Issues and Methods for Estimating the Share of Ethanol in the Motor Gasoline Supply

U.S. Energy Information Administration

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Abstract

This paper describes publicly available fuel ethanol data and suggests methodologies to estimate the percentage of ethanol used in the United States gasoline supply. These methods, which use historical U.S. Energy Information Administration (EIA) survey data and information from other sources, involve calculations based on motor gasoline and ethanol production, net imports, and inputs into refineries and blenders.

1. Introduction

Ethanol is primarily used as a gasoline blending component in the United States. Gasoline-powered cars and light trucks manufactured for the U.S. market since the late 1970s are designed to use up to 10 volume percent ethanol (E10). In recent years, E10 has become the majority of U.S. gasoline consumption. The U.S. Environmental Protection Agency (EPA) recently approved the use gasoline with up to 15 volume percent ethanol (E15) for model-year-2001 and newer cars and light trucks, but much work remains until this formulation is widespread.[1] Higher blends of ethanol such as E85 are currently available on a limited basis. These fuels can only be used in certain vehicles and require special pumps. Because of the outstanding issues that must be addressed to use fuels with more than 10 percent ethanol by volume, ethanol use at the level where every gallon of gasoline contains 10 percent ethanol is often referred to as the "blend wall".[2]

In the 2010 *Petroleum Supply Annual,* EIA estimated finished motor gasoline product supplied[3] of 3.28 billion barrels (138 billion gallons) in 2010 and ethanol inputs of 286 million barrels (12.0 billion gallons) in 2010. Ethanol production in 2010 was about 317 million barrels (13.3 billion gallons). Reported ethanol inputs were 8.7 percent of motor gasoline supplied, and ethanol production volume was 9.7 percent of motor gasoline supply volume. This level of consumption and production in relation to gasoline volume, coupled with expected ethanol production capacity of over 14 billion gallons in 2011, leads some analysts to believe that the ethanol blend wall has already been reached or will be during 2011.

The approaching saturation of the gasoline pool motivated the ethanol industry to seek approval for a mid-level blend exceeding 10 percent ethanol. Without a mid-level blend such as E15, incremental domestic ethanol production could only be exported or blended to E85, a blend of 70 to 85 volume percent ethanol and 30 to 15 volume percent gasoline. E85 is currently sold in very limited volumes due to infrastructure limitations on both the demand and supply sides. Flexible-fueled vehicles (FFV) are capable of using high-level ethanol blends such as E85. Special storage tanks and pumps are required for the retail sale of E85. In 2009 the EPA and the Department of Energy (DOE) began to test a sample of vehicle makes and models that are in widespread use. In October 2010, the EPA approved the use of E15 in cars and light trucks manufactured after 2006, and in January 2011 approved the use of E15 in cars and light trucks

[1] A sample of the issues to be addressed is the use of E15 in Reformulated Gasoline (RFG) markets, prevention of the use of E15 in older vehicles and all non-road equipment, resolution of potential liabilities if misfueling does occur, and ensuring the safety of retail pumps with E15 instead of E10.

[2] Ethanol is not blended to gasoline in pure form. It must be denatured, or made undrinkable, by the addition of other substances. In this paper "ethanol" will mean denatured ethanol which contains 2 to 5 gallons of other chemicals, typically naphtha-range material from petroleum or natural gas processing, for every 100 gallons of pure ethanol.

[3] Products supplied approximately represents consumption of petroleum products because it measures the disappearance of these products from primary sources, i.e., refineries, natural gas-processing plants, blending plants, pipelines, and bulk terminals

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manufactured between 2001 and 2006[4]. Together, these vehicles are estimated to account for approximately 60 percent of vehicles being driven in the United States as of January 2011[5].

Many interested parties, including auto manufacturers, ethanol producers, petroleum refiners, and legislators, have been following calculations of the current fraction of ethanol in gasoline, typically using data from the Energy Information Administration (EIA). This methodology paper examines the existing sources of ethanol data and highlights the different issues with the calculation of the percentage ethanol blend in gasoline. The paper also recommends improved ethanol metrics for future development.

