDDTESCL+ BDDTESCL(t-1))
		+CDRFSBD*1.7
		+ETSPCECL
		+ETIMCECL
		+(LFSPRDCD-CDRFSBD)*1.7
		+BDRDPRD*1.7
		-RFADE) *RFADCPG
```

Advanced RIN price
MAX(RFCNCPG, Alternative 1)

Cellulosic RIN price

Alternative 1
Cellulosic RIN clearing, with complementary slackness

0= (ETSPCECL
+ETIMCECL
+(LFSPRDCD-CDRFSBD)*1.7
-RFCEE)*RFCECPG

Alternative 2
Credit established by EISA if cellulosic requirement is waived

ETCECR10

Cellulosic RIN price
MIN(MAX(RFADCPG, Alternative 1), Alternative 2)

Biodiesel RIN price

Alternative 1
Biodiesel RIN clearing, with complementary slackness

0 = (BDSPRD
-BDDEXN
-BDDTESCL
+ BDDTESCL(t-1)
+CDRFSBD
-RFBDE)*RFBDCPG

Biodiesel RIN price
MAX(RFADCPG*1.5, Alternative 1)

Ethanol market

0 = ETSPRDCL
+ETDTESCL(t-1)
-ETDTESCL
+ETSIMNCL
-ETDISCL

Biodiesel market

0= BDSPRD
+BDDTESCL(t-1)
+LFSPRDCD
-BDDEXN
-BDDOM
-BDDTESCL

Distillers grains market

0= DGSPRD
-DGDEXP
-DGCONLV

HFCS-42 market

0 = HFSPRDOS
-HFDDOMOS
-HFDEXNOS

Non-food corn oil market

0= FCPRDCL
-CLDBIO
-CLDFED

Percent changes in dependent variables given a 1% change in independent variables, 2010-2012[1]

Dependent variable	Independent variable	Percent Changes Short-Run	Long-Run
Motor Fuel Use			
MGSTOTCL	UGPRTCL/PDCGNP	-0.11	-0.74
MGSTOTCL	ETPRTCL/PDCGNP	-0.01	-0.04
MGSTOTCL	log(ZCE92W/POPTOTW)	0.12	0.46
DISLS	DIPRT/PDCGNP	-0.13	-0.13
DISLS	ln(ZCE92W/POPTOTW)	0.39	0.39
ETDISCLPROJ	MGSTOTCL1	1.01	1.01
BDDDOMTRPROJ	BDPREQ/DIPRS	-0.78	-0.78
Ethanol			
ETDADCL	(ETPRTCL)/PPIRPP	-0.02	-0.02
ETDADCL	MGSTOTCL*ETADD*(1-ETDE85CL/MGSTOTCL/.74)	1.00	1.00
ETE15PEN	ETPRTCL/UGPRTCL	-455.26	-1300.74
ETME85CL	(ZTIME - 1980)	0.52	0.61
ETDTESCL	ETSPRDCL	0.12	1.19
Conventional Ethanol Production			
ETCAPDM	(CRNRBDM-CRNCC)/PDCGNP	0.00	3.88
ETCAPWM	(CRNRBWE-CRNCC)/PDCGNP	0.00	1.87
ETSPNCCL	(0.75*ETPADCL+0.25*ETPFBCL)/PDCGNP	0.36	0.89
ETSPNCCL	(0.75*ETPADCL+0.25*ETPFBCL)/SGPFRMCL	0.51	1.26
ETSPNCCL	(0.75*ETPADCL+0.25*ETPFBCL)/WHPFRMCL	0.23	0.59
Corn Fractionation			
FCNRT	.0093*GDPD + .0227*PPINGAS	-0.47	-0.47

[1] These estimates represent elasticities for equations with linear or log-log functional forms. For other functional forms, such as logistic, they are estimates of the percent changes but might not be considered the elasticity. The estimates were calculated using average values from the 2010-2012 period. This can lead to some extreme values in situations where the dependent variable is very small over that timeframe (e.g. ETE15PEN).