2. Description of Motor Gasoline and Ethanol Data Sources

EIA currently publishes ethanol and motor gasoline data in the Monthly Energy Review (MER), the Petroleum Supply Monthly (PSM), and the Weekly Petroleum Status Report (WPSR). The surveys used to collect data for the MER and PSM are the EIA-810 "Monthly Refinery Report," EIA-812 "Monthly Product Pipeline Report", EIA-814 "Monthly Imports Report," EIA-815 "Monthly Bulk Terminal and Blender Report," EIA-817 "Monthly Tanker and Barge Movements Report, and EIA-819 "Monthly Oxygenates Report." The weekly surveys used to gather ethanol data are the EIA-800 "Weekly Refinery Report," EIA-802 "Weekly Product Pipeline Report", EIA-804 "Weekly Imports Report," EIA-805 "Weekly Bulk Terminal and Blender Report," and EIA-809 "Weekly Oxygenate Report." These surveys are filed by operators of relevant facilities within the 50 States and the District of Columbia, and, in certain cases, such as import data, U.S. territories such as Puerto Rico and the Virgin Islands. Motor gasoline and ethanol exports are reported on a monthly basis, but are not collected from EIA surveys. The export data are provided by the U.S. Bureau of the Census forms EM-522 and EM-594 as noted in Appendix B of the PSM.

The data are aggregated to the level of Petroleum Administration for Defense Districts (PADD) and to the national level as well.[6] Survey forms and instructions can be found on the EIA website[7], while an explanation of sampling methods used on the weekly surveys and other survey and data estimations can be found in Appendix B of the WPSR[8] and Appendix B[9] of the PSM for the monthly surveys. Weekly data are collected to help monitor markets closer to real time. This survey data is limited in scope and represents companies' preliminary estimates before metered data is available in some cases. This analysis will be focusing on the monthly data series from the PSM as monthly data are more complete and have incorporated corrections to preliminary estimates and to any errors found in the weekly data.

EIA does not collect fuel ethanol export volumes but publishes data collected the U.S. Bureau of the Census. Census tracks less specific volumes of Ethyl Alcohol exports for non-food use, which is assumed to be primarily fuel ethanol. Using the two HS-10 harmonized tariff codes for Ethyl Alcohol exports for non-food use[10], the most current export figures can be retrieved through this database. A good summary for using this database and other sources is provided by the

[4] Environmental Protection Agency, Office of Transportation and Air Quality, Fuels and Fuel Additives - E15: http://www.epa.gov/otaq/regs/fuels/additive/e15/

[5] "U.S. EPA approves E15 for 2001 and newer vehicles," American Coalition for Ethanol, January 21, 2011, http://www.ethanol.org/pdf/contentmgmt/EPA_approves_E15_for_0106_vehicles_1212011.pdf

[6] PADD Region Map, http://www.eia.doe.gov/pub/oil_gas/petroleum/analysis_publications /oil_market_basics/paddmap.htm

[7] Petroleum Survey Forms, http://www.eia.gov/oil_gas/petroleum/survey_forms/pet_survey_forms.html

[8] Appendix B, Explanatory Notes and Detailed Methods Report, Weekly Petroleum Status Report, http://www.eia.doe.gov/pub/oil_gas/petroleum/data_publications/weekly_petroleum_status_report/current/pdf/appendixb.pdf

[9] Appendix B, PSM Explanatory Notes, Petroleum Supply Monthly, http://www.eia.doe.gov/pub/oil_gas/petroleum/data_publications/petroleum_supply_monthly/current/pdf/psmnotes.pdf

[10] Harmonized 10 Digit Tariff Codes (HS-10) 2207200000 and 2207106000

USDA's Economic Research Service.[11] This export data series was included in the EIA Petroleum Supply Monthly (PSM) ethanol supply and disposition for the first time in January 2011. This series will appear in future PSM data and is included in the revised 2010 data reported in the Petroleum Supply Annual (PSA).