Dependent variable	Independent variable	Percent Changes Short-Run	Long-Run
FCNRT	CLPNF*0.1686	1.82	1.82
FCNRT	2.95*DGPMKT/2000	-0.50	-0.50
Cellulosic Ethanol			
ETCEVARC	CRVARC	0.16	0.16
ETCEVARC	WHVARC	0.12	0.12
ETCEVARC	SBVARC	0.14	0.14
ETCEVARC	HAPFRM	0.32	0.32
ETCEVARC	CRNRML	0.26	0.26
ETCEVARC	WHNRML	0.39	0.39
ETCEVARC	SBNRML	0.31	0.31
ETCEVARC	(PPINGAS1*2/3+lag(PPINGAS1)/3)	0.09	0.09
ETCEVARC	CROTCDM	0.66	0.66
ETSPOASA	ETPADCL/PDCGNP*lag(ETSPOACL)	0.46	0.46
Other Renewable Diesel	BDPPLTCL/PDCGNP*lag(BDSRDPRD)	0.23	0.23
Distiller's Grains			
DGVFEBE	DGDCOBE*CRPFRM*2000/56	0.81	0.81
DGVFEBE	DGDSMBE*SMP48D	0.19	0.19
DGVFEPK	DGDCOPK*CRPFRM*2000/56	0.72	0.72
DGVFEPK	DGDSMPK*SMP48D	0.28	0.28
DGVFEBR	DGDCOPK*CRPFRM*2000/56	0.49	0.49
DGVFEBR	DGDSMPK*SMP48D	0.51	0.51
DGVFEDY	DGDCOPK*CRPFRM*2000/56	0.40	0.40
DGVFEDY	DGDSMPK*SMP48D	0.60	0.60
DGVEN	(WPI051/WPI051$_{1996}$)*36.48	1.00	1.00
DGVFZ	PPI9NFZ/PPI9NFZ1997*0.26/0.82	1.00	1.00
CLDFED	CLPNF/SOPMKT	-0.01	-0.01
Other Corn Processing			
GFPR21	SMP48D	0.07	0.07

Dependent variable	Independent variable	Percent Changes Short-Run	Long-Run
GFPR21	CRPFRM	0.37	0.37
GFPR21	DGPMKT	0.41	0.41
GFPR21	LN(GFDDOM) (LN(MAX(0.001,GFDDOM))	-0.15	-0.15
GMPR60	SMP48D	0.86	0.86
GMPR60	LN(GMDDOM) (LN(MAX(0.001, GMDDOM))	-0.04	-0.04
CLPRCH	SOPMKT	0.09	0.09
CLPRCH	LN(CLDFOD) (LN(MAX(0.001, CLDFOD))	-0.09	-0.09
CRDHFC	CRGMWH/PDCGNP	0.31	0.62
CRDHFC	CRNRBWM/PDCGNP	-0.05	-0.10
CRDGLD	CRPFRM/SUPRAW	-0.12	-0.12
CRDSTR	CRPFRM/PDCGNP	-0.17	-0.17
CRDBEV	CRPFRM/PDCGNP	-0.15	-0.15
CRDCER	CRPFRM/PDCGNP	-0.15	-0.15
HFP55MW	HFPRMW	0.83	0.83
HFDDOMOS	HFP55MW/average(SUPRAW,SUPREF)	-0.15	-0.15
HFDDOMOS	max(0,HFP55MW-average(SUPRAW,SUPREF))	-0.08	-0.08
HFDDOMOS	ln(ZCE92W1/POPTOTW1)	0.13	0.13
-HFDEXMOS	HFPRMW/average(SUPRAW,SUPREF)	-0.12	-0.12
-HFDEXMOS	HFPRMW/CRPFRM	-0.07	-0.07
HFSPRDCL	Lag(HFSPRDOS)	0.75	0.75
HFSPRDCL	HFSPRDOS	0.25	0.25
HFDEXN	lag(HFDEXNOS)	0.73	0.73
HFDEXN	HFDEXNOS	0.25	0.25
GFDEXN	GFPR21/PDCGNP	-2.53	-2.53
GFDEXN	CRPFRM/PDCGNP	1.20	1.20
GFDEXN	SMP48D/PDCGNP	0.45	0.45
GMDEXN	GMPR60/PDCGNP	-1.21	-1.21
GMDEXN	SMP48D/PDCGNP	0.87	0.87
CLSPRD	(CRDGWM/3+CRDGWM1*2/3)*CLYLDWM	0.26	0.26

Dependent variable	Independent variable	Percent Changes Short-Run	Long-Run
CLSPRD	(CRDOWM/3+CRDOWM1*2/3)*CLYLDWM	0.50	0.50
CLSPRD	(FCPRDCL/3+FCPRDCL1*2/3)	0.32	0.32
CLDEXN	CLPRCH/PDCGNP	-0.62	-0.62
CLDEXN	SOPMKT/PDCGNP	0.38	0.38
CLDTES	CLPRCH/PDCGNP	-0.99	-0.99
CLDTES	CLSPRD	0.97	0.97
Biodiesel			
BDCAPSO	(BDNRTSO-0.2)/PDCGNP	0.00	-0.32
BDDDOMTR	(BDPREQ/(DIPRSM))	-7.21	-7.21
BDDDOMTR	DISLS	2.15	2.15
BDOTPRD	BDSOPRD	0.28	0.35
BDOTPRD	BDPPLT/PDCGNP	0.72	0.9
BDCAPRO	(BDNRTRO)/PDCGNP	-0.06	-7.89
BDCAPCL	(BDNRTCL-.1)/PDCGNP	0.05	8.15
BDDTESCL	BDSPRD	0.09	0.18
Trade Equations			
ETSIMPCL	ETPADCL/((ETPBZACL)*(1+ETTARVCL)+ETTARSCL)	0.12	0.12
ETDEXPCL	ETPFBCL/ETPBZACL	-1.14	-1.14
ETPBZAMA	POILRASA	0.33	0.33
ETPBZAMA	ETSIMNSA	-0.02	-0.02