3. Calculation of Ethanol Blending Volumes

Finished motor gasoline data are broken out into Conventional and Reformulated categories. Total domestic deliveries of finished conventional, reformulated, or total motor gasoline ("product supplied") within a PADD are calculated as a balance between supply (net production, imports, and net receipts) and other disposition (stock change and exports):

Product Supplied = (Refinery and Blender Net Production + Imports + Net Receipts + Adjustments) - (Stock Change + Exports)

A positive value for Stock Change denotes increasing motor gasoline stocks. Net Receipts are movements of motor gasoline between PADDs. A net inflow of gasoline is positive, and a net outflow of gasoline is negative. Since imports and exports have their own categories, net receipts are zero at the national level. The national formula for gasoline supply and disposition is otherwise identical to the regional equations.

Refinery and Blender Net Production is reported in more detail than the other items in the motor gasoline balance. Motor gasoline net production can be reported as Reformulated Blended with Fuel Ethanol, Other Reformulated, Conventional Blended with Fuel Ethanol, and Other Conventional. Starting in January 2010, Conventional Blended with Fuel Ethanol is further divided by ethanol content: 55 percent and lower and greater than 55 percent. We will utilize the reported ethanol-blended production in the next section.

Similarly, input of ethanol to the supply of liquid fuels is expected to equal the sum of production and imports less inventory accumulation and exports. In the ethanol balance, there is no term for product supplied, since all fuel ethanol is blended into motor gasoline or exported. This use is captured in Refinery and Blender Net Inputs.

However, several factors prevent total ethanol supply and disposition from balancing in the data that EIA collects. Some of these factors are timing of data reporting and incomplete coverage (e.g., small blenders and inventories held on rail cars). Therefore, an adjustment factor is used to balance supply and disposition. The adjustment is calculated as follows:

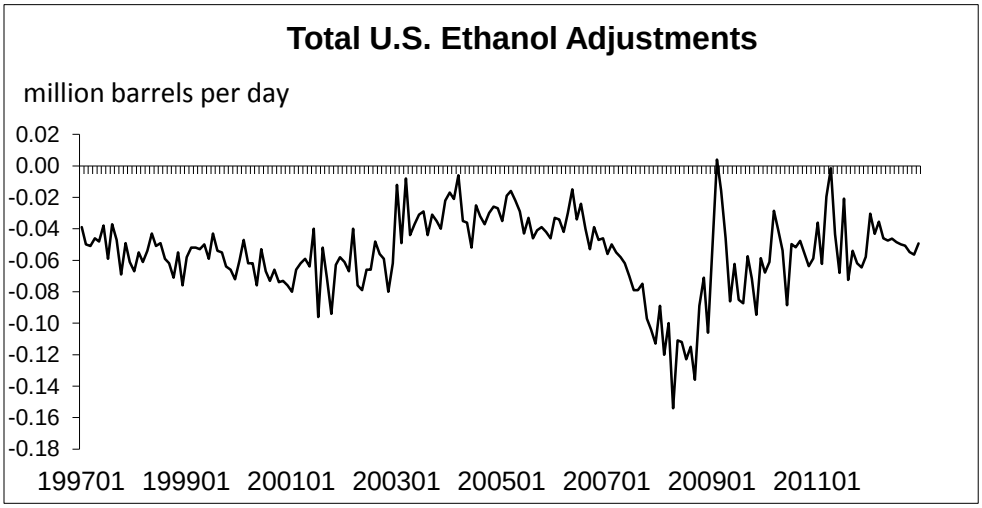
Ethanol Adjustments = (Stock Change + Exports + Refinery and Blender Net Inputs) - (Ethanol Plant Net Production + Imports)

Historically, when ethanol use and fuel ethanol exports were small, tracking ethanol blending activity was a relatively low priority, and blender reporting was incomplete as a result. Since EIA data collection covered a greater fraction of ethanol suppliers, surveyed production typically exceeded surveyed disposition, and a negative adjustment was used to represent the missing blending.