BDDEXN	(BDPPLT-BDTAXCR+BDTAREU+0.2)/(lag(BDPGER)*3/4 + BDPGER/4)	-1.24	-1.54
DGDEXN	DGPMKT/PDCGNP	-0.92	-0.92
DGDEXN	CRPFRM/PDCGNP	0.60	0.60
DGDEXN	SMP48D/PDCGNP	0.16	0.16

Impact multipliers

The impact multipliers presented in the table below illustrate how the US Biofuel model responds to exogenous price shocks. The biofuel model is not linked to other models in the FAPRI-MU system for these tests. These are technical experiments to assess model performance.

The key model assumptions remain the same, including the ability of EPA to adjust RFS requirements in response to changes in market conditions.

The price shocks include the following:

- *$1.00/bu. increase in the farm price of corn on a marketing year basis* – All else equal, an increase in this ethanol feedstock price lowers the net returns for ethanol production and ethanol supply is reduced. Ethanol prices rise and become less competitive with both domestic gasoline prices and the world price of ethanol. Demand for ethanol, most notably in mid- and high-level blends (e.g. E15 and E85), and export demand fall. The RFS adjusts under the market conditions to a level that is neither more, nor less, difficult to meet on a per-gallon basis. The conventional (D6) RIN price is unaffected, so a lower overall requirement implies lower overall compliance expenditures.

- *$10.00/cwt. Increase in soybean oil price on a marketing year basis* – All else equal, an increase in this biodiesel feedstock price lowers the net returns for soyoil-based biodiesel production and the respective supply falls. In addition, the higher soybean oil prices drive up the prices for both food- and nonfood-grade corn oil, which increases the returns to both wet- and dry-mill ethanol production. Ethanol production increases. As ethanol prices fall, and demand increases, the RFS adjusts to hold per-unit costs approximately unchanged. In this case, the biomass-based diesel mandate is more binding, as indicated by its higher RIN price. There is less potential for excess biomass-based diesel (D4) RINs to be used to meet the broader requirements, so there is somewhat higher demand for advanced (D5) and conventional (D6) RINs within a given compliance year and their RIN prices increase as well.

- *$10.00/bbl. Increase in crude oil (WTI) price on a calendar year basis* – All else equal, higher crude oil prices also imply higher prices for petroleum-based gasoline and diesel fuels. Although overall motor fuel demand decreases as a result, the higher motor fuel prices increase the competitiveness of biodiesel, as a whole, and ethanol in mid- and high-level blends. Production of the biofuels increases to meet the rising demand, and the RFS is adjusted as well. Somewhat higher RFS requirements, in addition to small changes in RIN values based on how RFS implementation is represented, leads to slightly higher overall RFS compliance costs.