Monthly data collection has become more complete since 2009, when the EIA-815 form was revised to collect data on all activity at petroleum product terminals, including ethanol inventory levels and blending. Response is required from all terminals within the U.S. with at least 50,000

[11] ERS USDA Briefing Room, Bioenergy: Biofuel, Biofuel Feedstock, and Coproduct Market Data, "Ethanol Imports and Exports," http://www.ers.usda.gov/briefing/bioenergy/biofueldata.htm#eth3

barrels of storage capacity. The major missing data are inventory volumes in rail cars. As ethanol use has grown, the volume in rail cars at any time has increased. This affects the change in inventories used in the supply-disposition balance. But even if this data were collected, we would not expect a perfect balance, as timing of supply and disposition reporting varies and typical survey reporting and coverage errors add to the imbalance. Ethanol blending that occurs outside of the primary collection system would affect the balance as well.



The Adjustments term is the balancing item at the National level. The National value is allocated across PADDs based on the ratio of reported ethanol blending in each district divided by the amount reported for the entire United States. At the PADD level, a Net Receipts term serves as an additional balancing item. The supply and disposition of ethanol are represented at the PADD level as follows:

Ethanol Plant Net Production + Imports + Net Receipts + Adjustments =
Stock Change + Exports + Refinery and Blender Net Inputs

The Net Receipts term consists of implied net inflows of product via pipeline, tanker ship, barge, rail car or truck. EIA surveys product movement by water or pipeline but not by rail or truck. As with motor gasoline, the Net Receipts term disappears in the national version of the supply and disposition equation.

4. Methods for Calculating the Ethanol Blend Ratio

Three methods for calculating an ethanol blend ratio are addressed in this section:

1. Total refinery and blender net inputs of ethanol compared with net production of gasoline blended with ethanol;
2. Ethanol consumption compared with total gasoline product supplied (implied gasoline consumption); and
3. Ethanol consumption compared with total gasoline product supplied plus exports, which considers the fact that some ethanol may be included in exported gasoline.

First, we begin by comparing refiner and blenders' net input of fuel ethanol to their production of gasoline-ethanol blends. Results are displayed in Table 1.

Table 1: Net Input of Ethanol, Percent of Net Production of Gasoline Blended with Ethanol

	March 2010	June 2010	September 2010	December 2010	March 2011	June 2011
PADD 1	10.05	10.03	10.03	10.03	10.01	9.96
PADD 2	10.07	10.08	10.09	10.07	10.12	10.09
PADD 3	9.99	10.04	10.03	10.04	10.04	10.02
PADD 4	9.97	9.96	10.14	10.19	10.13	10.16
PADD 5	10.04	9.86	10.04	10.06	10.05	10.12
U.S.	10.04	10.02	10.05	10.05	10.05	10.04

Sources: *Petroleum Supply Annual 2010 Volume 2*, Tables 15 and 16. *Petroleum Supply Monthly*, March 2011 through August 2011, Tables 1, 5, 9, 13, 17, and 21.

Table 1 indicates that in 2010, nearly every gallon of ethanol-blended gasoline contains 10 percent ethanol by volume. The volumes of ethanol-blended gasoline include some small volumes of blends with greater than 55 percent ethanol, which are likely E85 but are not specifically identified as such. This is one reason for averages slightly above 10 percent in some regions and months. Survey accuracy also contributes to such variations.

Second, we compared estimated ethanol consumption with total finished gasoline consumption. As noted previously, surveyed ethanol supply is usually greater than surveyed ethanol disposition. This paper assumes that the unrecorded blending activity is the main component of the ethanol adjustment. Ethanol consumption is estimated from supply and inventory data as:

Ethanol Consumption = Ethanol Plant Net Production + Imports
+ Net Receipts - Stock Change – Exports

Where *Net Receipts* = 0 at the National level.[12]

Since we assume that some ethanol is blended into gasoline without being reported as a refiner or blender input, it follows that the gasoline that it is blended with will likely not be reported as ethanol-blended gasoline. Therefore, the comparison should not be restricted to reported production of ethanol-blended gasoline. We first compare ethanol consumption to the overall supply of finished gasoline by PADD and for the entire U.S. in Table 2.