$1.00 increase in corn price (Marketing year)	Units	2014-2018 average change from base	2019-2023 average change from base
Crude oil price (WTI)	$/bbl	0.00	0.00
Retail gasoline price	$/gallon	0.00	0.00
Motor gasoline supplied	Million gallons	-153.71	-245.60
Ethanol production	Million gallons	-959.21	-1655.97
Ethanol production From corn	Million gallons	-998.68	-1707.77
Ethanol imports	Million gallons	2.37	2.09
Domestic disappearance of ethanol	Million gallons	-507.78	-1258.71
Ethanol exports	Million gallons	-443.29	-387.95
Conventional rack price, Omaha	$/gallon	0.18	0.16
Effective retail ethanol price	$/gallon	0.18	0.16
Conventional ethanol RIN value	$/RIN	0.00	0.00
Other advanced biofuels RIN value	$/RIN	0.00	0.00
Biomass-based diesel production	Million gallons	-2.75	-17.02
BD production from soybean oil	Million gallons	8.15	14.52
BD production from corn oil	Million gallons	-13.53	-36.73
Domestic disappearance of biodiesel	Million gallons	-2.59	-16.66
Biodiesel rack price, Des Moines	$/gallon	0.01	0.01
Biomass-based diesel RIN value	$/RIN	0.00	0.00
Net operating return (Biodiesel)	$/gallon	0.01	0.01
Corn for ethanol (Marketing year)	Million bushels	-423.35	-615.50
Net operating return (Dry-mill ethanol)	$/gallon	-0.05	-0.09
Overall applied standard	Million gallons	-489.68	-1250.85
Overall advanced biofuels	Million gallons	18.37	8.63
RIN compliance expenditures, total	Million $	-140.39	-445.20

$10.00 increase in soybean oil price (Marketing year)	Units	2014-2018 average change from base	2019-2023 average change from base
Crude oil price (WTI)	$/bbl	0.00	0.00
Retail gasoline price	$/gallon	0.00	0.01
Motor gasoline supplied	Million gallons	-19.17	-50.01
Ethanol production	Million gallons	248.50	283.26
Ethanol production From corn	Million gallons	251.13	287.77
Ethanol imports	Million gallons	58.79	191.43
Domestic disappearance of ethanol	Million gallons	277.26	431.35
Ethanol exports	Million gallons	28.54	42.32
Conventional rack price, Omaha	$/gallon	-0.01	-0.02
Effective retail ethanol price	$/gallon	-0.05	-0.05
Conventional ethanol RIN value	$/RIN	0.04	0.04
Other advanced biofuels RIN value	$/RIN	0.04	0.04
Biomass-based diesel production	Million gallons	-37.61	-209.14
BD production from soybean oil	Million gallons	-117.95	-337.61
BD production from corn oil	Million gallons	-19.67	-102.08
Domestic disappearance of biodiesel	Million gallons	-55.28	-224.73
Biodiesel rack price, Des Moines	$/gallon	0.58	0.47
Biomass-based diesel RIN value	$/RIN	0.36	0.21
Net operating return (Biodiesel)	$/gallon	-0.08	-0.30
Corn for ethanol (Marketing year)	Million bushels	102.47	101.71
Net operating return (Dry-mill ethanol)	$/gallon	0.01	0.01
Overall applied standard	Million gallons	258.84	91.54
Overall advanced biofuels	Million gallons	-18.58	-340.08
RIN compliance expenditures, total	Million $	1303.60	1009.91

$10 increase in crude oil price (Calendar year)	Units	2014-2018 average change from base	2019-2023 average change from base
Crude oil price (WTI)	$/bbl	10.00	10.00
Retail gasoline price	$/gallon	0.22	0.22
Motor gasoline supplied	Million gallons	-3087.18	-5570.93
Ethanol production	Million gallons	309.33	309.61
Ethanol production From corn	Million gallons	304.93	305.20
Ethanol imports	Million gallons	-2.80	-3.17
Domestic disappearance of ethanol	Million gallons	354.89	331.51
Ethanol exports	Million gallons	-50.17	-26.07
Conventional rack price, Omaha	$/gallon	0.02	0.01
Effective retail ethanol price	$/gallon	0.03	0.02
Conventional ethanol RIN value	$/RIN	-0.01	0.00
Other advanced biofuels RIN value	$/RIN	-0.01	0.00
Biomass-based diesel production	Million gallons	163.23	177.71
BD production from soybean oil	Million gallons	105.30	103.84
BD production from corn oil	Million gallons	24.28	36.66
Domestic disappearance of biodiesel	Million gallons	164.53	179.90
Biodiesel rack price, Des Moines	$/gallon	0.06	0.07
Biomass-based diesel RIN value	$/RIN	-0.03	0.00
Net operating return (Biodiesel)	$/gallon	0.06	0.07
Corn for ethanol (Marketing year)	Million bushels	113.33	109.29
Net operating return (Dry-mill ethanol)	$/gallon	0.02	0.01
Overall applied standard	Million gallons	596.46	604.53
Overall advanced biofuels	Million gallons	241.22	272.48
RIN compliance expenditures, total	Million $	16.56	65.62