[12] The national version of this calculation is published as "Ethanol Consumption" in Table 10.3 of the Monthly Energy Review. http://www.eia.gov/totalenergy/data/monthly/pdf/sec10_7.pdf

Table 2: Ethanol Consumption, Percent of Finished Gasoline Supplied

	March 2010	June 2010	September 2010	December 2010	March 2011	June 2011
PADD 1	9.52	10.21	9.78	10.3	9.63	10.54
PADD 2	8.87	9.44	9.17	9.41	9.24	9.39
PADD 3	7.79	8.78	8.83	9.01	9.08	9.64
PADD 4	5.18	5.89	6.13	6.84	6.48	7.51
PADD 5	9.71	9.52	9.12	10.44	10.14	10.59
U.S.	8.97	9.51	9.23	9.76	9.42	9.98

Sources: *Petroleum Supply Annual 2010,* Volume 2, Tables 1, 3, 5, 7, 9, and 11. *Petroleum Supply Monthly*, March 2011 through August 2011, Tables 1, 5, 9, 13, 17, and 21.

We see that as of March 2010, the implied concentration of ethanol in gasoline was well under 10 percent. A general upward trend is observed at the regional and national levels. By June 2011, ethanol consumption was very near 10 percent of gasoline supplied nationally. Ethanol consumption may exceed 10 percent of finished gasoline due to some high ethanol blends in the pool or due to some ethanol going into gasoline exports, which are not counted in Table 2.

The third method of calculation ethanol blend ratios considers the broadest measure of the pool of gasoline that is available for ethanol blending by including finished gasoline exports. Table 3 compares ethanol consumption with the sum of finished gasoline product supplied and exports. EIA does not track the inclusion of ethanol in gasoline that is destined for export. Any volumes of ethanol used in this way would count as finished gasoline exports, not ethanol exports. For this reason, it is appropriate to exclude ethanol exports from the numerator while including gasoline exports in the denominator.

Table 3: Ethanol Consumption, Percent of Finished Gasoline Supplied Plus Exports

	March 2010	June 2010	September 2010	December 2010	March 2011	June 2011
PADD 1	9.47	10.19	9.75	10.29	9.62	10.53
PADD 2	8.85	9.42	9.15	9.38	9.20	9.38
PADD 3	6.52	7.52	7.77	6.79	7.00	7.68
PADD 4	5.18	5.89	6.13	6.84	6.48	7.51
PADD 5	9.25	9.31	8.97	10.04	9.88	10.24
U.S.	8.62	9.23	9.01	9.22	8.98	9.56

Sources: *Petroleum Supply Annual 2010,* Volume 2, Tables 1, 3, 5, 7, 9, and 11. *Petroleum Supply Monthly*, March 2011 through August 2011, Tables 1, 5, 9, 13, 17, and 21.

The values in Table 2 and Table 3 for PADD 4 are identical, since gasoline exports from PADD 4 are rare and very small when they do happen. The changes in PADD 1 and 2 values from Table 2 to Table 3 are also small, since these regions are not major gasoline exporters. The inclusion of exports reduces the estimated ethanol fraction most for PADD 3, which includes the extensive Gulf Coast refinery system. As in Table 2, a general upward trend in the percentage of ethanol in finished motor gasoline is observed.

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4. Conclusion

Our analysis suggests that as of June 2011 the U.S. is using nearly all the ethanol it can while subject to a widespread blending limit of 10 percent and a very limited market for E85. Blending of ethanol into gasoline for export is a limited additional outlet, and direct export of ethanol is a potentially large outlet for additional ethanol production.

Both adjustments and net receipts are used as balancing items in the supply-disposition balance. Net receipts of motor gasoline are captured fairly well in EIA data, which covers pipeline and water movements of finished petroleum products and blending components. Rail movement, however, is conspicuously absent from EIA data, and most ethanol is shipped by rail. Expansion of EIA data collection to rail shipments and stocks in transit of ethanol is probably the single largest improvement that can be made to the estimation of the ethanol supply-disposition balance. Another enhancement for tracking ethanol disposition would be to break out ethanol-blended gasoline for export.